Thermo-electric characteristics of carbides

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THERMO-ELECTRIC CHARACTERISTICS OF CARBIDES

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INTRODUCTION.

The aim of this investigation is to obtain numerical data for the relationship between thermo-electromotive forces and temperatures for several grades of carbide and workpiecematerial (C45N).

For reasons of proper calibration, we carried out every experiment versus platinum (P_t). This metal has many advantages, such as:

- high melting point,
- great stability as far as corrosion is concerned,
- no transformation points.

METHOD OF TEST.

The calibration set-up consists among others of a radiation furnace and a cooling device, as can be seen in Fig. 1.

Both ends of the bar are connected with a platinum wire. The temperatures of the hot and cold junctions are measured by Chr /Al thermocouples and are put on paper-tape by means of a datalogger.

At the same time the emf voltage between the hot and the cold junctions of the calibration bar is put on this tape.

A good contact at the junctions is assured by the weight of the furnace.

The hot end of the calibration bar is protected against corrosion by means of an inert gas.

The cooling device operates by means of water and keeps the cold junctions approximately at 13°C.

TEST MATERIALS.

As mentioned before the tests are carried out for several grades of carbides and the workpiece material C45N. The carbides used are Sandvik grades S1, S2, S4, S6, H05, H1p, H10, H13, H20 and F02.

NUMERICAL ELABORATION. (see Fig. 2.)

With a regression-program (A - 2080 - 6) the polynomial coefficients of the calibration curve are calculated (used model: calibration bar voltage versus Pt $= a.T + b.T^2 + c.T^3$) (1).

More details are available on request.

RESULTS.

The results of all measurements are listed in Table 1.
In this table the coefficients a, b, and c are given for the carbides mentioned and the workpiece material C45N. Moreover, the 2σ-value (σ = standard deviation) of every coefficient as calculated by the regression-program is given.

DISCUSSION OF RESULTS.

In general, the shape of the calibration curves are parabolic.
It is possible to obtain the emf -relationship between one of these carbides and C45N-steel.
Therefore, the emf of S2 versus C45N is:

$$\text{emf}\ \frac{S2}{C45} = \text{emf}\ \frac{Pt}{C45} - \text{emf}\ \frac{S2}{Pt}.$$

In numerical values it will be:

$$\text{emf}\ \frac{Pt}{C45} = + 0.129 \times 10^{-1} \times T - 0.644 \times 10^{-5} \times T^2 + 0.549 \times 10^{-8} \times T^3$$

$$\text{emf}\ \frac{S2}{Pt} = - 0.949 \times 10^{-2} \times T - 0.34 \times 10^{-6} \times T^2 + 0.497 \times 10^{-8} \times T^3$$

$$\text{emf}\ \frac{S2}{C45} = + 0.224 \times 10^{-1} \times T - 0.610 \times 10^{-5} \times T^2 + 0.052 \times 10^{-8} \times T^3$$

(see Fig. 3.).

The heating-process calibrations are less stable and they do not reproduce so well as far as the materials with a negative emf are concerned.
The data of Table 1. are obtained from three or more well reproducible calibrations of the cooling-process.

The coefficients of Eq. 1. describes a curve through all the measuring-points of the calibration series with a very good technical accuracy (see Fig. 3.).

The C45/Pt calibration possesses in the upper range of the curve a loop. This loop is caused by the $A_{1,2,3}$ transformation energy. The A_c transformations absorb energy. During the A_r transformations the absorbed energy is released.
If no transformation should occur, the calibration curve should be in the middle of the loop mentioned before, because the absorbed energy and the released energy are of the same quantity (see Fig. 3.).
The coefficients of the calibration curve are determined to the average value of the A_c and A_r curve.

At the moment, research is going on in our laboratory into the backgrounds of being less stable of the carbide calibration curves in the heating-process.

REFERENCES.

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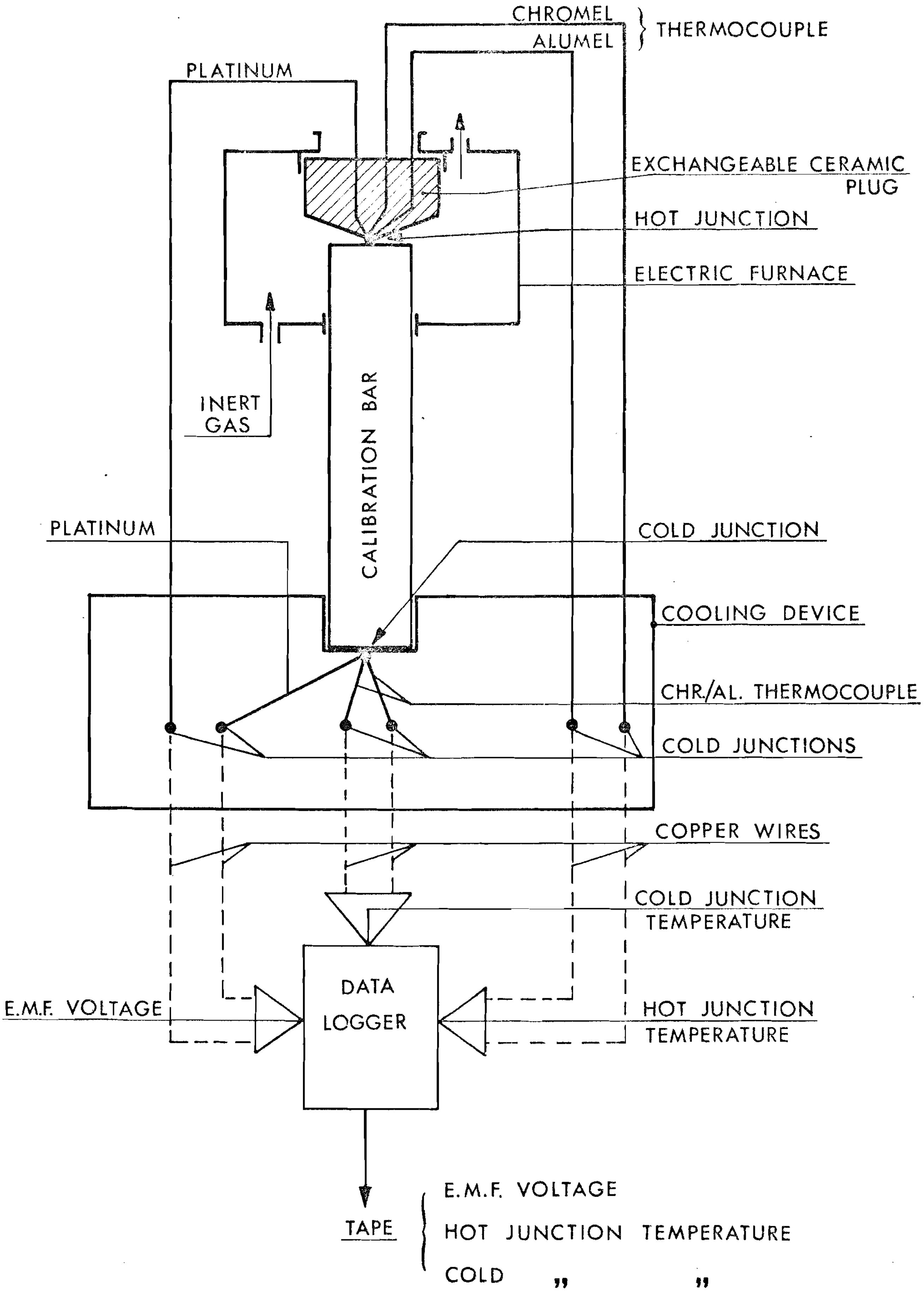

FIG. 1. CALIBRATION SET-UP

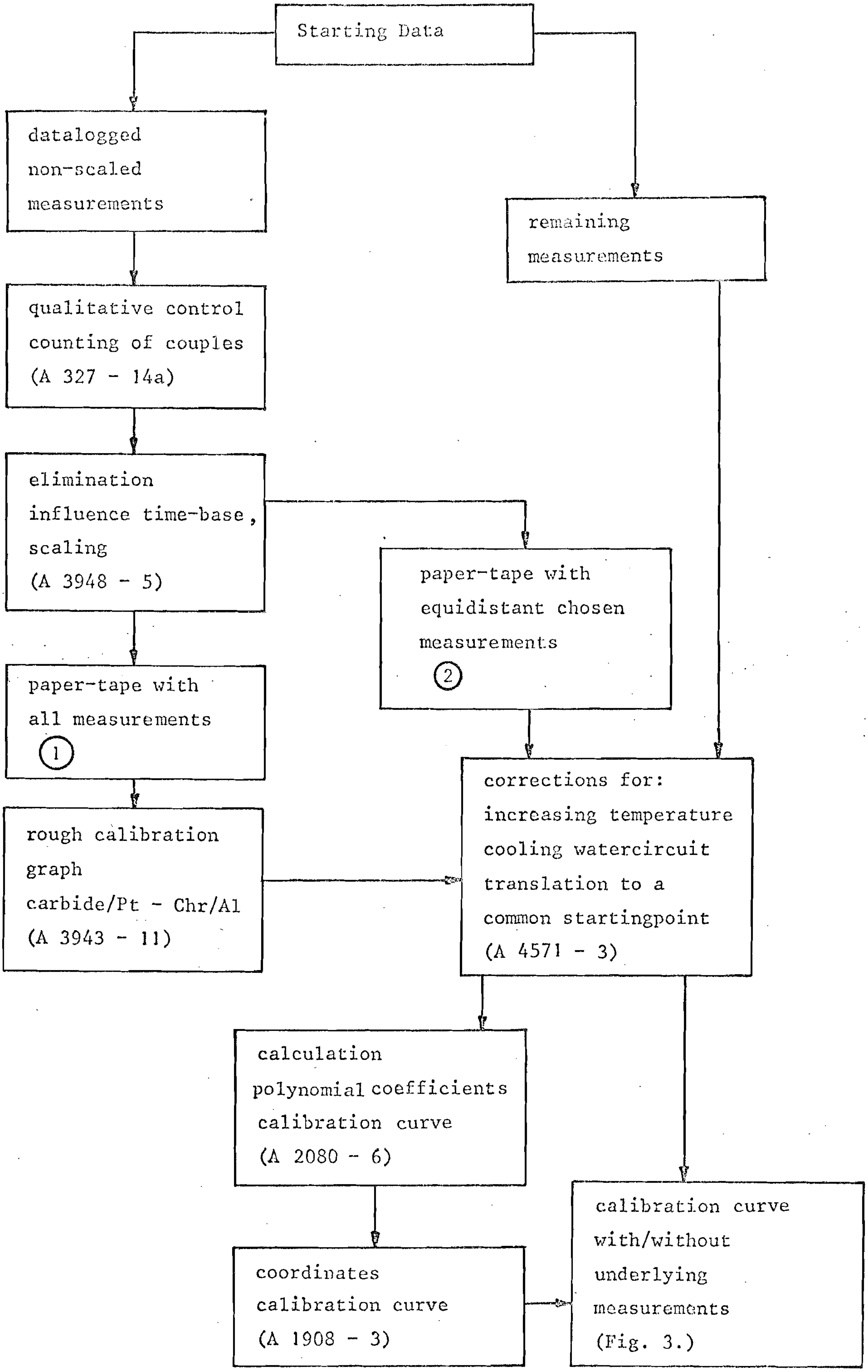

Fig. 2. Flow-chart of the numerical elaboration.

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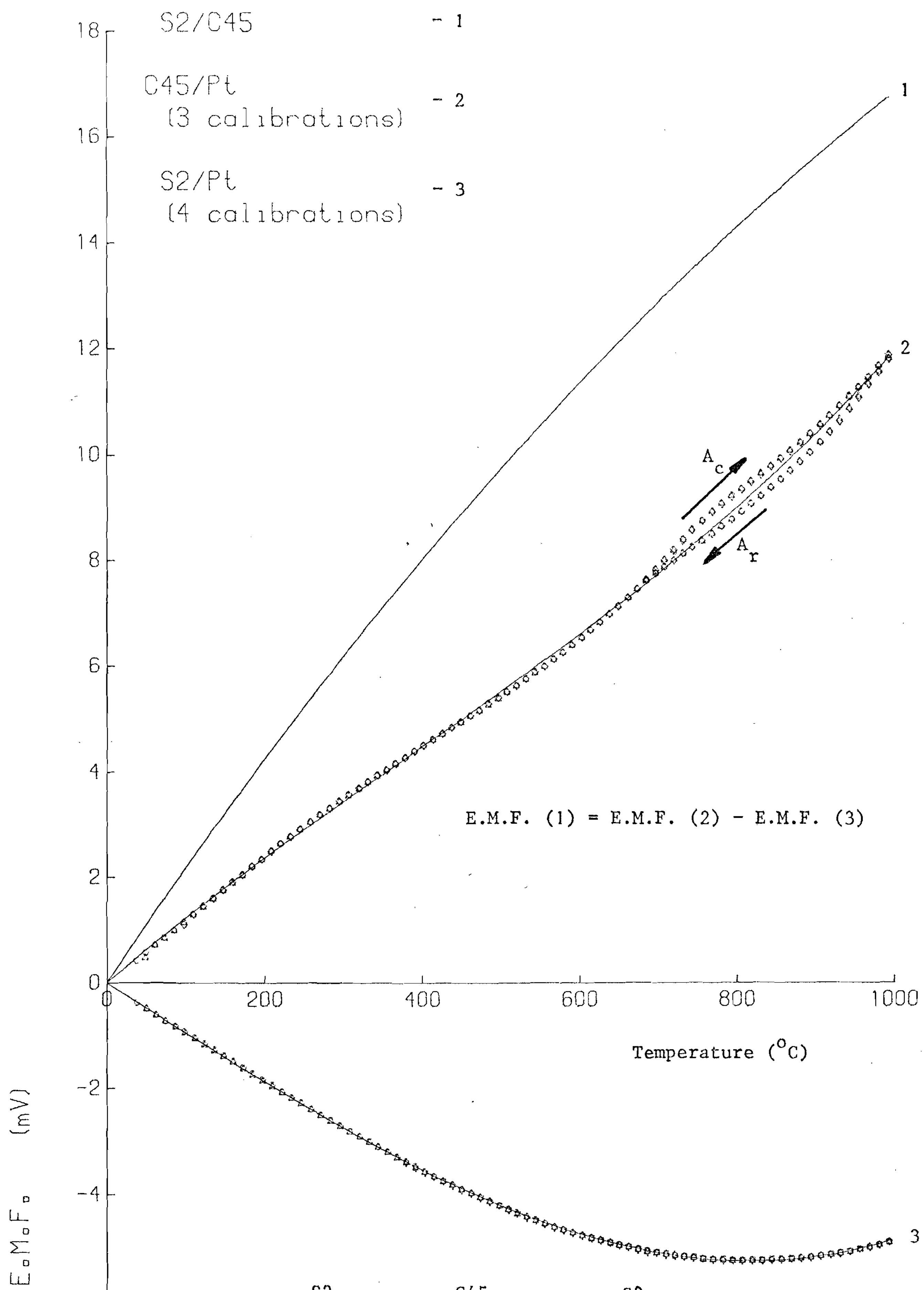

Fig. 3. E.M.F. $\frac{S2}{C45}$, E.M.F. $\frac{C45}{Pt}$ and E.M.F. $\frac{S2}{Pt}$ as a function of the temperature. The curve through the plotted loop determines the average value of the A_c and A_r energy.

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Materials versus Pt	emf coefficients with 2σ-values					
	a	2σ	b	2σ	c	2σ
carbide grade S1	$-0.349\mathrm{x}10^{-2}$	$0.3\mathrm{x}10^{-4}$	$-0.198\mathrm{x}10^{-5}$	$0.8\mathrm{x}10^{-7}$	$+0.479\mathrm{x}10^{-8}$	$0.6\mathrm{x}10^{-10}$
carbide grade S2	$-0.949\mathrm{x}10^{-2}$	$0.4\mathrm{x}10^{-4}$	$-0.343\mathrm{x}10^{-6}$	$0.100\mathrm{x}10^{-6}$	$+0.497\mathrm{x}10^{-8}$	$0.7\mathrm{x}10^{-10}$
carbide grade S4	$-0.729\mathrm{x}10^{-2}$	$0.4\mathrm{x}10^{-4}$	$+0.746\mathrm{x}10^{-6}$	$0.111\mathrm{x}10^{-6}$	$+0.387\mathrm{x}10^{-8}$	$0.8\mathrm{x}10^{-10}$
carbide grade S6	$-0.1015\mathrm{x}10^{-1}$	$0.5\mathrm{x}10^{-4}$	$-0.426\mathrm{x}10^{-5}$	$0.15\mathrm{x}10^{-6}$	$+0.830\mathrm{x}10^{-8}$	$0.11\mathrm{x}10^{-9}$
carbide grade H05	$-0.1090\mathrm{x}10^{-1}$	$0.9\mathrm{x}10^{-4}$	$+0.807\mathrm{x}10^{-6}$	$0.260\mathrm{x}10^{-6}$	$+0.475\mathrm{x}10^{-8}$	$0.19\mathrm{x}10^{-9}$
carbide grade HIP	$-0.866\mathrm{x}10^{-2}$	$0.5\mathrm{x}10^{-4}$	$+0.164\mathrm{x}10^{-5}$	$0.16\mathrm{x}10^{-6}$	$+0.374\mathrm{x}10^{-8}$	$0.11\mathrm{x}10^{-9}$
carbide grade H10	$-0.914\mathrm{x}10^{-2}$	$0.8\mathrm{x}10^{-4}$	$-0.569\mathrm{x}10^{-5}$	$0.23\mathrm{x}10^{-6}$	$+0.865\mathrm{x}10^{-8}$	$0.19\mathrm{x}10^{-9}$
carbide grade H13	$-0.841\mathrm{x}10^{-2}$	$0.7\mathrm{x}10^{-4}$	$+0.571\mathrm{x}10^{-7}$	$0.22\mathrm{x}10^{-6}$	$+0.493\mathrm{x}10^{-8}$	$0.16\mathrm{x}10^{-9}$
carbide grade H20	$-0.997\mathrm{x}10^{-2}$	$0.10\mathrm{x}10^{-3}$	$-0.496\mathrm{x}10^{-5}$	$0.30\mathrm{x}10^{-6}$	$+0.849\mathrm{x}10^{-8}$	$0.22\mathrm{x}10^{-9}$
carbide grade F02	$+0.430\mathrm{x}10^{-2}$	$0.5\mathrm{x}10^{-4}$	$+0.454\mathrm{x}10^{-5}$	$0.16\mathrm{x}10^{-6}$	$-0.106\mathrm{x}10^{-8}$	$0.12\mathrm{x}10^{-9}$
steel C45N	$+0.129\mathrm{x}10^{-1}$	$0.1\ \mathrm{x}10^{-3}$	$-0.644\mathrm{x}10^{-5}$	$0.42\mathrm{x}10^{-6}$	$+0.549\mathrm{x}10^{-8}$	$0.30\mathrm{x}10^{-9}$

Table 1. Coefficients of Eq. 1. for several grades of carbide and steel C45N.