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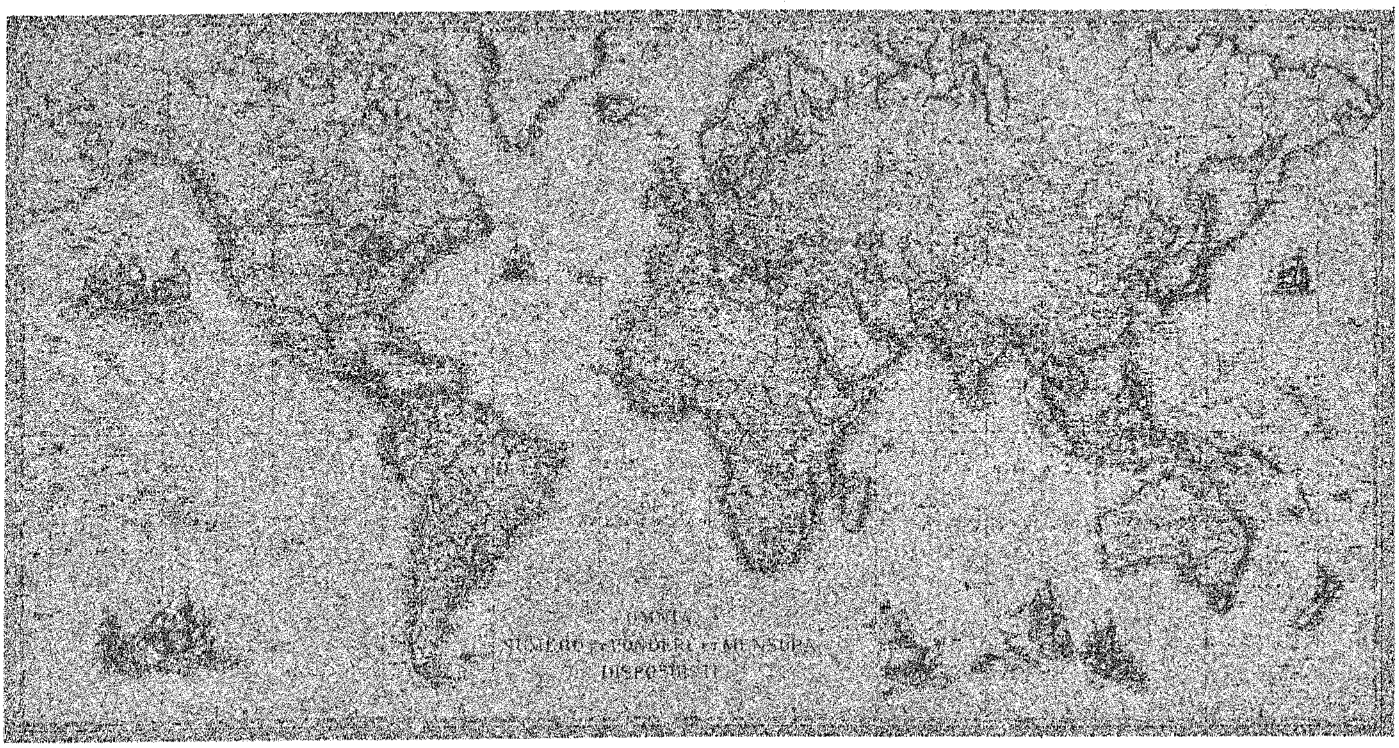

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AVERTISSEMENT

Nous avons pu constater un intérêt croissant pour des articles techniques et, pour faciliter la consultation, nous avons décidé de faire certains numéros du Bulletin « thématiques ». Ainsi ce numéro est surtout consacré aux **thermomètres médicaux.**

Le prochain numéro 93 de Décembre 1983 sera surtout consacré aux **produits préemballés.** Il reproduira des exposés faits au Séminaire OIML de Berne, 6-8 juin 1983.

Le chapitre « Documents reçus au Centre de Documentation » ne comportera, à partir de ce numéro, que les publications d'un intérêt tout particulier telles que lois, livres techniques et documents ne faisant pas partie d'une série périodique ou suivie. Les titres des normes métrologiques et des réglementations seront progressivement inclus dans des répertoires plus complets disponibles au BIML, sous forme de photocopies.

Un index des articles publiés depuis le début du Bulletin est déjà disponible sur demande.

We have noticed an increased interest for technical papers and to facilitate their consultation we have decided to devote some issues of the Bulletin to particular subjects. Thus this issue is in particular dealing with **clinical thermometers.**

Te next issue, n° 93, December 1983, will be devoted to **prepackaged products.** *It will reproduce some of the papers presented at the OIML Seminar in Bern, 6-8 June 1983.*

The item « Documents reçus au Centre de Documentation » will from this issue on include only publications of special interest such as laws, technical books and documents which do not form part of a periodical or continuous series. The titles of metrological standards and regulations will progressively be included in more complete repertories which will be available from the BIML in the form of photocopies.

An index to the papers published since the start of the Bulletin is already available on request.

REPUBLIQUE FEDERALE D'ALLEMAGNE

ELECTRICAL CLINICAL THERMOMETERS

by **Hans MAGDEBURG**
Physikalisch-Technische Bundesanstalt

SUMMARY — This paper gives a survey upon electrical clinical thermometers which can be obtained as portable (hand) thermometers or as instruments integrated in multiparameter monitors for hospitals. The temperature probes which contain in most cases thermistors may be interchangeable or fixed to the indicating unit. The maximum permissible errors as described in the 2nd pre-draft of an international recommendation on clinical electrical thermometers are ± 0.2 °C within the temperature range of 25 °C to 45 °C. The paper also describes the requirements on the construction and the behavior of the thermometers under the influence of different external disturbances as well as the tests for the pattern approval.

RESUME — Cet article passe en revue les thermomètres électriques médicaux qui sont disponibles sur le marché sous forme portable ou comme instruments incorporés dans des ensembles multi-paramètres de surveillance dans les hôpitaux. Les capteurs de température qui comportent dans la plupart des cas des thermistances peuvent être soit interchangeables soit reliés de façon permanente à l'unité indicateur. Les erreurs maximales tolérées décrites dans le 2e avant-projet d'une Recommandation Internationale sur les thermomètres électriques médicaux sont de ± 0.2 °C dans l'étendue de 25 à 45 °C.

L'article traite également les exigences sur la construction et le comportement des thermomètres lorsqu'ils sont soumis aux perturbations extérieures ainsi que les essais pour l'approbation de modèle.

ZUSAMMENFASSUNG — Der Aufsatz gibt einen überblick über medizinische Elektrothermometer, die als tragbare Handthermometer oder als in Multiparameter-Monitore integrierte Geräte erhältlich sind. Die Temperaturaufnehmer, die meistens Thermistoren enthalten, können austauschbar oder fest mit dem Anzeigegerät verbunden sein. Die im 2. Vorentwurf einer internationalen Empfehlung für medizinische Elektrothermometer beschriebenen Fehlergrenzen betragen ± 0,2 °C innerhalb des Temperaturbereiches von 25 °C bis 45 °C.

Die Anforderungen an die Konstruktion und das Verhalten der Geräte unter dem Einfluss verschiedener äusserer Störungen sowie die Prüfungen für die Bauartzulassung werden auch beschrieben.

Introduction

Since about 1970, an increasing number of electrical thermometers are being used to measure the temperature of the human body. Up to that time, with the exception of special applications, only mercury-in-glass thermometers were used [1], and their high precision was quite sufficient for medical applications. Users of thermometers, however, wanted larger measuring ranges and the possibility of monitoring, and they wanted to avoid the use of toxic mercury. All this led to the construction of electrical clinical thermometers, which are manufactured as monitors or portable thermometers.

In principle, the thermometers are composed of the probe and the display unit, containing the electronic circuit and the display. The probe may be interchangeable (with a plug) or fixed to the display unit. Distinguishing characteristics of different types of instruments can be found regarding either the application or the electrical construction. An attempt will be made to classify the thermometers according to both these characteristics.

In February 1983 the second preliminary draft of an international recommendation on electrical clinical thermometers was edited [2]. It replaces the first preliminary draft of August 1974. The second draft contains requirements on the construction and on the error limits of electrical clinical thermometers and describes the pattern approval procedure.

Description of the instruments

The sensors of the temperature probes are usually thermistors, in some cases metallic resistors. For special applications, particularly in laboratories, other types of sensors, e.g. thermocouples, are also used. The electrical resistance of thermistors and metallic resistors is temperature dependent (Fig. 1). Thermistors are semiconductors with a negative temperature characteristic, which means that their resistance decreases with increasing temperature. The characteristic line is similar to that of an exponential function which results in a relatively large but temperature-dependent temperature coefficient. This offers certain advantages for the following electrical circuit. The resistance of metallic resistors, e.g. platinum, increases with temperature. The temperature coefficient is only slightly dependent on temperature but is essentially smaller than that of thermistors.

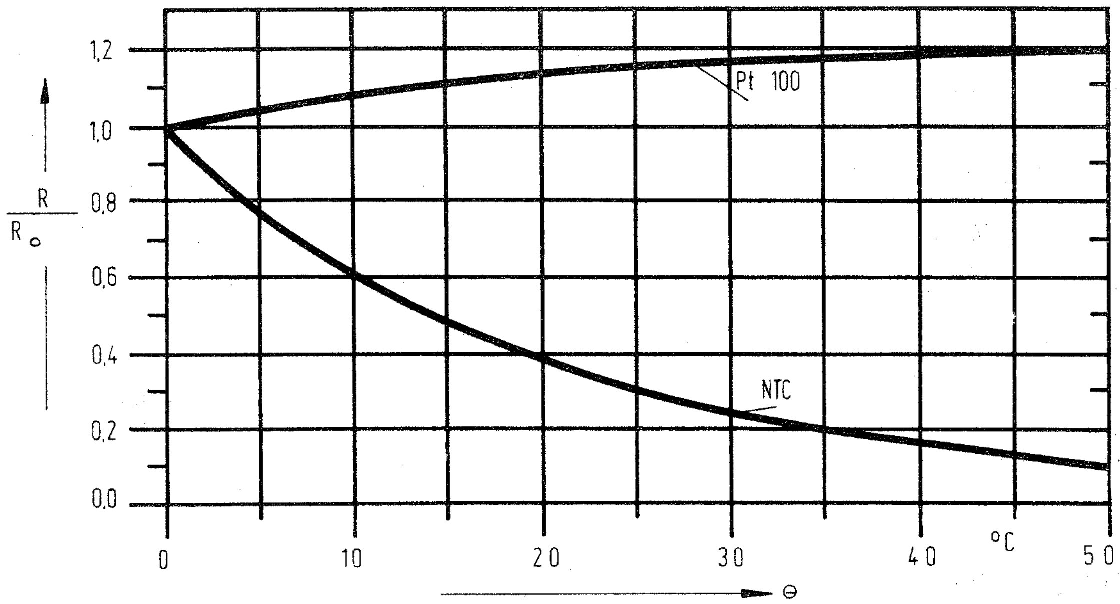

Fig. 1

Characteristic curves (Ratio of the resistance R/R_0 as function of the temperature Θ) of a platinum resistance sensor (Pt 100) and of a thermistor (NTC)

According to the purpose of application, temperature probes are of different shapes (Fig. 2). For rectal, axillary, esophageal or sublingual application, they are round with a plastic coating. The part containing the sensor is stiff or, if intended for esophageal application, completely flexible. Temperature probes for the supervision of the patient's temperature over long periods are fixed to the skin and are formed like flat discs. Temperature probes for the measurement of the actual skin temperature require special construction. They must have a low heat capacity and they must not disturb the normal heat exchange between skin and environment.

The measuring time of an electrical clinical thermometer depends mainly on the construction of the probe. After the probe has touched the tissue, within a certain time, the temperature of the sensor approaches that of the tissue. The increase of temperature with time (step-function response) corresponds to an exponential function, usually with more than one time constant. In practice, the steady state of measurement is often difficult to recognize when the application of the thermometer causes thermoregulation and the tissue temperature changes. The steady state will be quickly reached if the temperature probe has a low heat capacity and if its insulation has a low heat conduction resistance. The temperature probe is badly constructed if too much heat is conducted by the cable and the grip. In this case a considerable temperature deviation will remain even in the steady state which should be avoidable with temperature probes for application in body cavities. However it cannot be avoided completely with probes for application on skin. When measuring the skin temperature, the residual error must be approximately known and should be taken into account.

In axillary temperature measurements, it takes several minutes to reach the steady state, independent of the thermometer type. Before the thermometer is applied, the temperature of the axillary skin is much lower than the body temperature. The pressing of the arm against the body diminishes heat exchange with the environment, and only then does the temperature begin to increase.

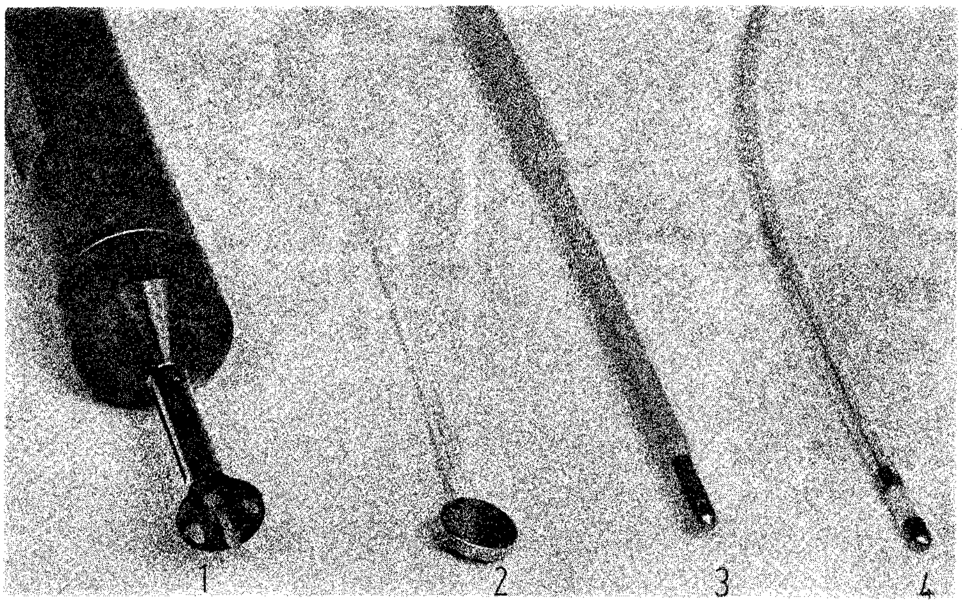

Fig. 2

Shapes of some temperature probes.
From the left : (1) Probe for the measurement of the actual skin temperature (tactile thermometer), (2) probe for the registration of the skin temperature, (3) rectal probe, (4) rectal and esophageal probe

Indicating units may be classified into two types :

Portable (hand) thermometers for the ambulant measuring of the body temperature and stationary (table) thermometers for use in hospitals. Both types include a large variety of instruments with different attributes.

Portable instruments are generally used for the same purposes as mercury-in-glass thermometers. Apart from some of the older analog instruments, they have digital indication. The probes are either fixed to the indicating unit or can be connected by plugs. The thermometers either resemble a small box or are similar in shape to a glass thermometer. Some types continuously indicate the actual temperature. They often have a large measuring range, and can therefore also be used for purposes other than medical. Other types have maximum-reading devices, like mercury-in-glass thermometers which store and indicate only the highest measured temperatures. There are also some types of thermometers which store and indicate the actual temperature at the push of a button.

In most cases, the aim is to obtain the correct local body temperature as quickly as possible. There are therefore types of thermometers which register the temperature and estimate its slope. These instruments indicate a calculated final temperature before the steady state has been reached. Irregular slopes are recognized and lead to longer measuring times or the instrument breaking off the procedure. A new measurement will then be required. If the measurement result is estimated to be correct, the final temperature will be indicated by an optical or acoustic signal.

Stationary thermometers in hospitals are used in particular for patient-monitoring in crisis situations (bedside monitor) or for the supervision of patients during operations or other medical treatment. Many types of instruments indicate other signals besides temperature on a screen. Most of those thermometers have alarm devices which operate if controlled temperature limit values are exceeded. In general it is possible to connect recorders or computers to the thermometers. It is also possible with some types to connect two or more temperature probes and to measure temperature differences.

Thermometers cannot be classified as portable or stationary instruments according to the type of electrical circuit. In both « basic types » analog and digital components are used. Only a few of the older models use exclusively analog components (with analog indication). The input components for the coupling of the probes are, however, analog in all models.

The non-linear characteristic curves of temperature probes (Fig. 1) require circuits for the linearization with means for the conversion of the output signal of the probe into a voltage or current signal which is proportional to the temperature. A bridge circuit is often used to convert the resistance of the probe to a voltage. In this case, a certain linearization can already be obtained by the layout of the bridge. The deviation of the bridge output signal from the theoretical curve in dependence on the temperature then has the typical shape of an s-curve (Fig. 3). It is only possible to linearize thermistors in this way within a limited range: for larger ranges, the systematic deviations become too great. Larger measuring ranges can therefore only be obtained by a series of different bridge circuits which can be switched over or by digital linearization. In the latter case the characteristic curves of the probes are converted by microprocessors, this procedure not requiring any limits of the range of temperature.

In practice, almost all possible types of circuits, both those with only analog linearization and those with only digital linearization, as well as mixtures of both, are to be found. Those thermometers which are produced in large series contain for the most part integrated components which carry out almost every function, beginning with the amplification of the input signal and ending with the generation of the control signal for the display.

The input amplifiers and the analog circuits for the linearization of the temperature signals of stationary monitor instruments are often installed in special modules. This also applies to other measuring values such as blood pressure, heart frequency, respiration frequency etc. In medical instruments of this type the output signals of the different modules are further processed in a basic device and then all directed to the display (usually a screen). In an increasing number of cases the instruments have microprocessors which carry out not only the linearization and conversion of the measuring signals but also all control and operating functions.

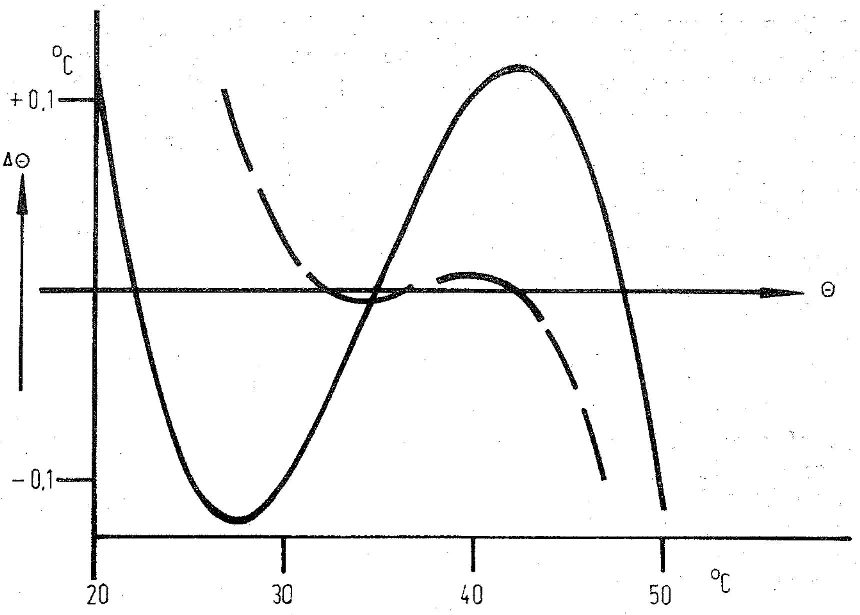

Fig. 3

Remaining error ΔΘ as function of the temperature Θ of the measuring signal of a thermistor probe after linearization by means of analog components,
——— for a temperature span of 30 °C, — — — — for a temperature span of 20 °C

Measuring errors

The maximum permissible errors of mercury-in-glass thermometers are + 0.1 °C and — 0.15 °C, though in the rather narrow range of temperature between 35.5 °C and 42.0 °C [1] (Fig. 4).

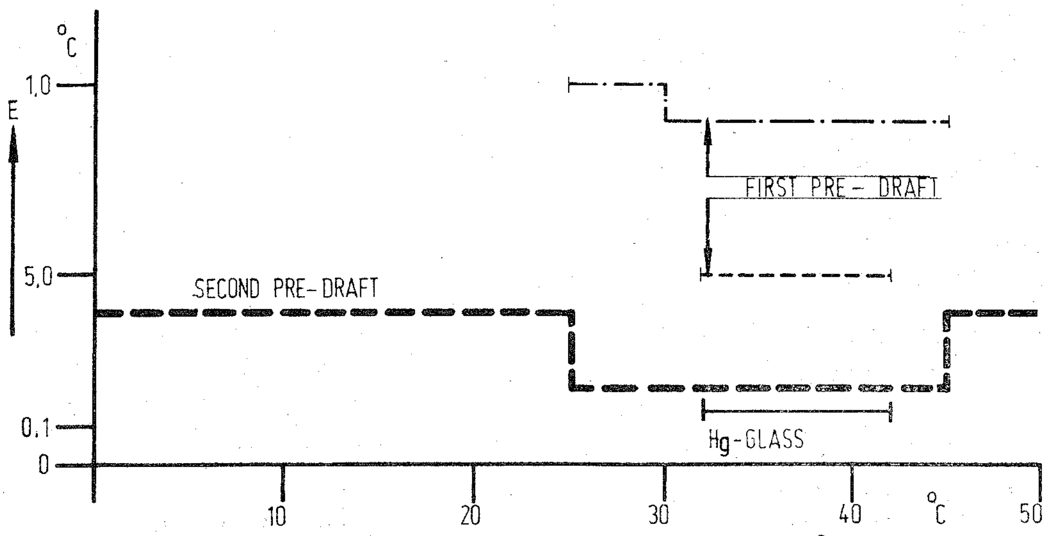

Fig. 4

Maximum permissible errors E as function of the temperature Θ of mercury-in-glass thermometers and clinical electrical thermometers as described in the first and second pre-draft of an international recommendation

At the time of the first preliminary draft of an international recommendation for electrical clinical thermometers [2], the errors of the electrical thermometers were rather large, corresponding to the existing state of the art. The characteristic curves of the probes were linearized at this time only by the use of analog components, and temperature ranges corresponding to a span of more than 20 °C were not taken into consideration. In the first preliminary draft the error limits for temperature probes were given in °C and those for indicating units were given in percent of the measuring span. This was rather difficult to read because if one wanted to know the error limits of a complete thermometer in °C, it entailed a lot of calculation work. The error limits for some thermometers with different measuring spans are shown in Fig. 4.

In the second preliminary draft of January 1983 [3], the error limits are therefore generally expressed in °C. They are smaller than before, corresponding to the present state of the art, and there is not much difference between them and the error limits of mercury-in-glass thermometers. In the second preliminary draft the maximum permissible errors of complete thermometers are ± 0.2 °C within a temperature range from 25 °C to 45 °C, which is of interest for most medical applications. For temperatures outside this range, the thermometer's errors must not exceed ± 0.4 °C. From experience with different thermometers tested for pattern approval, it could be proved that most clinical electrical thermometers can keep within these error limits at ambient temperatures between 15 °C and 25 °C. At other ambient temperatures, the measuring errors can possibly increase by 0.1 °C.

The OIML predraft

The second preliminary draft of an international recommendation for electrical clinical thermometers of January 1983 [3] prescribes requirements on the construction, the shape, the documentation and the test conditions for pattern approval. Electrical clinical thermometers can be treated as complete instruments or as combinations of interchangeable temperature probes and of interchangeable indicating units. It must be possible to treat probes and indicating units independently because, particularly in hospitals, these parts are stored and cleaned separately. Besides this, temperature probes are more subject to wear and tear than are indicating units and must be replaced from time to time. Because of the interchangeability, error limits of both components are defined independently. They amount to ± 0.1°C for probes and indicating units in the temperature range between 25 °C and 45 °C.

By the construction of the plugs and by inscriptions, it must be ensured that only probes and indicating units with the same characteristic curves are combined.

In contrast to mechanical components, the wear and tear of electronic components cannot be visually detected. Without warning and according to statistical probability, at any time, an electronic component may become defect and cause an error which will not be recognized. It must therefore be possible for the user of the thermometer to check at any time the correct functioning of its electronic components. Compromises must, however, be made between the perfection of the checking result and the possibility of checking the thermometer without interfering with its normal use. The check must be done either automatically without disturbing the temperature measurement or by hand with minimum effort and outlay.

Many types of electrical clinical thermometers, portable instruments, in particular, have push buttons for checking purposes. If such a push button is manipulated, the probe will be disconnected and replaced by a precision resistor corresponding to a certain value of temperature which must then be indicated when the thermometer is functioning correctly. A supplementary check of the display by generating the figures 88.8 is also necessary. Some types of thermometers have no check push button but generate the checking procedure automatically after the instrument has been switched on.

The exchange of the probe for a precision resistor is only one of several possible examples, but one which is quite frequently applied. In many types of thermometers with microprocessors, test signals are automatically generated in periodical temporal intervals which run through the circuits and which are then internally compared with reference values, all without the user noticing the process. Only in the case of a deviation between the test signal value and the reference value does a warning signal appear on the screen, telling the user that something is wrong.

Changes in the characteristics of temperature probes cannot be discovered in this way. The temporal measuring stability of the probes must therefore be guaranteed by requirements on their construction and by endurance tests.

Electrical clinical thermometers are supplied with power either by public mains or by generators or batteries. It must be ensured in all cases that voltage changes do not result in measuring errors. Thermometers directly supplied by mains must not exceed the maximum permissible errors if the supply voltage is within + 10 % and — 15 % of its nominal value. Thermometers operating from generators or batteries must either work correctly and independently of the voltage or warn the user that something is wrong. The blanking of the indication can be understood as a warning signal.

According to the national regulations of various OIML member states, it is possible for officially verified thermometers to be connected to unverified recorders or other instruments for supplementary indication. It must be ensured that these instruments do not influence the indication of the thermometers and result in undetectable errors. When the signal outlets of the thermometers are short-circuited or supplied with voltage or current, any changes in the value of the primary indication must be either negligible or clearly false. High external voltages which lead to thermometers becoming defective or to a considerable change in the indicated temperature values are easily noticed. However, there are certain restrictions corresponding to the safety requirements for users or patients which must not be endangered by external voltages.

Requirements for the safety of the user are principally based upon documents of the International Electrotechnical Commission [4]. Temperature probes must be insulated to prevent false measurements caused by short circuits. The user's safety as regards electricity, however, is not guaranteed by this insulation, as there may be fissures particularly on worn probes which have often been disinfected. Indicating units of clinical electrical thermometers should therefore be constructed in such a manner that there can be no danger to the user, even in the event of defective temperature probes.

Pattern evaluation

The examination for pattern approval must ascertain that the pattern complies with the requirements of the recommendation and that correct measurement results of temperature and adequate repeatability are basically ensured, even if the thermometer is exposed to external interferences. However, correct adjustment can only be tested by examining each thermometer, individually.

First of all, from circuit diagrams and construction drawings it is estimated whether correct indication of the measured temperature is to be expected and whether the limits of the maximum permissible errors will be maintained, even in cases where the different components of the thermometer have the most disadvantageous values within their tolerances (the worst case depending on ambient temperature, ageing, etc.). The errors of measurement will then be tested under reference conditions of ambient temperature, supply voltage and humidity but also under other conditions which could possibly occur in practice. The influence of extreme storage conditions is also checked.

With electrical thermometers used in hospitals and also in private households, there is an increased danger that the function of the electronic component will be influenced by wire-borne and radiated electromagnetic interference. The sources of these disturbances may be surgical instruments, heat therapy instruments, walky-talkies, etc. It must therefore be checked to ascertain that the thermometer's indication does not change under these influences.

Literature

[1] International Recommendation No 7, Clinical thermometers, (mercury-in-glass, with maximum device) second edition 1978.

[2] First Pre-Draft of an International Recommendation on Electrical Clinical Thermometers for Continuous Measurement, August 1974.

[3] Second Pre-Draft of an International Recommendation on Electrical Clinical Thermometers, February 1983, (French original of January 1983).

[4] IEC-Publication 601-1, Edition 1977, Safety of medical electrical equipment.

REPUBLIQUE DEMOCRATIQUE ALLEMANDE

DYNAMISCHE EIGENSCHAFTEN von MEDIZINISCHEN QUECKSILBERGLASTHERMOMETERN mit MAXIMUMVORRICHTUNG

G.M. KESSLER
Amt für Standardisierung, Messwesen und Warenprüfung

KURZFASSUNG — Das dynamische Verhalten medizinischer Quecksilber-glasthermometer mit Maximum-vorrichtung wird beschrieben. Der Einfluss der Anwendungsbedingungen und der technischen Ausführung des Thermometers auf das dynamische Verhalten wird diskutiert. Es werden Vorschläge zu einer verbesserten Beschreibungsform für das dynamische Verhalten der Thermometer unterbreitet und begründet.

*RESUME — L'auteur décrit le comportement dynamique de thermomètres médicaux (à mercure, en verre, avec dispositif à maximum) et l'influence sur celui-ci des conditions d'application et de la réalisation technique des thermomètres. Des propositions pour améliorer la qualité de description du comportement dynamique des thermomètres sont présentées et motivées *.*

*SUMMARY — The author describes the dynamic characteristics of medical thermometers and their dependence of conditions of use and type of design and presents proposals for improving the description of the dynamic characteristics **.*

1. Allgemeines

In der Medizin ist die Kenntnis der Körpertemperatur der Patienten mit einem hohen Maß an Genauigkeit und Zuverlässigkeit erforderlich. Die medizinischen Quecksilberglasthermometer mit Maximumvorrichtung (im folgenden Fieberthermometer genannt) unterliegen daher in vielen Ländern der staatlichen Eichpflicht. In der DDR ist die Eichung durch die ASMW-Vorschrift Meßwesen « Temperatur; Medizinische Maximumthermometer; Arbeitsanweisung zur Eichung » vom Mai 1978 reglementiert, die unter Berücksichtigung der Internationalen Empfehlung Nr. 7 der OIML « Medizinische Thermometer (Quecksilberglasthermometer mit Maximumvorrichtung) » (im folgenden OIML-RI Nr. 7 genannt) entstand. Die der ASMW-Vorschrift Meßwesen zugrunde liegende Auffassung zur Bestimmung des Anzeigefehlers unter Berücksichtigung des dynamischen Verhaltens der Fieberthermometer ist in vorliegendem Artikel dargelegt.

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* Note de la Rédaction.

Des expériences conduites dans d'autres laboratoires avaient déjà abouti à une modification de la RI N° 7 en ce qui concerne le comportement dynamique. Celle-ci a été incorporée dans la révision sanctionnée par la Ve Conférence Internationale de Métrologie Légale, en octobre 1976. Pour éviter une description trop compliquée du comportement dynamique, le texte modifié était orienté vers des méthodes pratiques de vérification.

** Experiments in other laboratories had already led to a modification of RI N° 7 as regards the dynamic characteristics during the revision sanctioned by the 5th International Conference of Legal Metrology in October 1976. To avoid a rather complicated description of the dynamic behaviour the revised text was formulated with respect to practical methods of verification.

2. Das dynamische Verhalten von Fieberthermometern

Unter dem dynamischen Verhalten von Thermometern versteht man die Abhängigkeit des zeitlichen Verlaufs der Thermometeranzeige vom Verlauf der zu messenden Temperatur. Das dynamische Verhalten von Fieberthermometern spielt einerseits eine wesentliche Rolle für die Verkürzung der Meßzeiten bei der routinemäßigen Temperaturmessung einer großen Anzahl von Patienten, andererseits aber auch für die Verkürzung der Prüfzeiten bei der Eichung der Fieberthermometer.

Das dynamische Verhalten der Fieberthermometer hängt außer von den Eigenschaften der Thermometerwerkstoffe und dem konstruktiven Aufbau in entscheidendem Maße von den Anwendungsbedingungen ab. Eine sichere Beurteilung der dynamischen Eigenschaften ist daher nur im Zusammenhang mit der Kenntnis der Bedingungen möglich, die den Wärmestromfluß zwischen dem Fieberthermometer und dem Meß- bzw. Prüfmedium bestimmen. Diese Wärmeübertragungsbedingungen können jedoch bei der üblichen Anwendung der Fierberthermometer in der medizinischen Praxis und bei der eichtechnischen Prüfung so große Unterschiede aufweisen, daß die so gewonnenen Kennwerte nicht unmittelbar vergleichbar sind.

Als übliche Anwendungsbedingungen der Fieberthermometer sind in der Humanmedizin die der rektalen, der sublingualen und der axillaren Messung und in der Veterinärmedizin die der rektalen Messung anzusehen. Die für den Temperaturausgleich zwischen Meßobjekt und Thermometerkörper notwendige Wärme wird bei diesen Anwendungsfällen im wesentlichen durch Wärmeleitung übertragen. Konvektiver Wärmeübergang ist von untergeordneter Bedeutung.

Die Eichung der Fieberthermometer erfolgt dagegen unter völlig veränderten Wärmeübertragungsverhältnissen. International hat sich die Prüfung in mehr oder weniger bewegten thermostatierten Wasserbädern durchgesetzt. In diesem Fall erfolgt der Wärmeaustausch zwischen dem Prüfmedium und dem Fieberthermometer vorwiegend durch erzwungene Konvektion, und die durch Wärmeleitung übertragene Wärmemenge ist vernachlässigbar klein.

Der wirksame thermische Widerstand zwischen dem Fieberthermometer und dem Prüfmedium ist bei dieser Prüfung um ein mehrfaches kleiner als bei den üblichen Anwendungsbedingungen.

Ein Beispiel für das hieraus resultierende sehr unterschiedliche dynamische Verhalten von Fieberthermometern in einem mit der Strömungsgeschwindigkeit $v \approx 0{,}4$ m/s bewegten (Prüfbedingung gemäß OIML-RI Nr. 7) und einem ruhenden Wasserbad sowie bei axillarer Anwendung vermitteln die Übergangsfunktionen $h(t)$ in Bild 1 (Kurven 1, 2 und 3).

Untersuchungen ergaben, daß die Einstellzeit t_{99} der Fieberthermometer bei axillarer Anwendung um den Faktor 20 bis 40 größer als bei Messungen in einem bewegten Wasserbad ist. Deutliche Unterschiede zeigen sich ebenfalls beim Vergleich der Übergangsfunktionen, die in einem bewegten und in einem ruhenden Wasserbad gemessen wurden. Dies ist darauf zurückzuführen, daß selbst bei Benutzung bewegter Wasserbäder aufgrund unterschiedlicher Strömungsgeschwindigkeiten und unterschiedlicher Turbulenzgrade beträchtliche Unterschiede in den Werten der wirksamen Wärmeübergangszahlen α auftreten. Die Einstellzeit t_{99} wird bei der Messung in einem ruhenden Wasserbad um den Faktor 2 bis 5 größer als bei der Messung in einem mit der Strömungsgeschwindigkeit $v \approx 0{,}4$ m/s bewegten Wasserbad.

Der praktisch mögliche α-Bereich in bewegten Wasserbädern ist allerdings noch weitaus größer als der durch $v = 0{,}4$ m/s und $v = 0$ eingegrenzte Bereich. Es ist folglich damit zu rechnen, daß die Einstellzeit t_{99} aufgrund der unterschiedlichen Wärmeübergangszahlen in unterschiedlich stark bewegten Wasserbädern noch größeren Schwankungen unterliegt. Dies führt zu dem Schluß, daß es für eine eindeutige und vergleichbare Charakterisierung des dynamischen Verhaltens der Fieberthermometer erforderlich ist, die Prüfbedingungen zu quantifizieren.

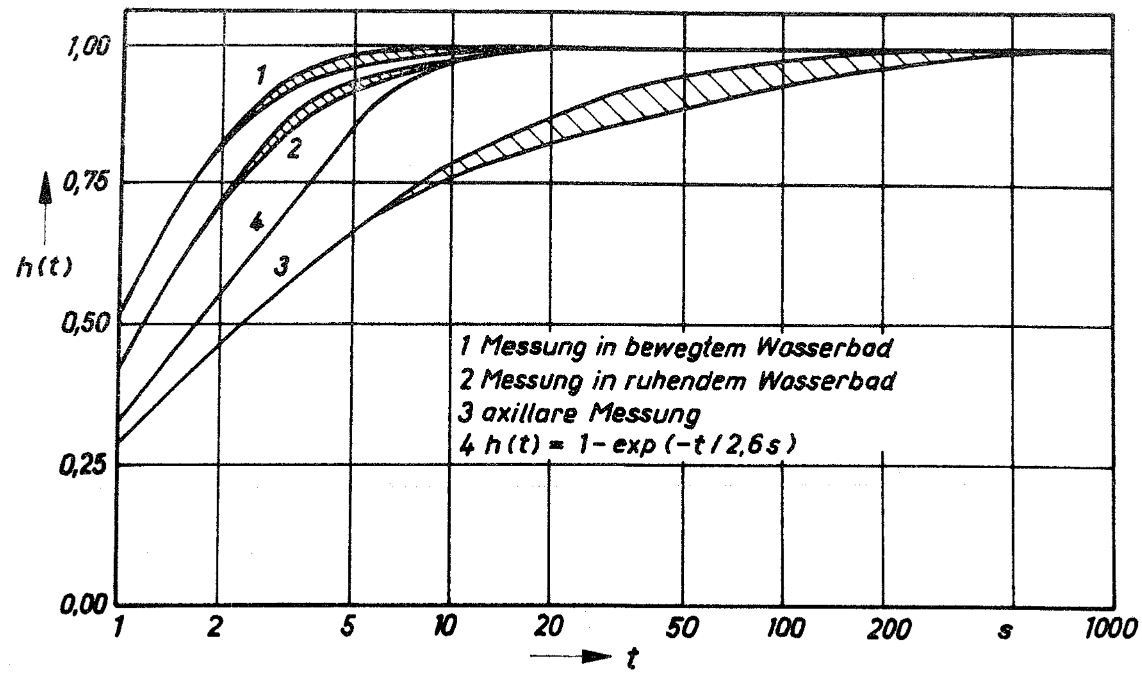

Bild 1 — Übergangsfunktionen von Fieberthermometern im Vergleich mit der Funktion $h(t) = 1 - \exp(-t/2{,}6\ \mathrm{s})$ nach OIML-RI Nr. 7 [1]

Es ist außerdem notwendig, festzulegen, auf welche Weise die unter Prüfbedingungen gewonnenen Kennwerte auf die üblichen Anwendungsbedingungen umgerechnet werden können. Dies ist erforderlich, da man aus der Relation der in einem bewegten Wasserbad gewonnenen dynamischen Kennwerte verschiedener Thermometerbauarten nicht auf die gleiche Relation unter den üblichen Anwendungsbedingungen schließen kann.

Da für Fieberthermometer insbesondere das Einstellverhalten auf den Anzeigeendwert (durch eine Einstellzeit charakterisierbar) von Bedeutung ist, soll dieses anhand des Bildes 2 näher untersucht werden.

Der Vergleich der Meßkurven 1, 2, 3 und 5 mit der Übergangsfunktion des Verzögerungsgliedes 1. Ordnung mit der Zeitkonstante $\tau_1 = 2{,}6$ s zeigt, daß das dynamische Verhalten der Fieberthermometer (unabhängig von der Bauart) nicht dem von Verzögerungsgliedern 1. Ordnung entspricht, welche sich durch die einfache Exponentialfunktion

$$h(t) = 1 - \exp(-t/\tau_1) \qquad (1)$$

allgemein charakterisieren lassen.

Praktisch zeigen Fieberthermometer angenähert Verzögerungsverhalten 1. Ordnung lediglich für den Zeitberich von 0 bis 5 s. Ab $t \simeq 5$ s weicht in der halblogarithmischen Darstellung der Verlauf der Übergangsfunktion der Fieberthermometer in Einschlußform vom anfänglichen geradlinigen Verlauf nach Gleichung (1) ab, da neben τ_1 weitere Zeitkonstanten wirksam werden.

Dieses charakteristische Verhalten von Fieberthermometern in Einschlußform läßt sich dadurch erklären, daß nach Ablauf der ersten Sekunden die nicht unbedeutende Wärmeträgheit der Verbindungskapillare und in geringerem Maß auch die der Meßkapillare zur Wirkung kommt.

Der von den Meßkurven 2 und 3 (Bild 2) eingegrenzte Bereich ergibt sich unter vergleichbaren Prüfbedingungen für verschiedene Fieberthermometer in Einschlußform, die sich außer in der Gefäßform und -größe, der Art der Maximumvorrichtung (Stift-

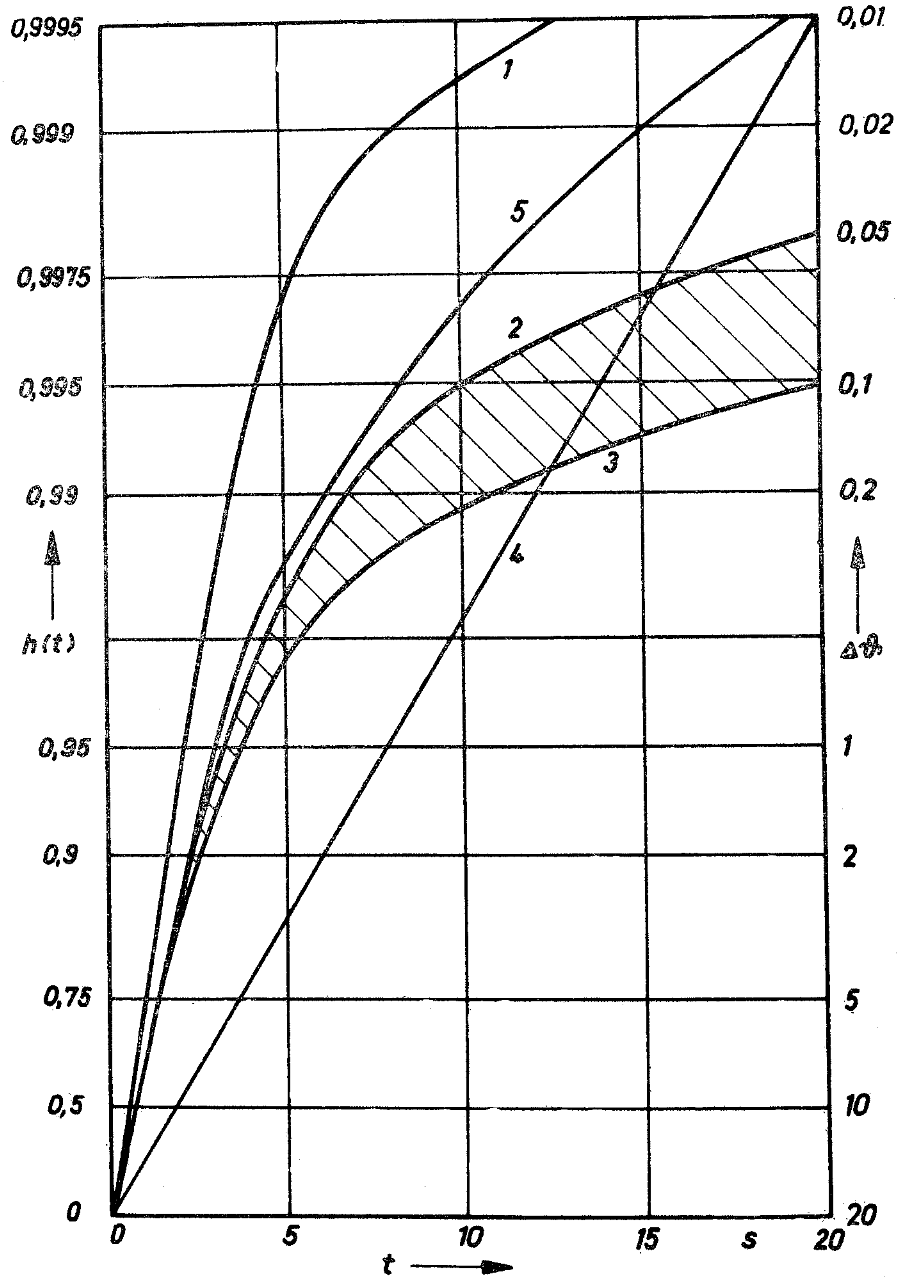

Bild 2 — Übergangsfunktionen von Fieberthermometern in bewegtem Wasserbad im Vergleich mit der Funktion $h(t) = 1 - \exp(-t/2{,}6\ \mathrm{s})$

1	Fieberthermometer in Stabform	Messungen in Wasser bei $v \simeq 0{,}4$ m/s, $\theta_2 - \theta_1 = 20$ K
2 und 3	Grenzkurven für unterschiedliche Fieberthermometer in Einschlußform (nach Untersuchungen im Amt für Standardisierung, Meßwesen und Warenprüfung)	
4	$h(t) = 1 - \exp(-t/2{,}6\ \mathrm{s})$ nach OIML-RI Nr. 7 [1]	
3 und 5	Grenzkurven für unterschiedliche Fieberthermometer in Einschlußform (nach Angaben des niederländischen DIENST VAN HET IJKWEZEN) ; Messung in bewegtem Wasserbad	

system oder Kapillarverengung) vor allem im Volumen der Verbindungskapillare unterscheiden.

Untersucht wurden Fieberthermometer mit Volumina der Verbindungskapillare von 0,55 mm³ (entspricht Kurve 2) bis 7 mm³ (entspricht Kurve 3).

Weniger ausgeprägt ist dieser Effekt bei Fieberthermometern in Stabform ; der Einfluß der Wärmeträgheit der Meßkapillare ist jedoch nicht vernachlässigbar klein (Kurve 1 ; Bild 2).

Die Meßkurven 3 und 5 (Bild 2) stellen den Übergangsverlauf verschiedener Fieberthermometer in Einschlußform dar, die unter anderen Prüfbedingungen im nierderländischen DIENST VAN HET IJKWEZEN ermittelt wurden.

Die Übergangsfunktionen der im ASMW untersuchten Fieberthermometer in Einschlußform aus acht Ländern (UdSSR, DDR, BRD, Japan, CSSR, Polen, Italien, Frankreich) fallen sämtlich in den durch die Kurven 2 und 3 begrenzten (schraffierten) Bereich.

Die im niederländischen DIENST VAN HET IJKWEZEN ermittelten Übergangsfunktionen von Fieberthermometern verschiedener Bauart liegen dagegen in dem größeren, durch die Kurven 3 und 5 eingegrenzten Bereich. Dies zeigt, daß durch unterschiedliche Prüfbedingungen die dynamischen Kennwerte und -funktionen, die von verschiedenen metrologischen Institutionen ermittelt wurden, nicht unmittelbar vergleichbar sind.

3. Internationale Normung

International sind die Forderungen an die metrologischen, konstruktiven und konsistenten Eigenschaften von Fieberthermometern in der OIML-RI Nr. 7 festgelegt. Seit Erlaß der 1. Ausgabe im Oktober 1968 wurden drei Varianten zur Beschreibung der dynamischen Eigenschaften zur Anwendung empfohlen.

Die z. Z. gültige 2. Ausgabe der OIML-RI Nr. 7 [2] von 1978 enthält folgende Festlegungen :

« Wird ein Thermometer mit der Temperatur θ_1 ($15\,°C \leqslant \theta_1 \leqslant 30\,°C$) plötzlich in ein gut bewegtes Wasserbad mit der konstanten Temperatur θ_2 ($35{,}5\,°C \leqslant \theta_2 \leqslant 42\,°C$) eingetaucht und nach 20 s wieder herausgezogen, so muß die Anzeige des Thermometers nach seinem Abkühlen auf die Umgebungstemperatur (15 bis 30 °C)

— die zulässigen Fehlergrenzen von + 0,10 K und — 0,15 K einhalten und

— darf nicht mehr als $0{,}005 \cdot (\theta_2 - \theta_1)$ von seiner für die Temperatur θ_2 stabilisierten Anzeige abweichen.

Diese stabilisierte Anzeige ist die Anzeige des auf Umgebungstemperatur abgekühlten Thermometers, nachdem es zuvor vollständig im thermischen Gleichgewicht mit dem Wasserbad mit der Temperatur θ_2 gestanden hat ».

Diese Verfahrensweise weist im Zusammenhang mit dem Anhang A.3. « Bestimmung der Anzeigefehler » der OIML-RI Nr. 7 einen prinzipiellen Mangel auf. Mit der zitierten Festlegung aus [2] geht die für $t = 20$ s unbedingt erforderliche Trennung zwischen statischen und dynamischen Fehleranteilen der Fieberthermometer verloren.

Die Fieberthermometer müssen nach [2] die statischen Fehlergrenzen von + 0,10 K und — 0,15 K einhalten. Diese Werte gelten für die stabilisierte Anzeige der Fieberthermometer entsprechend oben angegebener Definition.

Wie Bild 2 (Meßkurven 2 und 3) verdeutlicht, weichen die Anzeigen der Fieberthermometer in Einschlußform nach Ablauf von 20 s Eintauchzeit in einem bewegten Wasserbad bei einer Temperatursprungamplitude von 20 K noch um 0,11 K bis 0,04 K vom statischen Anzeigewert ab, d. h., es liegt noch kein statisches Regime vor. Da die dynamischen Fehleranteile für $t = 20$ s in der Größenordnung der zulässigen Grenzen für die statischen Fehleranteile liegen, ist die oben formulierte Forderung, daß die Thermometeranzeigen zum Zeitpunkt $t = 20$ s die zulässigen Fehlergrenzen von + 0,10 K und — 0,15 K einhalten müssen, nicht gerechtfertigt. Die Festlegungen im Anhang A.3. der OIML-RI Nr. 7, Abschnitt « Bestimmung der

Anzeigefehler », lassen es jedoch zu, daß der Anzeigefehler der Fieberthermometer bereits nach 20 s Eintauchzeit im Prüfbad als die Differenz zwischen der Thermometeranzeige und der Prüfbadtemperatur bestimmt werden darf.

Diese Festlegungen sind im Zusammenhang mit dem realen dynamischen Verhalten der Fieberthermometer nicht eindeutig, da sie die Möglichkeit der bewußten Manipulation der statischen Anzeigewerte der Fieberthermometer in der Weise zulassen, daß man die Fieberthermometer im statischen Zustand (thermisches Gleichgewicht zwischen Prüfbad und Fieberthermometer) so kalibriert, daß sie nach 20 s Eintauchzeit bereits den Sollwert (Prüfbadtemperatur) innerhalb der zulässigen Fehlergrenzen richtig anzeigen, den sie bei richtiger Kalibrierung erst nach Erreichen des thermischen Gleichgewichtes mit dem Prüfbad erreichen würden.

Aufgrund dieser Tatsache ist es zur richtigen Kalibrierung der Fieberthermometer erforderlich, international eindeutige Festlegungen zur Fieberthermometerdynamik zu treffen.

Zusammenfassend wird festgestellt, daß die gegenwärtig geltenden internationalen Festlegungen zur Dynamik und zur Bestimmung der statischen Fehleranteile von Fieberthermometern entsprechend nachfolgenden Punkten überarbeitungsbedürftig sind :

1. Getrennte Festlegungen für die Fehlergrenzen der statischen und dynamischen Fehleranteile der Fieberthermometer :

   Die wegen der unterschiedlichen Dynamik bei Anwendungs- und Prüfbedingungen anzustrebende Trennung der Bestimmung dynamischer Kennwerte von der statischen Prüfung ist dann vollständig erreichbar, wenn für den statischen Fehleranteil

$$e_{stat} = \theta_2 - \theta_A \; (t = \infty) \qquad (2)$$

   und für den dynamischen Fehleranteil

$$e_{dyn} \; (t_E) = \frac{\theta_A \; (t = \infty) - \theta_A \; (t_E)}{\theta_A \; (t = \infty) - \theta_1} \qquad (3)$$

   verwendet wird.

2. Festlegung definierter Prüfbedingungen zur Bestimmung der Thermometerdynamik :

   Diese Festlegungen müssen sich insbesondere auf

   — die Wärmeübertragungsbedingungen

   — die thermische Rückwirkungsfreiheit zwischen dem Prüfbad und den Fieberthermometern und

   — die Einschränkung des Abkühlungstemperaturbereiches

   bei der Thermometerprüfung beziehen. Für die gegenwärtig festgelegten Prüfbedingungen [2] ist es zweckmäßig, die Wärmeübertragungsbedingungen entweder durch die Wärmeübergangszahl α oder verbal durch die entsprechenden Einflußgrößen auf α zu charakterisieren.

   Vorschlag für die Prüfbedingungen :

   — Temperatursprung mit der Amplitude
   $A = \theta_2 - \theta_1$

   — Umgebungstemperatur $\theta_1 = (23 \pm 3)$ °C

   — Sprungendtemperatur $\theta_2 = 35{,}5$ bis 42 °C

   — strömendes Wasser mit der Strömungsgeschwindigkeit $v = (0{,}4 \pm 0{,}05)$ m/s

   — senkrechte Thermometeranströmung

   — Änderung von θ_2 : $\leqslant 0{,}01 \cdot A$

4. Normung in der DDR

In der DDR wurde ein Grundlagenstandard zur Bestimmung und Beschreibung der Dynamik von Berührungsthermometern erarbeitet [3], der in [4] bereits vorgestellt wurde. Spezielle Festlegungen für Fieberthermometer enthält der Erzeugnisstandard TGL 7893/01. Die Prüfung auf Einhaltung der statischen und dynamischen Fehleranteile wird in einem bewegten Wasserbad mit konstanter Strömungsgeschwindigkeit durchgeführt. Durch exakt definierte Prüfbedingungen wird der direkte Vergleich der dynamischen Eigenschaften von Fieberthermometern unterschiedlicher Bauart ermöglicht. Die gewählte Beschreibungsform der Thermometerdynamik erscheint zum gegenwärtigen Zeitpunkt als die für die Funktion der Fieberthermometer (rein anzeigendes Thermometer) günstigste Beschreibungsform :

— Die gewählten dynamischen Kenngrößen besitzen für anzeigende Berührungsthermometer universelle Gültigkeit. Damit wird ein Vergleich der dynamischen Eigenschaften von Fieberthermometern mit anderen Thermometerarten möglich.

— Die Prüfbedingungen sind qualitativ und quantitativ festgelegt. Dies schafft die Grundlage für eine objektive Beurteilung und für den direkten Vergleich des dynamischen Verhaltens verschiedener Thermometer.

— Die statischen und dynamischen Fehleranteile sind getrennt voneinander festgelegt. Damit werden eindeutige Prüfergebnisse für die jeweiligen Fehleranteile gewährleistet.

— Die Angabe dynamischer Kennwerte ist in [3] vorzugsweise für die üblichen Anwendungsbedingungen der Thermometer vorgeschrieben. Die zusätzliche Angabe der dynamischen Kennwerte für bereits festgelegte Prüfbedingungen wird zugelassen. Damit erhalten sowohl die Anwender als auch die Hersteller die notwendigen Informationen über die dynamischen Eigenschaften für die jeweils interessierenden Anwendungsbedingungen.

Literaturnachweis

[1] OIML-RI Nr. 7 — 1. Ausgabe Okt. 1968.

[2] OIML-RI Nr. 7 — 2. Ausgabe 1978.

[3] TGL 33208 « Berührungsthermometer ; Beschreibungsverfahren für das dynamische Verhalten ».

[4] G.M. KESSLER et F. BERNHARD — Méthode de description du comportement dynamique des thermomètres de contact. Bulletin de l'OIML N° 74, p. 7-19 mars 1979.

PAYS-BAS

DISPOSABLE CLINICAL THERMOMETERS

by **G.J.C. NIPPER**
Dienst van het IJkwezen

SUMMARY — This paper describes the operation and test methods of disposable clinical thermometers of the colour-dot type. It is an English translation of two papers already published in Metrovisie, the review of the Dutch Metrology Service.

RESUME — L'article ci-dessous décrit le fonctionnement des méthodes d'essai des thermomètres médicaux jetables, utilisant des spots colorés. C'est une traduction en anglais des deux articles déjà parus dans Metrovisie, le revue du Service de Métrologie des Pays-Bas.

Definition

A disposable clinical thermometer is a type of thermometer by which in general the whole instrument is not suited for reuse. The words « the whole instrument » is inserted because of the fact that there are electronic thermometers of which only the sensor is not suited for reuse. The word « in general » is inserted at is has appeared that the actual design of the disposable thermometers can be reused after cooling at a low temperature. As a result of loosing sterility however it is hardly to expect that this will be a normal procedure.

Up till now only one design of the disposable clinical thermometer is known. However it is likely that in the near future designs based on other principles will appear.

Design

The thermometer consists of an aluminium or synthetic bearer of which one end is spoon shaped. In this part fifty holes are pressed, devided in two groups each existing of 5 rows of 5 holes (see figure 1). The holes, afterwards named dots, are filled with a chemical substance which changes colour at a distinct temperature.

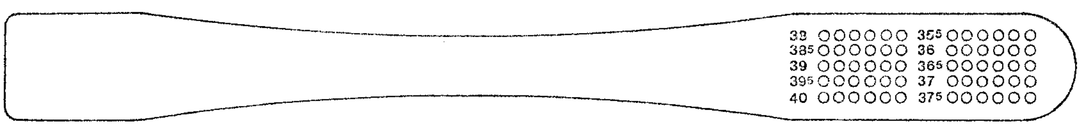

Fig. 1

Disposable colour-dot clinical thermometer

The composition of the substance differs a little from dot to dot in such a way that each dot will change colour at a temperature 0.1 °C different of the next.

The temperature measured can be derived from the number of discoloured dots. The temperature indicated by the first dot is printed at the beginning of each row. Each next dot in the row will indicate a 0.1 °C higer temperature. In this way the first group of 25 dots encloses a temperature interval from 35.5 °C up to and included 37.9 °C and the second group a temperature interval from 38.0 °C up to and included 40.4 °C. The dots (holes) are covered with a transparent sheet, that guarantees a watertight protection. In case of an aluminium bearer the remaining part on both sides is covered with a white synthetic sheet. The original design of the disposable clinical thermometer was developed in about 1969 in the USA. After several evolutions of the design now two types are on the market. The two types show essentially no important differences *.

Operation

As mentioned above the dots are filled with a chemical substance with a crystal structure and consisting of two components. By varying the proportion of the components in the substance it is possible to change the melting point by 0.1 °C. The basis of its manufacture is an accurate weighing process. In the dot being essential for the indication of a specific temperature and in the dots destined for the indication of lower temperatures all the solid ought to be melted.

Consequent to its nature and its purity the substance remains in a mestatable state as an undercooled liquid after the thermometer is cooled down. It is obvious that the solid in some dots intended to indicate higher temperatures (0.1 °C till 0.4 °C) will partly be melted. After being cooled down the liquid in these dots will recrystallise consequent to the presence of solid. The dots filled exclusively with liquid remain in an undercooled liquid state.

The substance in the dots is provided with a colourindicator which is responsible for the colourchange of the dots when the solid has melted. The original yellow-brown to light-rose colour of the dots turns into dark-blue or red (dependent on the manufacture), if the solid wholly or partly has melted. If recrystallization take place this colour will disappear and the original colour will return.

Application

During transport and storage the disposable thermometer may not be exposed to a temperature higher than 25 °C. Therefore these thermometers are less suitable for domestic purpose. In view also of the size of the package unit a clinical application is obvious.

Due to the shape the disposable thermometer is exclusively suitable for oral measurement. The placement in the mouth of the sensing element however is not arbitrary. Extensive study in the USA has proved, that there are two so-called heat pockets, where the temperature of the mouth has a maximum. These pockets are on both sides of the frenum near the junction of the basis of the tongue and the floor of the mouth (see Fig. 2).

The temperature in the mouth varies rather strongly as is showed in figure 2a. This means that the thermometer shall be placed carefully under the tongue on the left or right side of the frenum, in such a way that the spoon shaped part is as near as possible in the heat pocket.

Due to the measurements in the mouth only a short measuring time can be applied. Generally a patient cannot be demanded to keep a thermometer in his mouth for more than 1 to 2 minutes. Actually the measuring time of both manufactures

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* Manufactured by Bio-Medical Sciences, Incorporated in Fairfield, NJ, USA and Pymah Corporation, Somerville, NJ, USA.

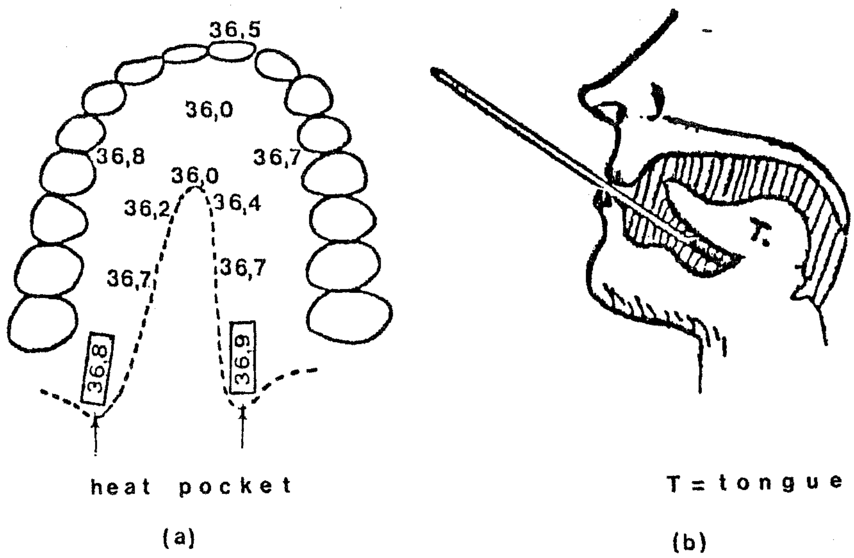

Fig. 2

amounts to 60 seconds. After taking the thermometers out of the mouth one has to wait 10 to 15 seconds before the temperature can be read out. No reading shall be made after 5 minutes because of the fact that after that time recrystallization can take place in a number of dots, so there is a chance of faulty readings.

Properties

Although the construction of the disposable thermometers is comparatively simple, the properties of these thermometers are rather complicated. For this complicated behaviour a number of causes can be indicated partly arising from the properties of the thermometers partly arising from the behaviour of the mouth.

These causes are :

1. The thermal conduction between mouth and thermometer and the thermal conduction through the tissue of the mouth.
2. The heat of fusion necessary to convert the solid completely into liquid.
3. The independent behaviour of the dots.
4. The metastable state of the liquid in the dots.
5. The condition of the mouth before measurement.

Consequent to these causes the temperature-time characteristic of the disposable thermometers shows a cursion shape. The characteristic reproduced in Fig. 3 is probably built up from two partial curves. The first partial curve shows the temperature course of the thermometers after insertion in the mouth. In that stage only the thermal conduction between the tissue and the thermometer is important. The influence of the thermal conduction inside the tissue and the environmental temperature is hardly perceptible. This part of the curve practically corresponds with the temperature-time characteristic of the thermometer in a waterbath.

As a result of the quick raise of the temperature of the thermometer, the temperature of the mouth will not yet be restored from fall of temperature as it results from the insertion of the thermometer and the opening of the mouth. After the thermometer practically having reached the actual temperature of the mouth the change of temperature will follow the second partial curve. In that situation the

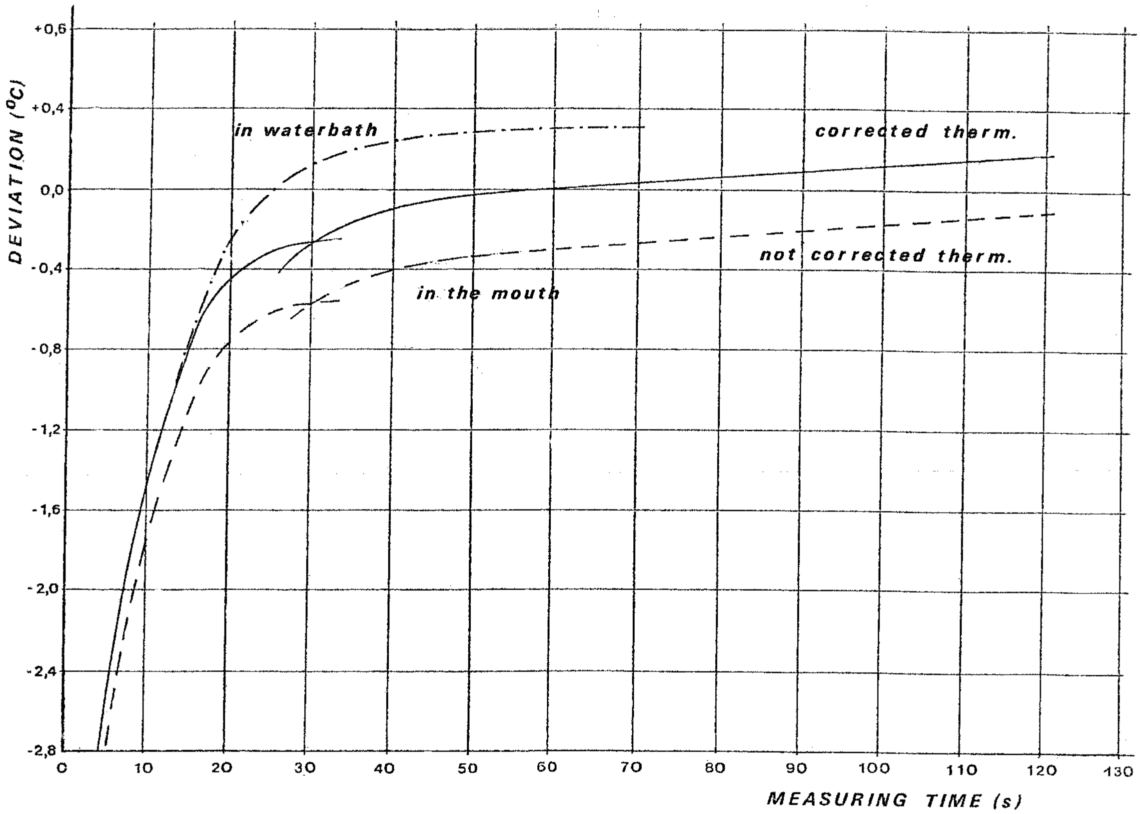

Fig. 3

temperature difference between the mouth and the thermometer is small. The transfer of heat as a result of the bad thermal conduction of the tissue will be delayed, so that no temperature balance is reached. As a consequence the disposal thermometer will reach the real temperature of the mouth after considerable time (10 to 15 min).

Therefore the thermometer will indicate a lower temperature at the moment that the measuring time as declared by the manufacturer is expired (for both manufacturers the measuring time is 60 s). The course of temperature is shown by the dashed curve in Fig. 3. The temperature difference with the real temperature of the mouth that owing to this is found turns out to be 0.3 °C for both manufactures. In order to achieve an actual temperature of the mouth indicated with sufficient accuracy the disposable thermometers will be provided with a systematic error of + 0.3 °C. The course of temperature of the thermometer corrected in this way is indicated by the continuous line in Fig. 3. If a corrected disposable thermometer is tested in a waterbath the temperature follows the dot and dash line in Fig. 3. The temperature difference of + 0.3 °C that will be indicated by the thermometer in a waterbath is called IVD, what is an abbreviation of « in vivo vitro difference » (vivo - mouth, vitro - materbath). The temperature-time characteristic in Fig. 3 is drawn up on the basis of a number of in vivo tests on different testpersons.

Deviations of the individual thermometer from this characteristic can result from defects of the thermometers or from external disturbances, such as :

— *Independent behaviour of the dots*

Different behaviour of the dots may be caused by a wrong composition of the chemical substance and by the degree of admission of this substance in the dots. In view of the fact that the way in which the substance is composed and on the quality control during and on the end of the production, it is hardly to expect that errors in the composition may occur. Deviations in the degree of admissions however have been established.

— *Metastable state of the substance in the dots*

The substance has to be very pure. The existance of impurities may disturb the metastable equilibrium through which recrystallization will occur. Recrystallisation may occur at any place and can be observed as not discoloured dots among discoloured ones. This phenomenom is called « skip ». After the elapse of the fixed time interval of 5 min, within the thermometers must be read, the numbers of skips may increase strongly. We will return to this subject, when discussing the requirements the disposable thermometers have to meet.

— *Condition of the mouth before measurement*

The condition of the mouth can strongly be influenced by hot or cold drinks, breathing through the mouth, moistness of the mouth etc. Also the environmental temperature, the thickness of the tissue and the presence of a denture may effect the temperature of the mouth.

Owing to this it is possible that at the end of the prescribed measuring time the temperature could not yet have been recovered from the disturbances mentioned above. In the operating instruction added to the package of the thermometer one has payed attention to this.

As it appears from this the mouth is not the most suited place to measure the temperature of the human body. Temperature measurements in the rectum or in the external auditory canal are more accurate. With the modern patient observing systems the oral measurement is however preferred. In Anglo-Saxon countries oral temperature measurement has always been the usual method.

Technical requirements

The most important requirements which the thermometers must meet are in short :

I The thermometers must have a temperature range at least from 35.5 °C to 40.4 °C.

II On each thermometer or on its wrapping must be stated the length of time during which the thermometer is to be kept in the mouth.

III The maximum permissible errors are :
(— 0.2 + a) °C, (+ 0.2 + a) °C

where a represents the difference stated by the manufacturer and which difference appears when the thermometer is heated in a water bath of 37 °C, respectively in the mouth at a mouth-temperature of 37 °C during the period mentioned under II

IV The maximum permissible error applies under a number of conditions, the most important of which is :

— the thermometer is read within a period starting 10 s after removing the thermometer from the water bath and ending 5 minutes later.

V A shortening of the time indicated under II with 20 % or a lengthening of that time with 10 seconds during temperature measuring in a water bath may not cause a shift in the indication of more than 0.1 °C.

The length of time mentioned in II is an important condition for the correct indication of the thermometers. From the temperature-time characteristics in Fig. 4 it appears that after the usual measuring time of 60 s has elapsed the temperature balance has not yet been reached. As a result deviations of this time will lead to rather different indications. For this reason the requirement in point V is drafted in order to prevent that the measuring time is chosen too short so that at the end of that period the temperature-time characteristic is too steep. In that case a small deviation from this time would lead to unacceptable variations of the temperature indication. In Fig. 4 this requirement is shown graphically.

In the maximum permissible error is included the systematic error (IVD) introduced by the manufacturer in order to achieve a correct temperature indication in the mouth. Both manufacturers known at present apply a shifting of + 0.3 °C.

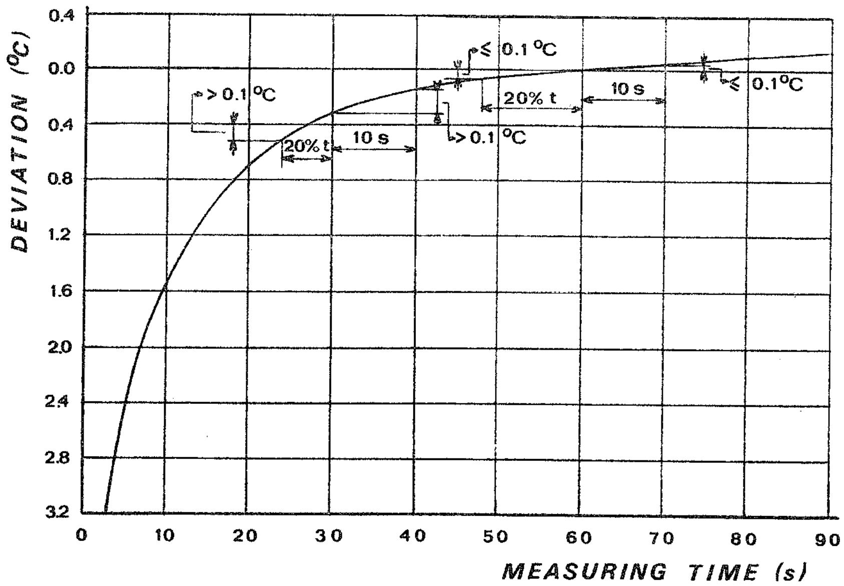

Fig. 4

Test method

An inspection of a batch of disposable thermometers is carried out on a sample of 100 thermometers taken at random from the batch. The result of the inspection of the sample is decisive for the acceptance or rejection of the batch. The term batch is used for the continuous production of one machine during one or a number of successive days and representing up to 150 000 thermometers.

This condition is made in order to attain that batches are offered which are produced under uniform conditions. Moreover, by limiting the number of thermometers in the batch it is achieved that the sampling inspection is not incidental, but takes place regularly.

By the manufacturer and under his responsibility a sample of 230 thermometers is taken at random from the batch. This sample has to be well wrapped and sent to the Metrology Service via importers. The shipment is accompagnied by a statement on the size and the item number of the batch and the results of the final test carried out by the manufacturer. The Metrology Service divides the sample in two parts, each of 100 thermometers. The meaning of this is explained later on. The remaining 30 thermometers are kept in reserve for eventual replacement of defective thermometers.

Owing to the fact that the behaviour of the 50 temperature dots is independent it is obvious that an equal number of measuring points should be applied. However not only the temperature dots in question but also the adjacent dots influence the size of the error. This means that if 50 measuring points are chosen a part of the dots are involved several times in the judgement of the error. For that reason the number of measuring points has been limited to 16 which means that a sequence of 16 waterbath temperatures, progressing with 0.3 °C, is applied.

Because of the fact that every thermometer can be used only once it would be necessary to test different thermometers at different measuring points, so that a sample size of 1 600 thermometers would be necessary.

In order to limit this large number of thermometers, an inquiry has been made into the possibility of inserting a disposable thermometer several times in a water-bath, the successive bath-temperatures of which are progressive in value.

For this inquiry three questions have to be answered.

— Is there a chance that through repeated immersions the cover sheet becomes detached from the dots so that the substance in the dots will be affected ?
— Is there a chance of a connection between the dots which might cause mixing of the substance ?
— Is there a chance that as a result of repeated changes in temperature the properties (for instance the melting temperature) change, which would also lead to a change in the indication ?

Extensive tests have shown that the chances of moisture entering the dots or of a short-circuiting between the dots are negligeable. The properties of the thermometers on the other hand are rather affected by repeated immersions. The extent however was so small that no significant deviations from the temperature curve was noted. The effect of the repeated immersions on the recrystallisation of the dots (skips) was very great ; after several immersions the stability appeared to be considerably better.

On the basis of this result it was decided to examine a sample of 100 thermometers for compliance with regard to maximum permissible errors and to examine another sample of 100 thermometers to the appearance of non discoloured dots (skips).

Acceptance criteria

In order to establish the acceptance criteria for disposable thermometers the characteristics are divided into three groups, according to the importance of these characteristics in relation to the quality of the thermometers. This importance is expressed in the sharpness with which the acceptance criteria are defined.

a. Characteristics of the third category.

These include faults in the workmanship, such as incorrect cut bearer, sharp or damaged edges, incorrect identification on the wrapper, dirt in or on the thermometer, etc.

Acceptance criteria : not more than 12 faults in one sample.

b. Characteristics of the second category.

These include faults in the sensing element which could lead to an erroneous indication, such as

— three or more dots are already discoloured before usage,
— after cooling down of the thermometers, which have been exposed to a temperature of 40 °C, three or more dots have not changed colour,
— the temperature numbers are not clearly readable,
— the protection screen over the temperature dots has been damaged.

Acceptance criteria : not more than 6 faults in a sample.

(The presence of non-discoloured dots (skips) occurs often and does not lead to a wrong interpretation of the measuring results, provided the number of these skips is small. Therefore a limit of three skips is established).

c. Characteristics of the first category.

These include errors in the indication.

— with regard to the total number of errors :

acceptance criteria : 97 % of the measurements may have an error ⩽ 0.2 °C

— with regard to the number of errors for every measuring point : acceptance criteria : for every measuring point tested at most 4 thermometers may show an error > 0.3 °C

— with regard to the response time :

acceptance criteria : both the shortening of the measuring time by 20 % and the lengthening of the measuring time by 10 s in relation to the given measuring time may not cause an average shift in the temperature indication of the entire sample of more than 0.1 °C.

(In consultation with the Ministry of Health it is established that 97 % are to be within a tolerance of ± 0.2 °C ; this means that a batch with 2 % faulty thermometers has a 99.5 % chance to be accepted. A consideration was that these thermometers are used only once, so that a wrong indication can lead only once to a wrong determination of the body temperature. Moreover the second criterium prevents a concentration of wrong indications in a small area).

Test equipment

When designing the test equipment the following facts and suppositions were taken into account :

1. For every sample test a fixed number of 100 thermometers is to be examined.
2. For every thermometer 16 measuring points are to be considered, so that for every sample 1 600 readings are carried out.
3. The observation of discoloured dots on a relatively small matrix of temperature dots will mean a strain on the eyes and may lead to a great number of erroneous readings.
4. The thermometers can only be tested once, so that in cases of doubt or a discussion with the manufacturer the sample test cannot be repeated.

On the basis of these starting points a test equipment has been developed which consists in broad outlines of the following elements :

— a waterbath in which the whole sample of 100 thermometers can be carried out at the same time,

— a lifting device which will be capable of immersing these thermometers simultaneously in the bath,

— a micro-film camera to photograph at every measuring point the thermometers lifted from the bath and cooled at room temperature, so that all the indications are recorded,

— a microprocessor controlling the whole procedure, such as the bath temperature, time of immersion, cooling time, the adjustment of the lifting device and the camera,

— a monitor to read out the developed micro-film.

In order to immerse at the same time the 100 thermometers of the sample a rack is used which can contain two groups of 5 rows of each 10 thermometers. The rack is show to the left in Fig. 7.

With the aid of a punch apparatus two holes are punched in the spoonshaped part of the thermometer (which contains the dots), whilst the rest of the bearer is cut off. The remaining part of the thermometer is then pushed on tiny cams with which the rack is provided.

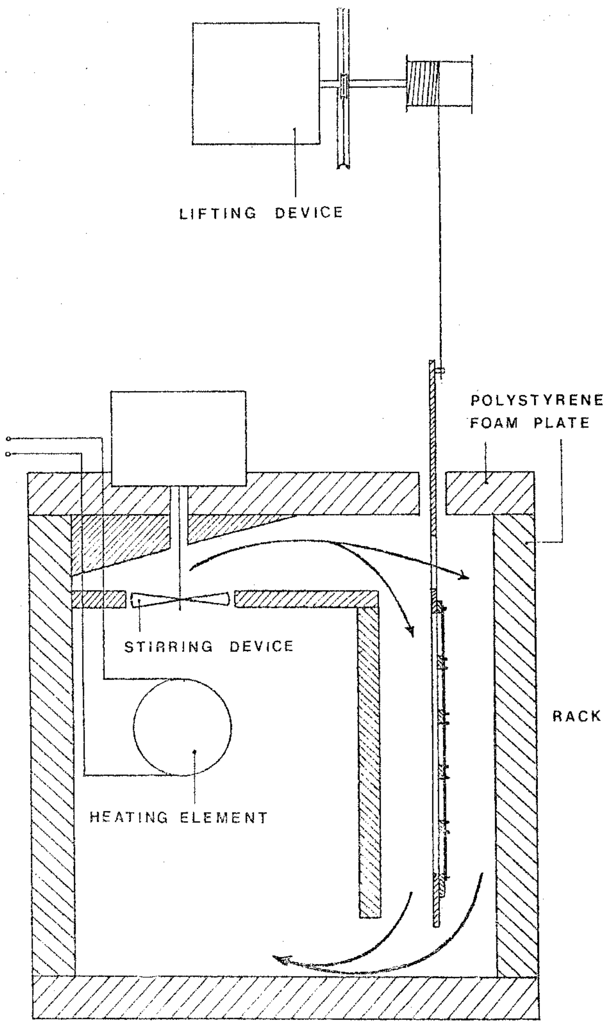

Fig. 5
Water bath

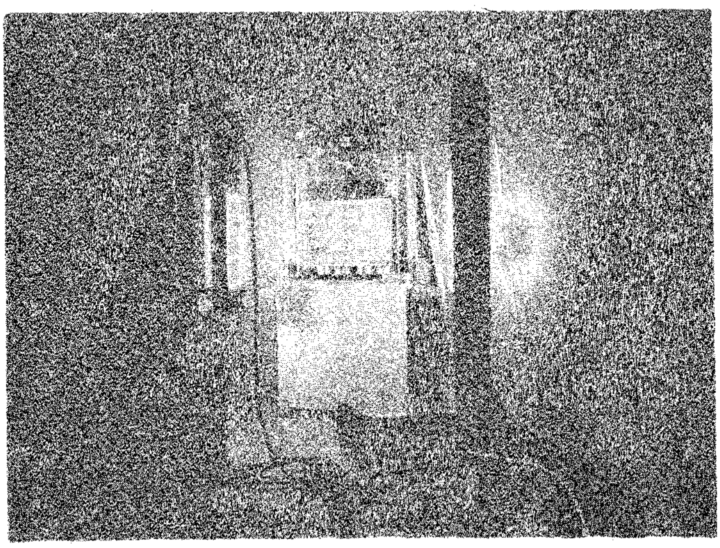

Fig. 6
Complete test installation

The rack can be immersed perpendicularly in the water bath with the aid of a lifting device (Fig. 5 and 6). The device consists of two conductors which keep the rack in the correct position and a cable drum driven by an electromotor, round which a cord is layed from which the rack is suspended. The water bath has been constructed entirely from polystyrene foam plate and is divided into two compartments. The rack is lowered in the narrow compartment, whereas the other compartment contains the heating elements and 4 stirring devices. These devices produce a homogeneous waterflow from top to bottom through the narrow compartment, so that both sides of the rack are in intensive contact with the waterflow. The temperature sensor is situated in the middle in front of the rack.

The capacity of the bath has been chosen as small as possible so that only a short heating period is needed. Moreover through the application of polystyrene as insulation material a very homogeneous temperature has been achieved. As a result of this it is however necessary to compensate for the drop in temperature caused by the immersion of the relatively cold rack. So a short period of reheating of the bath after the immersion of the rack is necessary.

In this way an accuracy is achieved which is better than 0.02 °C. Lighting of the thermometers is done with two sodium lamps. Because of the colour of the sodium light the discolouring of the dots in blue or red (depending on the make) is observed as black dots, the results of which is a sharp contrast on the photograph between discoloured and notdiscoloured dots. Together with the rack the camera registers also the temperature of the bath at the period of immersion.

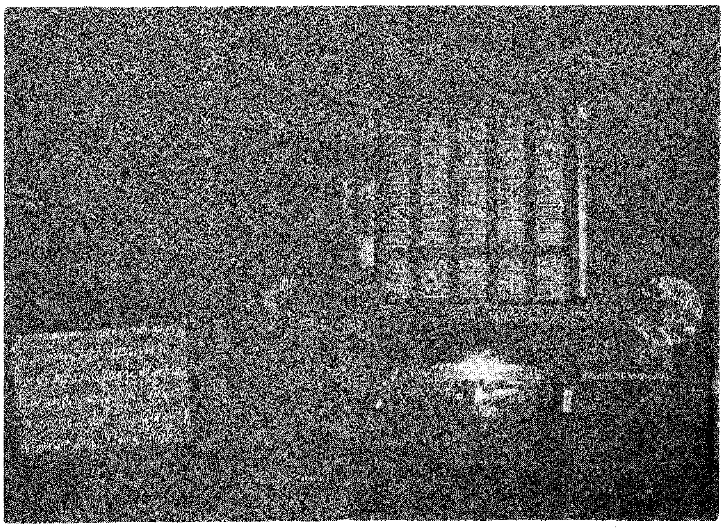

Fig. 7

Film reading monitor

The developed film is read out picture by picture with the aid of a monitor (Fig. 7). In this monitor the pictures are magnified and projected on a screen, so that the indications of the thermometers can be read easily. The film can be used for re-examination in case of doubt of the results of the tests or in the case of objection by the manufacturer. Before long the reading of the monitor will be carried out by means of a TV camera with the aid of a picture-recognition system.

Test procedure

The steering of the bath temperature, the lifting device and the microcamera is carried out by a micro-processor. The water bath is heated up to the temperature of the first test point. Then the lifting device lowers the rack into the bath and lifts it after one minute. After the rack with the thermometers is removed from the bath the micro-camera takes a picture of the rack every minute. The last picture taken after 5 minutes is decisive for the indication of the thermometer. In the meantime the bath has been heated to the next testpoint and the cycle starts again.

During the last two immersions described above an examination of the response time is carried out as follows : at the last but one immersion the lower half of the rack is kept immersed longer, and at the last immersion the top half of the rack is kept immersed for a shorter period.

After the examination of the indication an inquiry is carried out into the appearance of not discoloured dots (skips). For this purpose a second rack is used, which has already been provided with the second part of the sample. This rack is kept immersed at a temperature of 40 °C during a period of one minute.

In the same way as described above the micro-camera takes pictures of the rack after it has been removed from the water bath.

ROUMANIE

A GENERAL CLASSIFICATION of the METHODS of MEASUREMENT

by **Aurel MILLEA**
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SUMMARY — In this second paper useful for the teaching of metrology the author proposes an outline of a general classification of the methods of measurement (see OIML Bulletin n° 91).

RESUME — Dans ce deuxième article utile à l'enseignement de la métrologie l'auteur propose un plan de classification générale des méthodes de mesure (voir Bulletin de l'OIML n° 91).

1. The basic ideas of the classification

A mesurement is, without exception, a comparison *. The presence of a reference quantity (a standard) is essential in any measurement (although this is sometimes not obvious).

The measurement can be performed by *simultaneous comparison* or by *successive comparison.*

In the simultaneous comparison, the measurand (quantity to be measured) is directly compared to a reference quantity of the same kind. Examples : a length compared with the known length of a gauge block; a mass compared with the mass of a standard weight by means of a balance; a voltage compared with the voltage of a Weston cell by using a potentiometer.

In the successive comparison, the reference (comparison) quantity does not participate in every measurement: it is used for the initial calibration (or graduation) and, if necessary, the periodic recalibration of the measuring instrument, which stores in its « memory » the calibration information. This information, once received from the standard - or from several standards of different quantities, as for example when an ammeter is calibrated against a voltmeter and a shunt - is then transmitted by the measuring instrument every time a measurement is made. Examples: pressure measurement with a manometer; voltage measurement with a voltmeter; temperature measurement with a liquid-in-glass thermometer.

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* The indirect methods of measurement, involving the calculation of the measurand in terms of other directly measured quantities, may be regarded as a sequence of several measurements, and not as a single measurement (except when the calculation is automatically done inside the measuring instrument).

Consequently, in a simultaneous comparison the information is transferred at the same time from the standard and from the object under measurement, through the comparing instrument, to the observer (or other recipient of the measured data), whereas in the successive comparison this information is transferred in two stages, from the standard to the measuring instrument (at calibration) and then from the object under measurement to the measuring instrument and the observer.

Fig. 1 illustrates these two cases *.

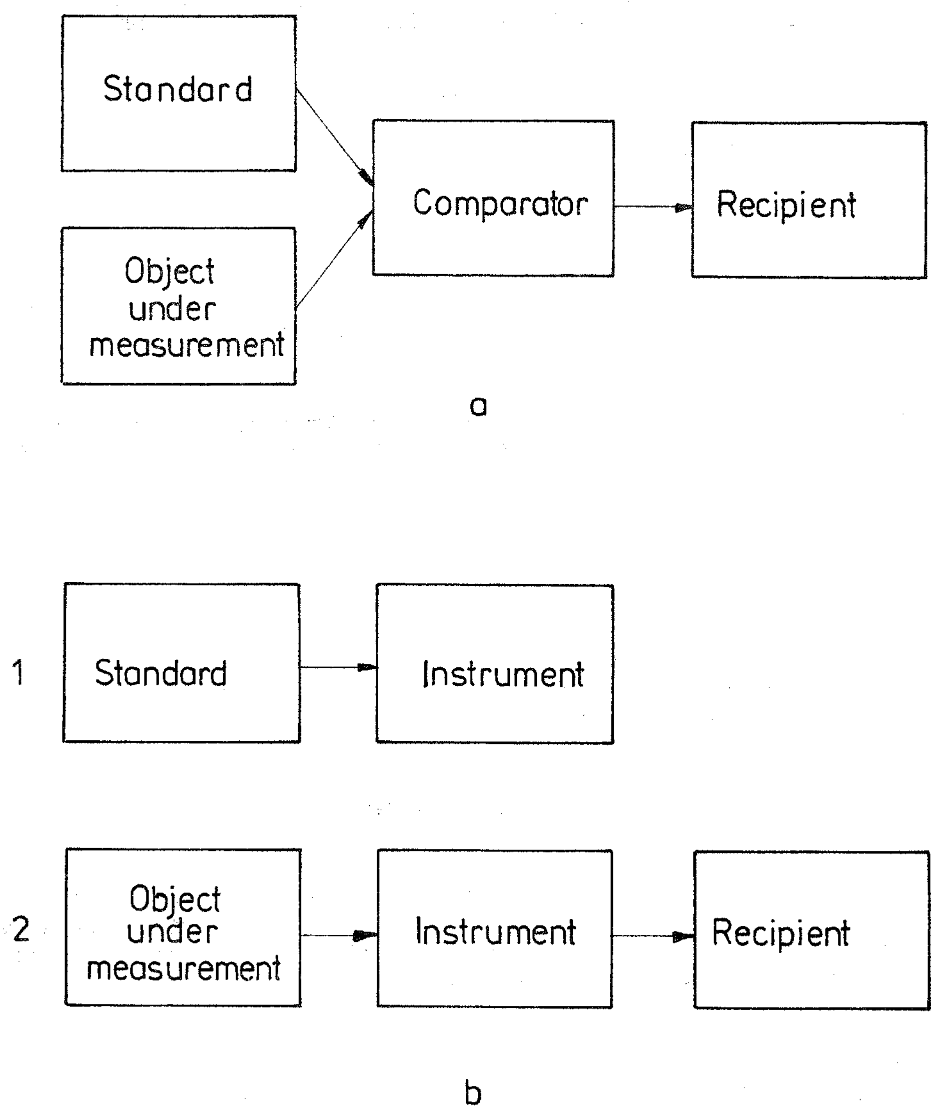

Fig. 1

The flow of measurement information in :
a. simultaneous comparison ;
b. successive comparison (1. calibration ; 2. measurement)

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* Although the concepts of simultaneous and successive comparison seem logical and straightforward, few textbooks point them out. They may be found (in a slightly different sense) in the book by K.B. Karandeev : « Special Methods of Electrical Measurements », Moscow, Gosenergoizdat 1963 (in Russian). The classification of the methods of measurement has further been developed in the author's books A. Millea : « Electrical Measurements. Principles and Methods », Editura Tehnica Bucharest 1980 and A. Millea : « Information and Uncertainty in Measurements », Editura Tehnica Bucharest 1982 (both in Romanian).

It may be of interest to note that historically the measurement by simultaneous comparisons was the first that appeared (for length, volume, mass measurement). Later, together with technological developments, the measurement by successive comparison has become prevalent, allowing the process of measurement to be more or less automated (in the case of direct indicating instruments). However, the method of simultaneous comparison is still predominant (and often solely used) for measurements of best accuracy in metrological laboratories of the highest rank.

2. Measurements by simultaneous comparison

The measurand can be compared either to a reference quantity of equal (or nearly equal) value, or to a reference quantity of different value. The two kinds of measurement may be called « 1:1 comparison » and respectively « 1:n comparison ».

2.1. Measurements by 1:1 comparison

The 1:1 comparison is either a direct comparison, when the measurand is directly compared to the reference quantity, or an indirect comparison, when the comparison is carried out by means of an intermediate device (comparator).

2.1.1. The direct 1:1 comparison

The direct 1:1 comparison can be performed by a differential method or a null method.

The *direct differential method* consists in measuring by a conventional method the difference d between the measurand x and the reference quantity x_o, assuming that $d \ll x_o$:

$$x = x_o + d. \qquad (1)$$

In the direct differential method the quantities x and x_o are supposed to be compared without interposing a comparing device or instrument (like a balance, a resistance bridge, etc.). The difference d is directly « generated » by opposing the two quantities x and x_o. Obviously, such an approach is only possible when comparing quantities that may take both positive and negative values (length, angle, force, voltage, etc.) and is not applicable in the case of essentially positive quantities (mass, resistance, capacitance, inductance, etc.).

In general, the quantity d is measured with a negligible error and therefore the uncertainty of the measurement is practically equal to the uncertainty of x_o.

The *direct null method* is a particular case of the differential method, in which the difference between the measurand and the reference quantity is brought to zero :

$$x = x_o. \qquad (2)$$

The direct null method is even less affected by the instrumental errors.

In general, the direct differential and null methods may be considered as the most accurate methods of measurement, since they minimize the intervention of instrumental errors.

2.1.2. The indirect 1:1 comparison

The indirect 1:1 comparison requires an intermediate comparator (comparing instrument). The main variants of the indirect 1:1 comparison are the method of simple comparison, the method of substitution and the method of transposition.

The method of *simple indirect 1:1 comparison* consists in the comparison of the two quantities - the measurand and the reference - by means of an instrument which may be called *1:1 comparator.*

The result is given by the expression

$$x = K\, x_o, \qquad (3)$$

where K is a factor ($K \simeq 1$) introduced by the comparator. This adds an important source of uncertainty to the process of measurement.

The measurement can actually be performed by a differential or a null method. However, in this case it would be proper to call them *indirect differential method* and respectively *indirect null method.* There is a definite difference between them and their « direct » counterparts. Thus, in the direct null method the null condition leads unconditionally to the equality $x = x_o$ (e.g. the null indication of the detector when comparing two voltages in opposition involves their equality), whereas in the indirect null method the null condition itself does not imply the equality of the compared quantities (e.g. a balanced resistance comparator bridge does not necessarily mean that the compared resistances are equal).

The *method of substitution,* which may also be called the method of equal effects, avoids the errors arising from the comparator, by a double measurement. The quantities to be compared x and x_o are in sequence applied to the comparator, which compares them with the same auxiliary quantity x_a. This gives

$$x = K\, x_a\, ;\ x_o = K\, x_a, \text{ hence } x = x_o. \qquad (4)$$

Thus, the factor K due to the comparator is eliminated, assuming that K and x_a are constant during the measurement.

The measurement by substitution may be accomplished, as in the previous case, by using the indirect differential method or the indirect null method.

The *method of transposition* offers another possibility of eliminating the error due to the comparator, by a double measurement. After a first comparison between x and x_o, they are interchanged and a second measurement is performed. Supposing that the comparator ratio K is unchanged, a new value x_o' of the reference quantity is obtained, resulting in

$$x = K\, x_o\, ;\ x_o' = K\, x, \text{ hence } x = \sqrt{x_o\ x_o'}. \qquad (5)$$

Again, the measurement may use the indirect differential method or the indirect null method.

2.2. **Measurements by 1:n comparison**

In the 1:n comparison, the measurand is compared to a reference (standard) quantity of different value.

There are two possibilities for simultaneous comparison of quantities of different values : by superposition techniques and by ratio techniques.

2.2.1. Superposition methods

The basic idea of the superposition methods is to combine several standards of appropriate values to arrive finally at a 1:1 comparison (or a sequence of 1:1 comparisons).

For this purpose, the reference quantities must be perfectly additive. The mass of several weights placed on a balance is exactly equal to the sum of their individual masses, which is not always true for the resistance (conductance) of series (parallel) connected resistors.

The characteristic equation of the superposition methods is

$$x = \sum_{i=1}^{n} x_i, \qquad (6)$$

where x_i are values of the superposed reference quantities. The quantities x_i can be in turn intercompared, in different combinations using 1:1 comparisons. If the number of these combinations equals or exceeds that of the compared quantities, one arrives at the method of closed series combination *.

Superposition methods are frequently used in high accuracy comparison of standards. Examples : the 1:10 comparison of masses, by using intermediate masses of values 1 ; 1 ; 1 ; 2 ; 5 ; the 1:100 resistance comparison by means of a Hamon-type series-parallel transfer resistor ; the measurement of a time interval by counting standard frequency pulses.

2.2.2. Ratio methods

The ratio methods (or ratiometric methods) allow two differing quantities to be directly compared to each other, by interposing a *ratio device*, that « divides » or « multiplies » in a known ratio one of the two quantities.

The well-known example of ratio device is the unequal arm balance. The accuracy of measurements using such a balance is far lower than that obtained by 1:1 comparisons. On the contrary, in electrical measurements very high accuracy ratio devices have been developed, permitting measurements by ratio methods of accuracies comparable to that of 1:1 methods.

The characteristic equation of ratio methods is

$$x = K\, x_o, \tag{7}$$

where K is a characteristic factor of the ratio device. In electrical measurements values of K adjustable in wide ranges are often encountered, with an accuracy up to 1 ppm or even better. To illustrate the performance attained in this direction, it may be mentioned that there exist commercial AC bridges which contain a single standard capacitor of 10^{-9} F and measure capacitance between 10^{-15} F and 10^{-3} F, by using two ratio transformers, each of them having the factor K adjustable between 0.001 and 1 000.

3. Measurements by successive comparison

The method of successive comparison is typical of direct indicating instruments, in which one or more conversions of the signal carrying the measurement information take place. Its main advantage is the simplification of the process of measurement. The method of successive comparison is imperative in the measurement of quantities for which a reference (standard) is inconvenient or impossible to be constructed.

The examination of two simple examples will reveal some interesting features of the successive comparison.

a. In a moving-coil ammeter the active torque $M_a = k_1 i$ equals the restoring torque $M_r = k_2\alpha$, hence the deflection angle α is given by (Fig. 2 a)

$$\alpha = \frac{k_1}{k_2}\, i, \tag{8}$$

where i is the current to be measured, and k_1, k_2 are constants of the instrument.

The relationship between the output quantity α and the input quantity i of the instrument includes the factor k_1/k_2 depending on constructive parameters of the ammeter. Instead of calculating them, in practice a *calibration* of the instrument is performed with a current $i = i_o$ of known value, giving a deflection $\alpha = \alpha_o$. Hence, $k_1/k_2 = \alpha_o/i_o$ and equation

* See VML (1978), term 5.2.3.

(8) becomes $\alpha = (\alpha_o/i_o)\ i$. The calibration may be interpreted as the transfer of an information to the instrument (the calibration information). This information is stored in the « memory » of the instrument, where it is kept for a long time (until excessive changes of one of the parameters of the instrument, lead to the necessity of recalibration). The « memory » of the ammeter includes its moving coil, permanent magnet, spring, graduated scale, etc.

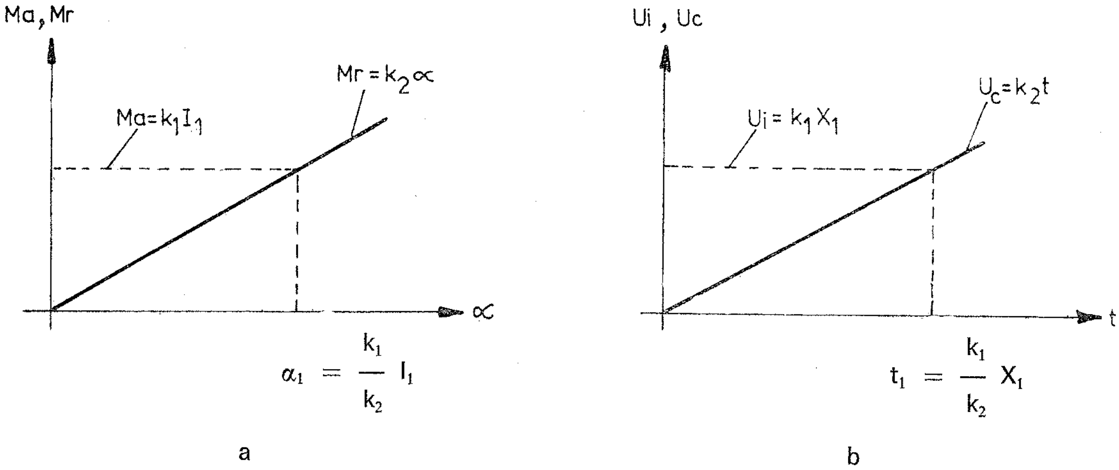

Fig. 2

Basic relationships in two cases of measurement by successive comparison :
a. with a moving coil ammeter ;
b. with a voltage/time conversion digital multimeter

The calibration information being stored, the instrument measures by itself, without a reference quantity (the current i_o). In every measurement the equality $M_a = M_r$ is automatically reached, at a deflection angle α depending on the measurand i. Thus, a simultaneous comparison occurs between the two torques M_a and M_r. Therefore, a measurement by successive comparison includes a simultaneous comparison between two intermediate quantities, one related to the measurand (the active torque M_a, determined by i), and the other related to the output quantity (the restoring torque M_r, depending on α). *The successive comparison replaces the direct comparison between the measurand and the reference quantity by a simultaneous comparison between two intermediate quantities, one determined by the measurand and the other determining the output quantity* (the indication of the instrument). Calibration is the operation that establishes the two relationships needed (in our example, between i and M_a, and respectively between M_r and α). The simultaneous comparison involved is « automatic » in the sense that balancing of the two torques M_a and M_r needs no external intervention.

b. In a *voltage/time conversion digital multimeter* the measurand x (DC or AC voltage and current, resistance, etc.) is first converted into an intermediate proportional voltage $u_i = k_1 x$. An internally generated linearly variable (ramp) voltage $u_c = k_2 t$ is used for comparison. A digital chronometer is started at the moment $t = 0$ and stopped when the two voltages become equal : $u_i = u_c$. This gives (Fig. 2 b)

$$t = \frac{k_1}{k_2}\, x. \tag{9}$$

The analogy with the moving coil ammeter is obvious. The scale factor k_1/k_2 is determined by calibration, applying a known input quantity x_o. The output quantity of the instrument is the time t. The « memory » of the instrument includes, in this case, the x/u_i converter and the ramp voltage generator. The simultaneous comparison inside the instrument results between u_i and u_c. The digital multimeter has an « electric memory », in contrast to the « mechanical memory » of the moving coil instrument.

4. Conclusions

Some essential features of the process of measurement have been discussed, in order to deduce general criteria for the classification of methods of measurement. Summarizing, the following classification scheme may be proposed :

- Comparison
  - Simultaneous comparison
    - 1:1 comparison
      - direct
      - indirect
        - simple
        - substitution
        - transposition
    - 1:n comparison
      - superposition
      - ratio methods
  - Successive comparison
    - with mechanical memory
    - with electrical memory
    - with other types of memory

This classification * seems to be logical, simple and consistent. It might provide a basis for new terms and definitions, in better agreement with the present-day development of metrology.

* Certain types of instruments may use several methods of measurement. Thus, a differential voltmeter measures according to a simultaneous 1:1 comparison - by a null method or a differential method (in terms of its internal reference voltage) - or a successive comparison (when the reference voltage is set to zero). As a further example, with a Q-meter one may measure a reactance by simultaneous 1:1 comparison (substitution) and a resistance by successive comparison.

LEGAL METROLOGY in DENMARK 1283-1683

by **A. HAEGSTAD**

As a complement to the paper on legal metrology in Denmark 1683-1982 published in n° 89 of the Bulletin, we are below reproducing a speech at the opening of the special historical exhibition of Danish weights and measures at the Technical Museum near Helsenor in May 1983 in the presence of the CIML Members.

This speech retraces the part of history of metrology in Denmark prior to the Royal Decree issued by Christian V in 1683. The author is a Lutherian minister who has taken great interest in historical metrology and is the eminent Danish specialist in this field.

En complément à l'article sur la métrologie légale au Danemark de 1683 à 1982 publié dans le n° 89 du Bulletin, nous reproduisons ci-dessous un exposé historique sur la métrologie au Danemark qui a été présenté à l'ouverture d'une exposition sur les poids et mesures au Musée Technique près de Helsenor, en mai 1983, en présence des Membres du CIML.

Cet exposé concerne la métrologie au Danemark avant le Décret Royal par Christian V en 1683. L'auteur est un pasteur luthérien qui est également un spécialiste éminent de la métrologie historique.

Ladies and gentlemen,

May I invite you to a walk in a beautiful garden ?

Not the Garden of Eden (as you might guess because I am a minister of religion). My garden has another name ! - To a hidden corner of mankinds history I shall have the pleasure to accompany you. The name of the garden is... *Historical metrology.*

In this garden the man has planted the most fruitful trees from the fields of human knowledge and experience : - Mathematics, physics, numismatics, agriculture, navigation, artillery, law and religion.

A 100 years ago the German professor of Ancient history *Karl Julius BELOCH* declared that the historical metrology is « eine wahre Hexenküche » (a true kitchen for witchcraft).

So near we are the castle of Kronborg, the scene for « HAMLET, prince of Denmark », I must oppose this German statement with a quotation from William Shakespeare :

Though this be madness, yet there is method in it.

To find the methods, to find the principles for fundamental and legal metrology in bygone times has been the object of my studies for now many years. But, as Polonius says in that same play by Shakespeare : - *Brevity is the soul of wit !* I shall confine myself to a few examples from my historical research.

Has metrology anything to do with religion ? Of course, a lot !

It is not accidental, that Mrs. JUSTITIA (you know the goddess of justice) has a pair of scales in her left hand and a sword in her right. She is a symbol of the society, and the society exists only when the outcome is divided or distributed - one way or another -

with *righteousness.* And even in classic times they knew, that you can weigh with greater accuracy than you can measure by the yardstick. Therefore Mrs. JUSTITIA has a balance and not a yardstick in her hand. - The sword reminds us that the weights to be used are decided by a person or an institution in power.

The balance is the fundamental metrology. The sword is the legal metrology.

Even in modern society the words of the Holy Scripture still apply :

« Ye shall do no unrighteousness in judgement
in meteyard, in weight, or in measure. »

Weighing and measuring has always been so connected with the conception of justice, that weighing and measuring was considered as holy functions. The religious aspect was underlined by the fact, that the right weights and the right measures were kept in the Roman temples. A tradition we can trace back to the civilizations in the Middle East. - We read in the 4th chapter of the *Lamentations :* « The holy stones are scattered along the street ». It means, that the prototypes of weight have been removed from the Temple of Jerusalem by the conquerors. *No prototypes, no justice !*

When christianity had been adopted as the religion of the Roman Empire, we find in Corpus Juris Civilis (the Roman Law) a decree from *emperor Justin* (the sixth century) demanding that weights and measures should be kept in the church of every city.

In the city of Visby (the wellknown merchant-town of Gotland) we have several churches from the Middleages. They have still a yardstick of iron fixed to te door. - No doubt a tradition from England, where they still have the expression « Be up to the door » ; it means « to keep the measure ».

On Danish territory of to-day we have no old yardsticks affixed to the church-doors, because the Royal Ordinance of 1683 (the 300th anniversary of which we are celebrating in these days) expressly ordered all old measures destroyed. Yet, we have one very interesting metrological monument preserved from the 13th. century, which I should like to mention to-day.

Inserted in the masonry of the church of Skælskor (a small town situated on the westcoast of this island) we have a slab of stone. Incised are *a circle and a yardstick.* The monument is called « The Bushel of Skælskor » and has up till now been rather enigmatic.

However, the proportion of the yardstick and the diameter of the circle is the squareroot of 576 to the squareroot of 512. When we use the theorem of Pythagoras, we may have a cylindrical bushel with a height of the squareroot of 64. The height will be 8 inches, or one third of the yardstick. If we fill this bushel with barley, the weight shall be about 40 kilos, or one fourth (a quarter) of the « Schiff-pfund » (Shippound) used in the Baltic traffic in Middleages. In fact, we exported barley from this town (Skælskor) to the breweries of Lübeck and the other German cities along the Baltic shore.

This metrological monument should be connected with *the earliest example of legal metrology* we know from Danish history. Our king *Erik* (with the nickname « Klipping » ; it means « Money-cutter ») decreed some day in *May 1283,* that the bushel should be measured by « that yardstick which Our father has instituted ». His father was king *Kristoffer I,* who established the said church of Skælskor ! So, we Danes may in these days celebrate too the *700th anniversary of Legal Metrology in Denmark.* It is remarkable, that our bushel by law 700 years ago was adjusted to an international standard in the Common Market of the Baltic Sea.

As you know, untill the introduction of the Metric system most cities on the European continent had their own weight, their own pound. Have a look into the many handbooks for merchants from the 17th and 18th century, and you will discover that there was more than 300 different pounds in Germany. Was there any method in the madness (if I may quote Shakespeare once more) ? Indeed, there was !

Most European pounds can be defined as *a certain number of a certain coin.* At first coins of silver, later goldcoins. The number of coins was decided by their purity. Let us take the French Troy-pound (la livre à deux marcs). Since the 1480ties we know the exact weight of the French Troy-pound: 489.5 g. But why this weight ? Because 144 Spanish Reals had this weight, and because this number of Spanish Reals contained exactly one Spanish pound of pure silver !

Another example. Why was the Amsterdam-pound equal to 494.09 g ? It was the weight of 17 Dutch Rijksdaalder (Reichsthaler). But why 17 Rijksdaalder ? Because they were equal to one pound so-called « Work-silver » after the weight in Cologne !

The Spanish silver from Latin America had an enormous importance to the European economy... and metrology !

The so-called Price-revolution about 1550 caused a wave of inflation allover Europe. The kings reduced the content of pure silver in their coins, and in order to conceal this fraud they raised the coinweight. Consequently the local pound (as a certain number of coins) would be heavier. Here we find the reason to the enormous export of « nested weights » from Nürnberg. By means of these « Einsatzgewichte » (poids de godet) the European cities and their merchants could keep their old pound for some time.

But a new definition of weight was needed.

Here the *European artillery* comes in with a solution. Gun bullets were up to an international standard and were classified according to their weight... after *the pound of Nürnberg.* The Nürnberg Artillery Scale and Artillery Pound was used more and more in Europe during the 17th. century.

So long the gun bullets were made out of hammered iron, there was no problem. But from the end of the 17th. century all cannon-bullets were made of cast iron, and *cast iron had different specific weight* from place to place. A new way out must be found.

The solution came in the year 1599. *The key-word was water !* The Spanish jesuitpater *Juan Bautista VILLALPANDA* found in Palazzo Farnese in Rome a Roman congius, a bronze-vessel from the time of emperor Vespasian. He filled it with water and discovered that *80 Roman libras (pounds) were equal to the weight of one Roman cubic foot of water.*

The archbishop *Ernest of Cologne,* who was not a member of Societas Jesu himself, but supported this religious order for the sake of the counter-reformation in Germany, took up this idea and drew up the lines for a system of weight and measure very like the later metric system. He consulted the famous Austrian astronomer *Johannes KEPLER,* who wrote that he found the idea fascinating, but impracticable. Shortly afterwards the archbishop Ernest died (1612), but thanks to the members of Societas Jesu the idea of linking weight and measure on the basis of water was kept alive.

Already in 1617 the Dutch astronomer *Willibrord SNELLIUS* in Leyden wrote about the weight of a rhenish cubicfoot of water. Thirty years later (1647) the British astronomer *John GREAVES* wrote a book about the Roman foot and the Roman libra. And so did the Swedish polyhistor *Georg STIERNHIELM.*

In Danish school-books you may read, that the Danish astronomer *Ole ROMER* was the spiritual father to the Royal ordinance of May the 1st, 1683. It is not the historical truth. The members of our « Collegio of Commerce » knew very well the European litterature about this splendid idea of linking weight and measure. They had the knowledge from the handbooks of the time, and they knew that *62 Nürnberg Artillery Pounds were equivalent to the weight of one Rhenish cubicfoot of water.* And they knew, that a Rhenish cubicfoot was equal to 32 Parisian pints.

In fact, the ordinance of May the 1st, 1683 prescribed some wellknown international standards to be used in Denmark and Norway. The *Rhenish foot,* the *Nürnberg Artillery Pound* and the *Parisian Pint* should be the *Danish foot,* the *Danish pound* and the *Danish « pot ».*

It is a sort of historical irony, that the most protestant, the most Lutheran country in Europe, Denmark... whose King on the 15th of April 1683 had signed a new Danish Law, according to which there should be no future for anybody who had attended schools following Jesuit ideas... that this particular country on the 1st of May in that same year (1683) should be the first country to realize the ideas of a Spanish Jesuit Monk in Palazzo Farnese.

Funnily enough, Palazzo Farnese belongs to-day to that country of France, which a century later gave birth to the Metric System.

RETENTISSEMENT des ACTIVITÉS de l'OIML dans la PRESSE TECHNIQUE

Le Centre de Documentation du BIML reçoit régulièrement différents journaux du domaine de la métrologie. Certains font souvent paraître des rapports sur les travaux de notre Organisation. Dans ce qui suit, nous donnons un bref aperçu de ces informations publiées dans les années 1981 et 1982.

Standardization, le Bulletin de l'Organisation Arabe pour la Normalisation et la Métrologie (ASMO) a publié un article sur le contrôle des poids et mesures (n° 3/1981) qui a été suivi par une description générale de notre Organisation (n° 4/1981). Standardization (n° 1/1982) a reproduit le rapport du BIML sur la mise en application des Recommandations OIML.

Carta metrologica, le journal de Sistema Interamericano de Metrologia (SIM) a publié un article par M. A. THULIN sur l'harmonisation des approbations de modèle (dans son n° 3). Dans le n° 4, la revue des livres a signalé la publication BIML « Fournisseurs d'équipement de vérification » et la parution en espagnol du Vocabulaire de Métrologie Légale.

PTB-Mitteilungen, le journal de Physikalisch-Technische Bundesanstalt (RFA) fait également des rapports sur la plupart des événements OIML. Un article écrit par M. B. ATHANE sur 25 années de l'OIML, sur la participation de la RFA et sur le rôle de M. le Prof. MUHE, a été publié dans le n° 1/1981. Des rapports détaillés sur sept réunions de Secrétariats OIML ont été publiés (n° 2, 3, 5/81, 1, 2, 6/82). Des traductions en allemand de deux projets de Recommandations OIML (n° 1/81, 2/82) ont été aussi publiées.

Le journal allemand sur le pesage « *Wägen + Dosieren* » a fait un rapport sur le séminaire OIML « Dispositifs électroniques incorporés dans les instruments de pesage et mesurage de volumes de liquides et de gaz », qui s'est tenu à Boras.

Standardisierung und Qualität, le journal de Amt für Standardisierung, Messwesen und Warenprüfung (ASMW, RDA), donne régulièrement des rapports détaillés sur la participation de la RDA dans les activités de l'OIML (n° 2/81 et 5/82), et sur des réunions de l'OIML (n° 2/81, 6/81, 6/82). Un article sur l'application des Recommandations OIML est paru dans le n° 7/81.

Le journal *Feingerätetechnik* (11'1982) a fait un reportage sur la réunion du SP 21 qui s'est tenue en 1982.

The *Review,* la revue de l'Institute of Trading Standards d'Australie, a publié un compte rendu de la 6e Conférence Internationale de Métrologie Légale (n° 3/1981) et des travaux des Secrétariats OIML (n° 6/81 et 6/82). L'approbation de modèle des instruments de pesage électromécaniques (une communication au Séminaire OIML à Boras) ainsi que le Système de Certification OIML étaient les sujets de deux articles publiés dans le n° 6/82 de cette même revue.

Consensus, le journal du Conseil Canadien des Normes, a publié un sommaire des activités de l'OIML à l'occasion de l'adhésion du Canada à l'Organisation. Un prospectus sur le même sujet a été publié par le Ministère de la Consommation et des Corporations, Canada.

NBS Special Publications 629 et 645, qui sont les rapports de la 66e et 67e Conférence Nationale des Poids et Mesures 1981 et 1982 (USA) font référence, à plusieurs reprises, aux activités de l'OIML, entre autres à propos de la réglementation des préemballés. Des rapports sur notre Organisation et sur la participation des USA sont aussi inclus.

Metrovisie, le journal de Dienst van het IJkwezen (Pays-Bas), mentionne les événements OIML dans la rubrique des nouvelles internationales. Les réunions de trois Secrétariats (n° 3/81, 5/81), le sigle OIML (n° 4/81) et le Séminaire à Boras (n° 5/81) ont été signalés.

Normalizacja, le bulletin du Comité Polonais de Normalisation, Mesures et Qualité, avait débattu la nouvelle version de la Recommandation Internationale n° 28 dans son n° 3/82 et a publié un article sur les travaux menés dans l'Organisation à propos de la certification des instruments de mesure (n° 10/82).

Československa Standardizace, la revue de l'Office de Normalisation et des Mesures de la Tchécoslovaquie (UNM), publiait dans le n° 12/1982 une description générale de notre Organisation, basée sur la « brochure bleue » bien connue, disponible au BIML.

Izmeritel'naya Teknika, le journal de mesures du Gosstandart (Union Soviétique), dans son n° 7/81, faisait un rapport sur la réunion du SP 31. Un rapport sur l'activité internationale de l'Institut Mendeleev a été publié dans le n° 12/82 du Journal *Metrologicheskaya Slushba SSSR* (Service de Métrologie de l'URSS). Dans la collection d'articles « *Coopération internationale dans le domaine de métrologie* » (Editions Standards, Moscou, 1982) les activités de l'OIML sont incluses.

Metrologia, édité par le Service National de Métrologie Légale du Venezuela, publia la traduction espagnole d'une partie du Vocabulaire de Métrologie Légale dans son n° 1/81. L'article du Président du CIML, M. K. BIRKELAND, sur les caractéristiques du développement de la métrologie est paru dans le n° 4/82.

Glasnik, le journal officiel du Bureau Fédéral des Mesures et Métaux Précieux de Yougoslavie, a publié la nouvelle liste des Recommandations Internationales et Documents Internationaux adoptés par la Conférence, dans les n° 4, 5 et 6/82.

Ces rapports et articles sont utiles pour la compréhension et l'utilisation des résultats de l'effort collectif des Etats Membres de notre Organisation.

Ferenc PETIK.

ECHOES of OIML ACTIVITIES in the TECHNICAL PRESS

The BIML Documentation Centre regularly receives various journals in the field of metrology. Some of these frequently report on the work of our Organization. In the following a brief survey of such information published in the years 1981 and 1982 is given.

Standardization, the bulletin of the Arab Organization for Standardization and Metrology (ASMO) published an article on weights and measures control (n° 3/1981), which was followed by a general description of our Organization (n° 4/1981). Standardization published the BIML report on the national implementation of OIML Recommendations (n° 1/1982).

Carta metrologica, the journal of the Sistema Interamericano de Metrologia (SIM) published a paper by Mr A. THULIN on the harmonization of pattern approval (n° 3). The Book Review in n° 4 discusses the BIML publication « Suppliers of verification equipment » and the Spanish version of the Vocabulary of Legal Metrology.

PTB-Mitteilungen, the journal of the Physikalisch-Technische Bundesanstalt (FRG) regularly covers most OIML events. A paper by Mr B. ATHANE on 25 years of OIML, on FRG participation and on the role of Prof. MUHE, was published in n° 1/81. Seven meetings of OIML Secretariats were reported in details (n° 2, 3, 5/81, 1, 2, 6/82). The German translation of two OIML draft Recommendations (n° 1/81, 2/82) also appeared.

The German journal on weighing « *Wägen + Dosieren* » gave an account on the OIML Seminar « Electronic devices incorporated in weighing and gas volume measuring instruments » in Boras.

Standardisierung und Qualität, the journal of the Amt für Standardisierung, Messwesen und Warenprüfung (ASMW, German Democratic Republic) gives detailed reports on the participation of GDR in OIML activities (n° 2/81, n° 5/82) and on OIML meetings (n° 2/81, 6/81, 6/82). A paper on the implementation of OIML Recommendations was published in n° 7/81.

The journal *Feingerätetechnik* (n° 11/1982) reported on the 1982 meeting of SP 21.

The *Review* of the Australian Institute of Trading Standards gave an account of the 6th International Conference of Legal Metrology (n° 3/81), of the work of OIML Secretariats and on OIML meetings (n° 6/81, 6/82). The pattern approval of electromechanical weighing machines (a lecture given at the OIML Seminar in Boras) and the OIML Certification System were the subjects of two articles published in n° 6/82 of this same Review.

Consensus, the journal of the Standards Council of Canada published a survey of OIML activities on the occasion of Canada joining our Organization. A leaflet with similar subject was published by Consumer and Corporate Affairs, Canada.

NBS Special Publications 629 and 645, Reports of the 66th and 67th National Conferences on Weights and Measures 1981 and 1982 (USA) make repeated reference to OIML activities, among others in connection with the regulations on prepacks. Reports on our Organization and on USA participation were also included.

Metrovisie, the journal of Dienst van het IJkwezen (Netherlands) reports on OIML events in the international news section. They reported on the meetings of three Secretariats (n° 3/81, 5/81), on the OIML logo (n° 4/81) and on the Seminar in Boras (n° 5/81).

Normalizacja, the review of the Polish Committee of Standardization, Measures and Quality discussed the new version of RI 28 in the issue n° 3/82 and published an article on the work in OIML connected with the certification of measuring instruments (n° 10/82).

Československa Standardizace, the review of the Czechoslovak Office of Standardization and Measurement (UNM) published in n° 12/1982 a general description of our Organization, based on the well-known « blue leaflet » available from BIML.

Izmeritel'naya Teknika, the journal of measurement techniques of Gosstandart (Soviet Union) reported on the meeting of SP 31 in n° 7/81. A report on the international activities of the Mendeleew Institute was published in n° 12/82 of the journal *Metrologicheskaya Slushba SSSR* (Metrological Service of the USSR). The collection of papers on « *International Cooperation in the field of Metrology* » (Publishing House of Standards, Moscow, 1982) is also discussing OIML activities.

Metrologia, the review of the National Service of Legal Metrology of Venezuela published a Spanish translation of a part of the Vocabulary of Legal Metrology (n° 1/81). The paper of the CIML President, Mr K. BIRKELAND, on the characteristics of the development of metrology was published in n° 4/82.

Glasnik, the journal of the Federal Bureau of Measures and Precious Metals of Yugoslavia published the new list of International Recommendations and International Documents adopted by the Conference in n° 4, 5 and 6/82.

These reports and articles on OIML help to comprehend and utilise the results of the collective work of Member States of our Organization.

Ferenc PETIK.

INFORMATIONS

REPUBLIQUE FEDERALE D'ALLEMAGNE

Nous tenons à féliciter Monsieur le Professeur Helmut MOSER à l'occasion de son 80e anniversaire qui a eu lieu le 17 août dernier.

M. MOSER, éminent expert en thermométrie et vice-président de la Physikalisch-Technische Bundesanstalt (RFA), a été un membre très actif au sein du CIML de 1961 à 1970 et du Conseil de la Présidence.

Depuis sa retraite en 1970, il fait partie des membres d'honneur de notre Organisation.

LITTERATURE

L'éditeur de l'ouvrage de Monsieur Jean TRAMUS « Notions élémentaires sur les instruments de mesure », traitant la théorie et la pratique des instruments de pesage, nous signale qu'il reste encore environ 30 exemplaires vendus au prix de 160 francs-français les deux tomes.

S'adresser à Elysées-Copies
7, rue d'Artois
75008 PARIS

INFORMATION

FEDERAL REPUBLIC OF GERMANY

We like to congratulate Professor Helmut MOSER on his 80th anniversary which took place on 17 August this year.

Mr MOSER, well-known expert in thermometry and vice-president of the Physikalisch-Technische Bundesanstalt (FRG), was a very active member of CIML from 1961 to 1970 and member of the Presidential Council.

Since his retirement in 1970 he is honorary member of our Organization.

LITERATURE

The editor of the books of Mr Jean TRAMUS « Notions élémentaires sur les instruments de mesure » concerning the theory and practice of weighing machines has indicated that he has still about 30 copies which are sold at 160 french-francs for the two volumes.

Write to Elysées-Copies
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REUNIONS

	Groupes de travail	Dates	Lieux
SP 11 - Sr 3	Balances manométriques	8-10 nov. 1983	BRATISLAVA TCHECOSLOVAQUIE
SP 27	Principes généraux de l'utilisation des matériaux de référence en métrologie légale	28 nov.-2 déc. 1983	MOSCOU U.R.S.S.
SP 5 - Sr 15	Compteurs et ensembles de mesure de liquides cryogéniques	5-7 déc. 1983	PARIS, BIML
SP 2 - Sr 4	Reconnaissance internationale des contrôles et des marques de vérification	29-30 mars 1984	PARIS, BIML
SP 31	Enseignement de la métrologie	2-3-(4) avril 1984	PARIS FRANCE
SP 22	Principes du contrôle métrologique	9-13 avril 1984	COBLENCE R.F. d'ALLEMAGNE
SP 22 - Sr 3	Principes selon lesquels l'essai de modèle doit être effectué		
SP 22 - Sr 4	Principes de la vérification primitive et ultérieure et de l'étalonnage des instruments		
SP 22 - Sr 6	Principes permettant d'assurer l'efficacité du contrôle métrologique		
SP 17	Mesure des pollutions	7-11 mai 1984	PARIS, BIML
SP 17 - Sr 2	Mesure des pollutions de l'eau		
SP 17 - Sr 4	Mesure des pesticides et des substances toxiques		
SP 7 - Sr 4	Instruments de pesage à fonctionnement non automatique	mai-juin 1984 *(provisoire)*	
SP 2 - Sr 6	Instruments électroniques.	juin 1984 *(provisoire)*	DELFT PAYS-BAS
SP 7 - Sr 2	Généralités. Dispositifs électroniques		
SP 20 - Sr 1	Contenu informatif de l'étiquetage	5-8 juin 1984	BERNE SUISSE
SP 20 - Sr 2	Vérification des quantités contenues dans les emballages		
SP 5 - Sr 16	Compteurs d'eau	9-10 mai 1984 *(provisoire)*	ROYAUME-UNI

Conseil de la Présidence	6-8 février 1984	LENINGRAD U.R.S.S.
Conseil de Développement	(4)-5-6 avril 1984	PARIS, BIML
Septième Conférence Internationale de Métrologie Légale	1-5 oct. 1984	HELSINKI FINLANDE
Vingtième Réunion du Comité International de Métrologie Légale		

CENTRE DE DOCUMENTATION

Documents reçus au cours du 3e trimestre 1983

BUREAU INTERNATIONAL DES POIDS ET MESURES — BIPM

Comité Consultatif des Unités
8e Session, 8 et 9 juin 1982

Comité Consultatif de Thermométrie
14e Session, 30, 31 mars et 1er avril 1982

Comité Consultatif pour la Définition du Mètre
7e Session, 3 et 4 juin 1982

COMMONWEALTH SCIENCE COUNCIL — CSC

Commonwealth Secretariat

CSC (82) MS-18 : Report of a Workshop on Metrology in Quality Assurance - Kuala Lumpur, 27-30 April 1982

CSC (82) MS-20 : Report on the Regional Workshop on Metrology for Developing Countries - Sydney, 30 August - 10 September 1982 :
Volume 1 - Second review meeting of the programme

CSC (82) MS-21 : Report on the Regional Workshop on Metrology for Developing Countries - Sydney, 30 August - 10 September 1982 :
Volume 2 - Proceedings
Part 1 : General metrology
Part 2 : Mass Standards and Measurements
Part 3 : Length Standards and Measurements
Part 4 : Temperature Standards and Measurements
Part 5 : DC Electrical Standards and Measurements
Part 6 : AC Electrical Standards and Measurements

CANADA

Direction de la métrologie légale

Caractéristiques pour l'approbation des types des compteurs d'électricité, transformateurs de mesure et appareils auxiliaires (Avril 1983) fr. et ang.

DANEMARK

Industriministeriet/Statens Tekniske Provenaevn
Register over autoriserede laboratorier, 1983

National Agency of Technology
Description of the nine Industrial Promotion schemes, May 1983
Metrology in Denmark. An Introduction

Dantest
Act N° 173 of April 8, 1982 on Weights and Measures (Metrology) (in English)

ETATS-UNIS D'AMERIQUE

National Bureau of Standards

NBS Special Publication 250 - April 1983 : Calibration and related measurement services - Appendix, Fees for services

NBS Special Publication 649 - April 1983 : Directory of International and Regional Organizations Conducting Standards - Related Activities (A. Breitenberg)

NBS Handbook 117 - Dec. 1975 : Examination of Vapor-Measuring Devices for Liquefied Petroleum Gas (S. Hasko)

NBS Handbook 137 - Dec. 1980 : Examination of Distance Measuring Devices (S. Hasko)

URSS

Gosudarstvennyi Komitet SSSR po Standartam

Gosudarstvennyi Standarty SSSR, Ukazatel' : 1, 2, 3, 4-1983
Ukazatel' Normativno - Tehniceskaja Dokumentacija v oblasti metrologii, 1983
Informacionno-poiskovyj Tezaurus po Metrologii i izmeritel'noj tehnike, Moskva 1979

VENEZUELA

Servicio Nacional de Metrologia

Ley de Metrologia (1-12-1980)

Resolucion mediante la cual se especifican las Unidades de Medida del sistema legal venezolano (30-4-1981)

Resolucion mediante la cual se determina que los productos que se vendan previamente envasados, etc. (25-6-1982)

Resolucion mediante la cual la Direction General de Tecnologia - Servicio Nacional de Metrologia lo referente a Tasas (21-10-1982)

Resolucion mediante la cual se especifican los instrumentos de pesar destinados a medir la masa de los cuerpos (8-5-1983)

RECOMMANDATIONS INTERNATIONALES

17 — Manomètres, vacuomètres, manovacuomètres indicateurs (instruments usuels)
Indicating pressure gauges, vacuum gauges and pressure-vacuum gauges (ordinary instruments)

18 — Pyromètres optiques à filament disparaissant
Optical pyrometers of the disappearing filament type

19 — Manomètres, vacuomètres, manovacuomètres enregistreurs (instruments usuels)
Recording pressure gauges, vacuum gauges, and pressure-vacuum gauges (ordinary instruments)

20 — Poids des classes de précision E_1 E_2 F_1 F_2 M_1 de 50 kg à 1 mg
Weights of accuracy classes E_1 E_2 F_1 F_2 M_1 from 50 kg to 1 mg

21 — Taximètres
Taximeters

22 — Tables alcoométriques internationales
International alcoholometric tables

23 — Manomètres pour pneumatiques de véhicules automobiles
Tyre pressure gauges for motor vehicles

24 — Mètre étalon rigide pour agents de vérification
Standard one metre bar for verification officers

25 — Poids étalons pour agents de vérification
Standard weights for verification officers

26 — Seringues médicales
Medical syringes

27 — Compteurs de volume de liquides (autres que l'eau). Dispositifs complémentaires
Volume meters for liquids (other than water). Ancillary equipment

28 — Réglementation technique des instruments de pesage à fonctionnement non-automatique
Technical regulations for non-automatic weighing machines

29 — Mesures de capacité de service
Capacity serving measures

30 — Mesures de longueur à bouts plans (Calibres à bouts plans ou cales-étalons)
End standards of length (gauge blocks)

31 — Compteurs de volume de gaz à parois déformables
Diaphragm gas meters

32 — Compteurs de volume de gaz à pistons rotatifs et compteurs de volume de gaz à turbine
Rotary piston gas meters and turbine gas meters

33 — Valeur conventionnelle du résultat des pesées dans l'air
Conventional value of the result of weighing in air

34 — Classes de précision des instruments de mesurage
Accuracy classes of measuring instruments

35 — Mesures matérialisées de longueur pour usages généraux
Material measures of length for general use

36 — Vérification des pénétrateurs des machines d'essai de dureté
Verification of indenters for hardness testing machines

37 — Vérification des machines d'essai de dureté (système Brinell)
Verification of hardness testing machines (Brinell system)

38 — Vérification des machines d'essai de dureté (système Vickers)
Verification of hardness testing machines (Vickers system)

39 — Vérification des machines d'essai de dureté (système Rockwell B, F, T - C, A, N)
Verification of hardness testing machines (Rockwell systems B, F, T - C, A, N)

40 — Pipettes graduées étalons pour agents de vérification
Standard graduated pipettes for verification officers

41 — Burettes étalons pour agents de vérification
Standard burettes for verification officers

42 — Poinçons de métal pour agents de vérification
Metal stamps for verification officers

43 — Fioles étalons graduées en verre pour agents de vérification
Standard graduated glass flasks for verification officers

44 — Alcoomètres et aréomètres pour alcool
Alcoholometers and alcohol hydrometers

45 — Tonneaux et futailles
Casks and barrels

46 — Compteurs d'énergie électrique active à branchement direct (de la classe 2)
Active electrical energy meters for direct connection (class 2)

47 — Poids étalons pour le contrôle des instruments de pesage de portée élevée
Standard weights for testing of high capacity weighing machines

48 — Lampes à ruban de tungstène pour l'étalonnage des pyromètres optiques
Tungsten ribbon lamps for calibration of optical pyrometers

49 — Compteurs d'eau (destinés au mesurage de l'eau froide)
Water meters (intended for the metering of cold water)

50 — Instruments de pesage totalisateurs continus à fonctionnement automatique
Continuous totalising automatic weighing machines

51 — Trieuses pondérales de contrôle et trieuses pondérales de classement
Checkweighing and weight grading machines

52 — Poids hexagonaux. Classe de précision ordinaire de 100 g à 50 kg
Hexagonal weights. Ordinary accuracy class, from 100 g to 50 kg

53 — Caractéristiques métrologiques des éléments récepteurs élastiques utilisés pour le mesurage de la pression. Méthodes de leur détermination
Metrological characteristics of elastic sensing elements used for measurement of pressure. Determination methods

54 — Echelle de pH des solutions aqueuses
pH scale for aqueous solutions

55 — Compteurs de vitesse, compteurs mécaniques de distances et chronotachygraphes des véhicules automobiles - Réglementation métrologique
Speedometers, mechanical odometers and chronotachographs for motor vehicles. Metrological regulations

56 — Solutions-étalons reproduisant la conductivité des électrolytes
Standard solutions reproducing the conductivity of electrolytes

57 — Ensembles de mesurage de liquides autres que l'eau équipés de compteurs de volumes. Dispositions générales
Measuring assemblies for liquids other than water fitted with volume meters. General provisions.

*58 — Sonomètres
Sound level meters

*59 — Humidimètres pour grains de céréales et graines oléagineuses
Moisture meters for cereal grains and oilseeds

* Projet adopté par le CIML - mai 1983.
A sanctionner par la Septième Conférence - octobre 1984.
Draft adopted by the CIML - May 1983.
To be sanctioned by the Seventh Conference - October 1984.

DOCUMENTS INTERNATIONAUX

D.I. N°

1 — Loi de métrologie
Law on metrology

2 — Unités de mesure légales
Legal units of measurement

3 — Qualification légale des instruments de mesurage
Legal qualification of measuring instruments

4 — Conditions d'installation et de stockage des compteurs d'eau froide
Installation and storage conditions for cold water meters

5 — Principes pour l'établissement des schémas de hiérarchie des instruments de mesure
Principles for the establishment of hierarchy schemes for measuring instruments

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Note — Recommandations internationales et Documents internationaux peuvent être acquis au
International Recommendations and International Documents may be purchased from
Bureau International de Métrologie Légale, 11, rue Turgot, 75009 PARIS.

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

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Correspondance adressée à
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Sous-direction de la Métrologie
Ministère des Industries Légères
Rue Ahmed Bey
Immeuble Colisée
ALGER

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