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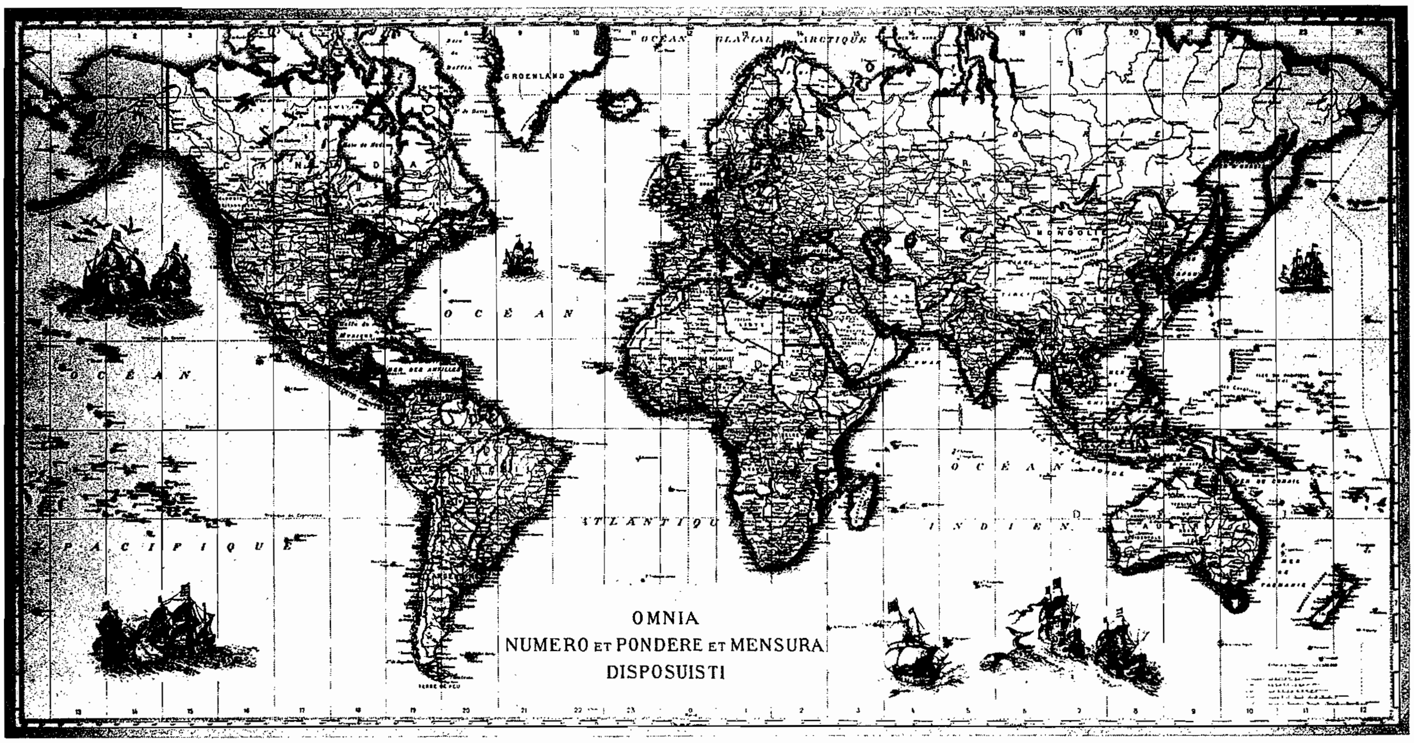

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ALLEMAGNE

DEVELOPMENT AND TASKS OF THE PHYSIKALISCH-TECHNISCHE BUNDESANSTALT (PTB)

by **H.G. GILLAR** and **M. KOCHSIEK**

Metrology and verification in Germany

In all states of the world, a highly developed metrology system is one of the most important prerequisites for the protection of health, the environmental protection, the protection of labour and the protection of the individual's legal status in all spheres of life; it is also a precondition for the efficient functioning of trade and industry, science and technology.

Diverse organizational forms and structures of the metrology system have developed worldwide. In a general sense, metrology can be divided into three fields which can be described by specific organizational structures and tasks. The fields concerned are the following:

- scientific,
- legal,
- industrial metrology.

Work in these three fields is closely interrelated, the fields are even mutually dependent.

Scientific metrology comprises all research work concerned with

- the International System of Units
- the units of measurement and their standards (realization, reproduction, conservation and dissemination)
- the measurements (methods, performance, determination of the accuracy of measurement)
- the measuring instruments (properties, sensors, etc.)
- the operators (education and training, abilities, etc.).

At an international level, there are state institutes for science and technology in all industrial countries - like the PTB in Germany - whose main field of work is that of scientific metrology. University institutes, research institutes and industry also contribute to the work done in this field.

In Germany, the basic principles of legal metrology have been stipulated by the Units Act and the Verification Act, including the relevant implementing ordinances and additional regulations. The physical and technical basis of the units to be applied in official and commercial transactions is today's International System of Units (SI) developed from the metric system.

The Verification Act is the legal basis for

- the prescription of mandatory verification
- the pattern approval and verification of measuring instruments and other tests to be carried out on them
- the accreditation of test centers for certain measuring instruments and the appointment of the managerial staff
- the metrological supervision
- regulations for prepackages and capacity serving measures.

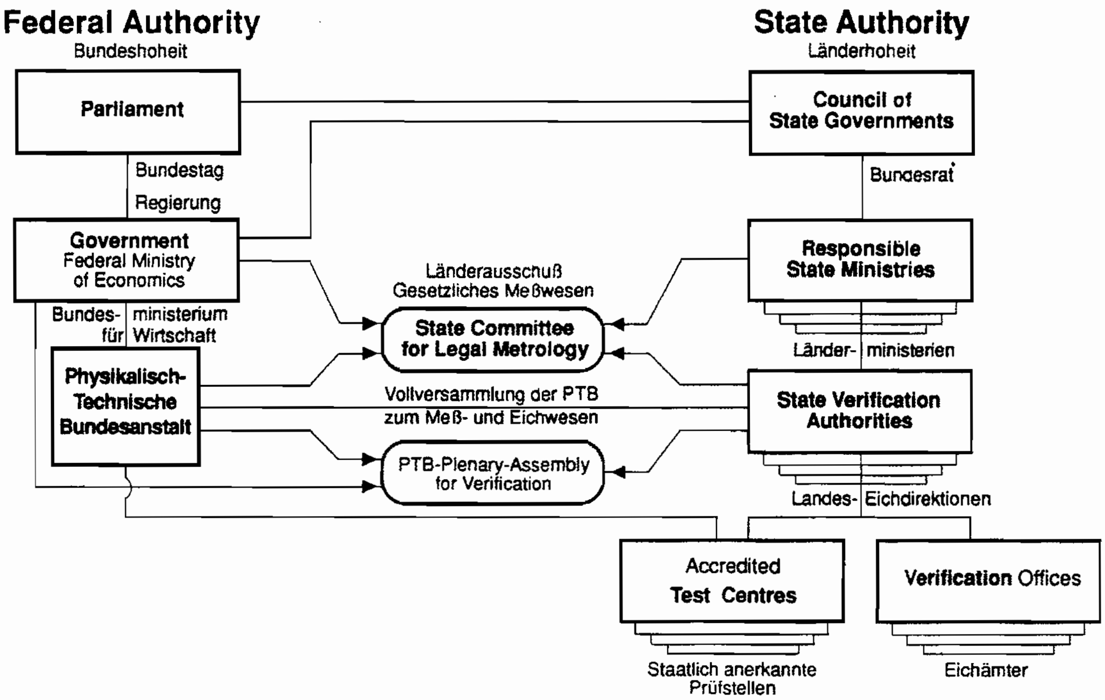


Fig. 1 – Status and cooperation of the institutions concerned with legal metrology in Germany.

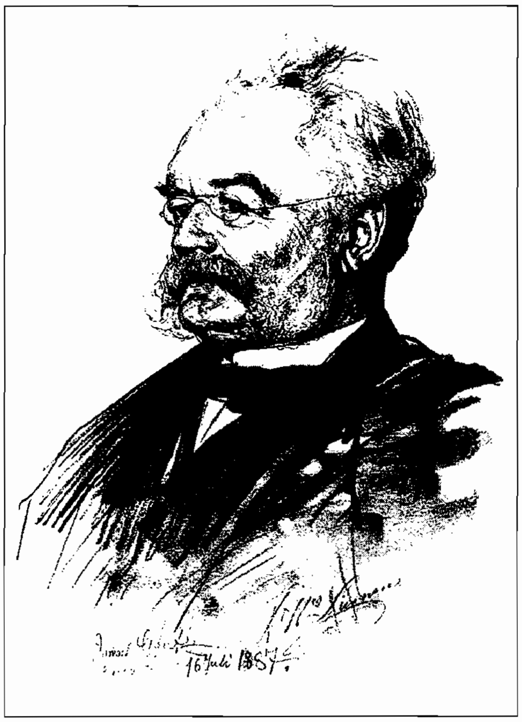


Fig. 2 – Werner von Siemens, one of the founders of the PTR and Hermann von Helmholtz, its first president.

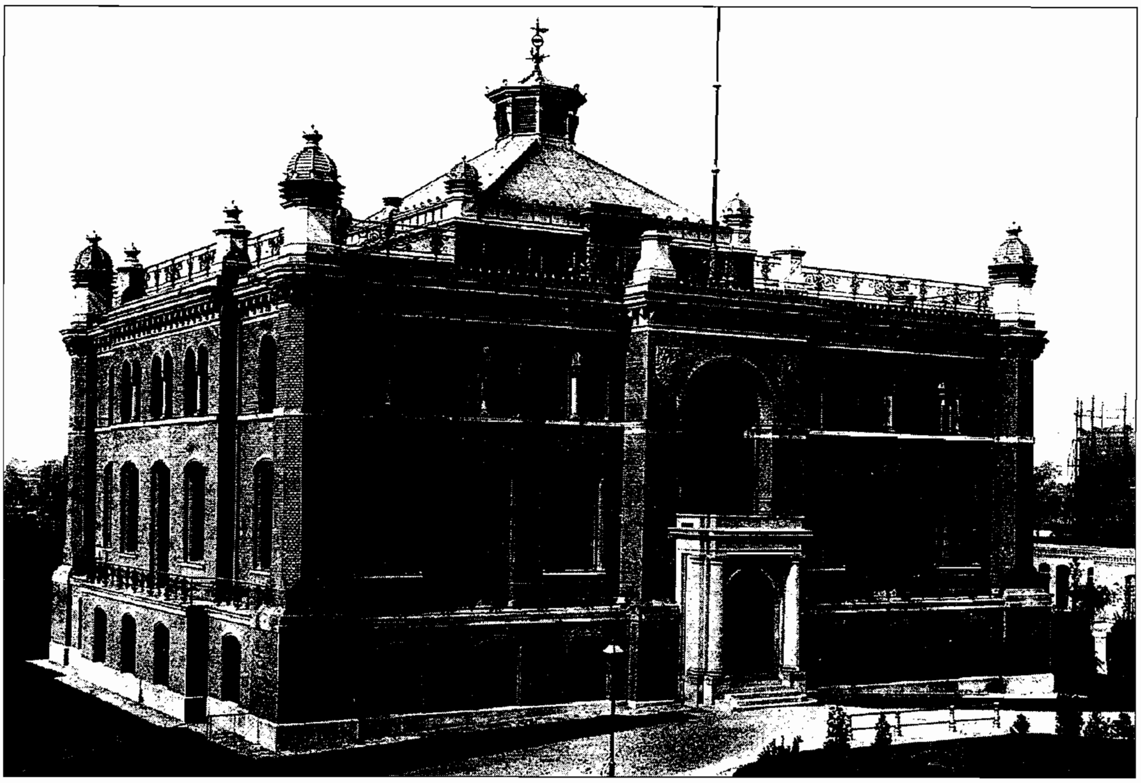


Fig. 3 – The Observatory, the PTB's oldest laboratory building in Berlin (constructed in 1890).

Uniform legislation throughout the Federal Republic for the fields of metrology and verification is ensured by the "Bundestag" (Lower House of the German Parliament) and the Federal Council, the upper House of Parliament. Implementing ordinances are issued by the Federal Government, in special cases by the Federal Minister of Economics.

Responsibilities for the fields of metrology and verification are shared by the Federal Government and the individual federal states. The leading principle is that the State is acting directly (by state controls, tests etc.) in the field of metrology only in those areas of public life where it must guarantee the correctness of measurements and which are of public interest. As a result of laws and regulations in metrology the PTB has become the highest technical authority for metrology in Germany, in addition to its being the national institute of science and technology.

Verifications of measuring instruments are carried out in verification offices the responsibility for which lies with the federal states. Instruments for measuring water, gas, heat and electricity may also be certified by state-approved test centers installed in a public utility or at the manufacturer. (Fig. 1).

Industrial metrology is governed by the needs of industry, and details are clarified in cooperation with the user and/or consumer. In Germany, like in almost all industrial countries, industry's great needs for calibrations are satisfied by a calibration service, the DKD (Deutscher Kalibrierdienst).

Historical review

The Physikalisch-Technische Bundesanstalt (PTB) is the successor to the Physikalisch-Technische Reichsanstalt (PTR) founded in Berlin in the year 1887. It is the world's oldest national institute of science and technology. Its most important initiator and one of its founders was the industrialist Werner von Siemens. Under the direction of its first president, Hermann von Helmholtz, the PTB took up work in October 1887 (Fig. 2).

For the first time, a national institute (Fig. 3) was established in which scientists could perform research work without the obligation to teach and independent of commissions on behalf of industry. It was recognized that correct measuring is of fundamental importance to technology, trade and industry, and that a neutral national institute must be entrusted with the development of and research work in the field of precision metrology. After its example, the National Physical Laboratory was founded in England in 1900, and in the year 1901 the National Bureau of Standards was established in the USA.

The PTR carried out basic physical research, particularly in the field of metrology, and tested measuring instruments for their accuracy and construction. With the realization of the electrical units and the supervision of measuring instruments for electrical quantities, legal tasks were assigned to it for the first time in 1898. In 1923, the "Reichsanstalt für Maß und Gewicht" (Weights and Measures Office) was incorporated with the PTR. Thus the PTR was responsible for all legal units and became the supervisory authority of the verification and test offices.

Besides the performance of legal tasks, large-scale basic research was carried out leading to numerous important discoveries. The names of famous scientists and Nobel prize winners, e.g. Friedrich Kohlrausch, Emil Warburg, Walter Nernst, Friedrich Paschen, Johannes Stark, Wilhelm Wien, Hans Geiger, Walter Bothe or Walther Meißner stand for highlights of scientific work.

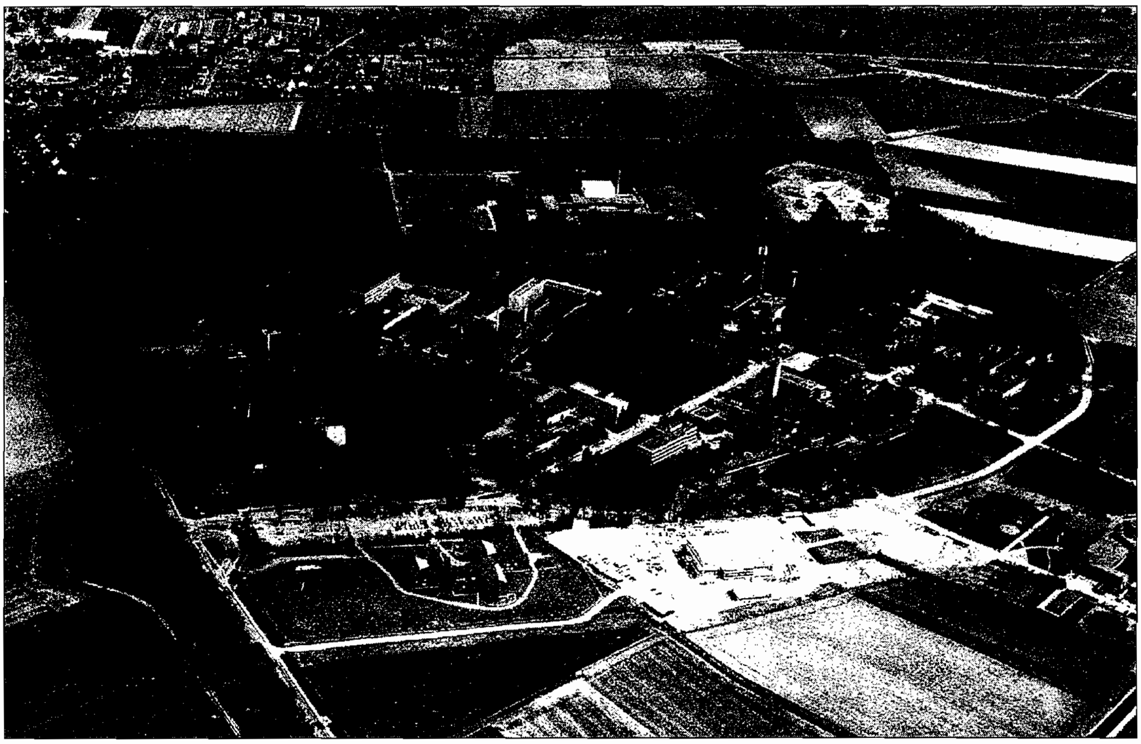


Fig. 4 – Headquarters of the Physikalisch-Technische Bundesanstalt in Braunschweig.

In 1945, when the German Reich collapsed, most of the laboratories had already been moved to different sites in the Germany of those days, those in Berlin had been destroyed. The laboratories which had been moved to West Germany were concentrated in Braunschweig and, in 1950, under the name Physikalisch-Technische Bundesanstalt, became the metrological state institute of the Federal Republic of Germany (Fig. 4). The institute which had been set up in the rebuilt buildings of the old PTR in West Berlin was affiliated to the Physikalisch-Technische Bundesanstalt in Braunschweig as the Berlin Institute in 1953.

From the laboratories of the PTR which had been moved to Thuringia, the "Deutsches Amt für Maße und Gewichte" (DAMG, German Weights and Measures Office) came into being in 1946 on the territory of the Soviet-occupied zone. Basis for this was an order of the Soviet military administration. The DAMG which also has its origin in the PTR existed until 1964. After several amalgamations and restructurings, the "Amt for Standardisierung, Meßwesen und Warenprüfung" (ASMW, Agency for Standardization, Metrology and Commodities Testing) came into being in the former GDR in 1973.

The headquarters of the ASMW were in Berlin-Friedrichshagen. In addition to the tasks of standardization and commodities testing, the ASMW was entrusted with all official tasks as far as metrology in the GDR was concerned, to ensure the uniformity of measures and the correctness of measurements. As a result of the unification of the two German states in 1990, the ASMW ceased to exist and the PTB assumed responsibility also for the territory of the five new federal states. With the taking-over of a large percentage of the ASMW staff and establishment of a new office in Berlin-Friedrichshagen, the metrology section of the ASMW was incorporated into the PTB, resulting in an enlarged PTB with a functional organizational structure and an appropriate distribution of functions as a prerequisite of efficient work.

The PTB's tasks and main fields of work

As the national institute of science and technology and the highest technical authority for metrology and certain sectors of safety engineering, the PTB must create the foundations of scientific, technical and legal metrology and exercise control functions in the fields of metrology and safety engineering.

The PTB realizes the legal units in metrology ; it is engaged in research and development work, in particular in the field of metrology, carries out tests on measuring instruments and installations and cooperates in technical committees and legislative bodies which are concerned with questions of metrology, standardization, testing, quality assurance and safety engineering.

The knowledge of metrology and the PTB's experience in this field are of benefit to the natural sciences, as a highly developed metrology system is a precondition for successful experimental research work. Knowledge and the fruits of experience are also passed on to industry, for which metrology of the highest precision is the prerequisite for mastering modern technologies.

In accordance with laws and regulations, a great number of tasks have been assigned to the PTB (Fig. 5).

The realization of the units as the foundation of the whole metrological system is the PTB's basic task. This task requires a measuring technique of the highest precision and extensive research work to allow the units to be realized with the highest possible accuracy, always making use of the most up-to-date results of research in physics.

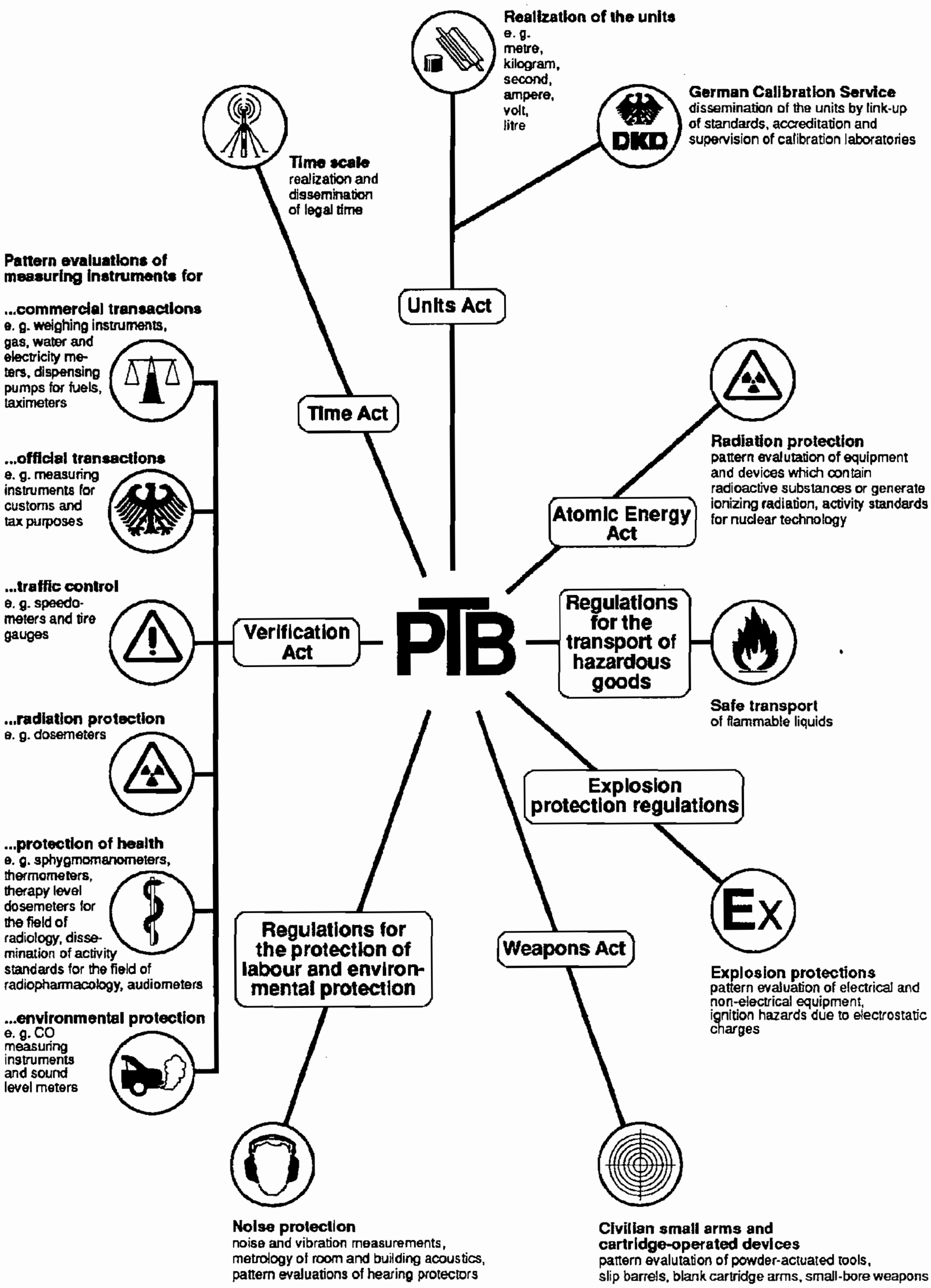


Fig. 5 – The legal tasks of the PTB

Fig. 6 – The CS1 and CS2 atomic clocks, Germany's national time standard.

The PTB must not only realize and disseminate the unit of time, the second, but also - in accordance with the Time Act - the legal time for the Federal Republic of Germany, i.e. the lapse of time. The PTB time scale is determined on the basis of atomic clocks (Fig. 6) and emitted in continuous operation all over Europe via the long-wave transmitter DCF 77.

According to the Verification Act the PTB is obliged to carry out type tests and approve the patterns of measuring instruments for verification. In addition, it must test the standard instruments and auxiliary testing devices of the verification authorities and state-approved test centres. It cooperates in national and international organizations and committees dealing with questions of metrology, verification and standardization. This work also covers cooperation in the drawing-up of drafts of laws and regulations. The PTB's "Plenary Assembly for verification affairs" and the "Legal metrology" committee comprising representatives of the federal states draw up recommendations for adapting and further developing the regulations in the field of legal metrology.

Tasks in the field of medical metrology and radiation and environmental protection have increasingly gained in importance. These fields are of great importance because physical processes such as radioactive radiation or noise influence man's environment to an ever increasing extent and because physical equipment is increasingly used for procedures of both medical diagnosis and therapy. If the approval of measuring instruments has been prescribed for these fields, pattern evaluations are made and the relevant regulations elaborated in cooperation with other authorities and industry.

Macroscopic physical quantities can, via fundamental constants, be referred to quantum measures which, according to today's knowledge of physics, are independent of place and time, contrary to the macroscopic quantities themselves. The aim therefore is to realize the units in metrology by fundamental constants and to arrive at realizations of the units which are independent of external conditions. In addition, the fundamental constants allow an insight into the structure of physical phenomena and make connections between their different ranges possible.

The determination of the values of the fundamental constants with the highest possible accuracy is therefore of the greatest importance for the whole field of physics and in particular for metrology. The PTB carries out intensive experimental and theoretical work in this field and has made the first important contributions to it with the aim of determining

- Avogadro's constant,
- the gravitation constant,
- the gyromagnetic coefficient of the proton,
- the magnetic flux quantum and
- the quotient of Planck's constant and neutron mass.

Various materials are used as material measures and reference materials in science, industry and trade. This requires as exact a knowledge of the physical properties as possible. The PTB designs precision devices for measuring the physical parameters and carries out investigations into the determination of electric, magnetic, thermal and optical properties of solid matter, the determination of the variables of state, e.g. the density, the viscosity and the surface tension of liquids, the humidity of gases as well as into the neutron scattering on solid matter.

An exact knowledge of the atomic and nuclear material properties is of particular importance in nuclear medicine, nuclear engineering and environmental protection. Characteristic data of radionuclides and transport quantities, such as range, backscattering coefficient and slowing-down length of ionizing rays (photons, electrons, neutrons) are determined at the PTB. In the case of neutrons, the effective cross sections are also measured. Knowledge of these data is the basis of radiation dosimetry.

In many fields of industrial metrology the PTB makes measurement technology of the highest precision accessible to industry and thus makes a significant contribution to the preservation of its competitive capacity. In the sphere of the industrial measuring technique for length and area, for example, the Bundesanstalt carries out precision measurements of the dimensions, shape and position of machine elements, gauges and other bodies. A highly developed precision metrology is a prerequisite for precision manufacture, which in turn is the basis of the manufacture of interchangeable parts without which an economically efficient production would no longer be possible today. However, new technologies which have been developed in the fields of electricity, optics and acoustics also require new measuring methods and instruments. The magnetic signal storage techniques used to a great extent in commerce and administration for which reliability and interchangeability are important prerequisities, are an example of this. Here, the PTB makes an important contribution to the development of relevant measuring methods.

Safety engineering serves the protection of employees (safety provisions for workers) and of the population (protection of such persons who are not involved) against explosions of flammable gases, vapours, mists and dusts and it also serves the protection of persons in the handling of civil firearms and ammunition. The Bundesanstalt determines the threshold values of the physical parameters, non-compliance with which constitutes a hazard, and it carries out safety tests of facilities, instruments and safety equipment used for the handling of dangerous substances. The pattern evaluations and the approvals of the instruments, facilities and equipment are made within the scope of statutory rules and regulations or of provisions of trade cooperative associations. The tests guarantee a minimum safety standard by specifying certain constructional features and operating conditions of the devices which may constitute a hazard.

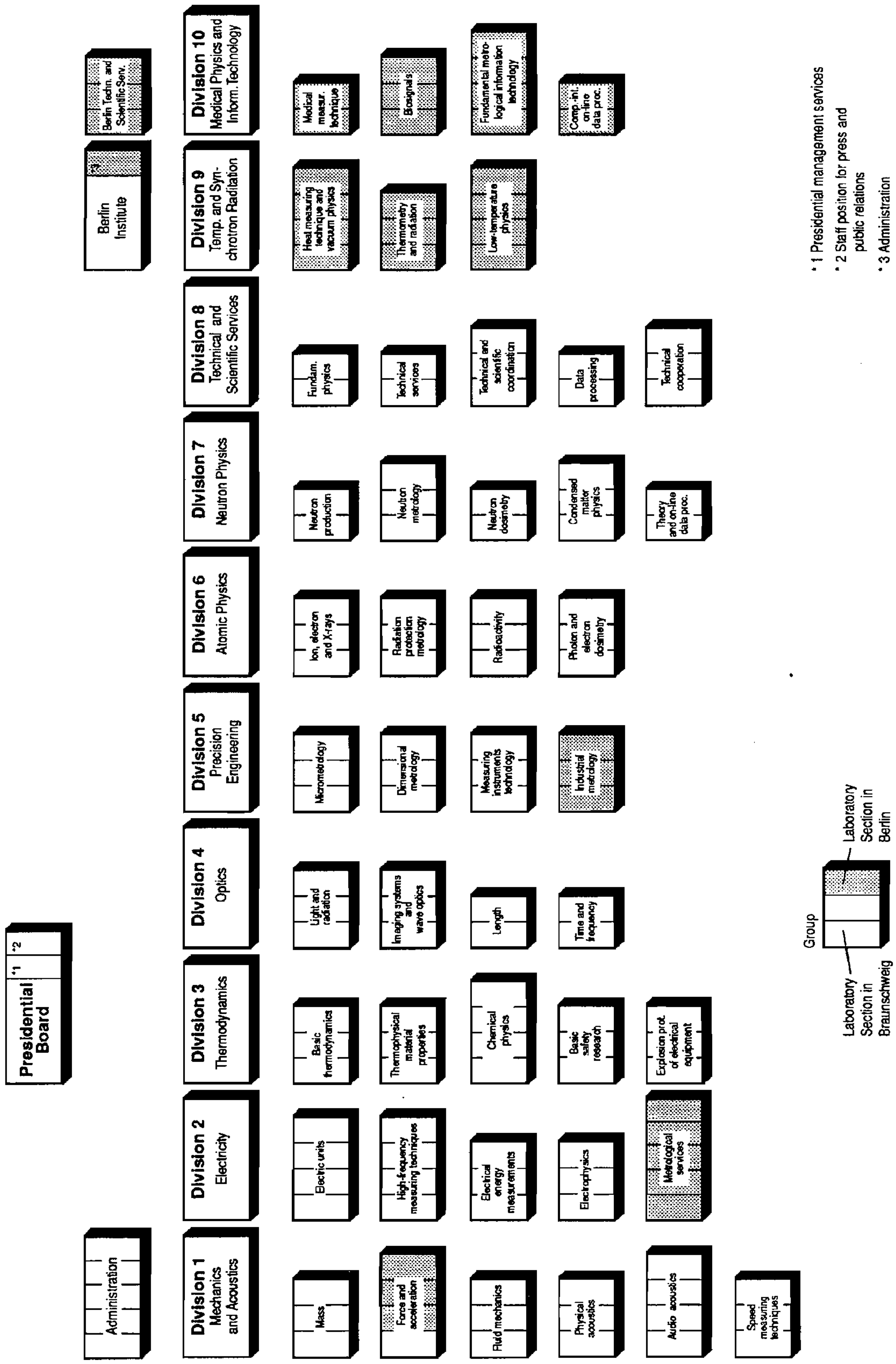


Fig. 7 – Simplified organisation chart of the PTB (as of 15-10-1991).

In addition, the PTB advises the authorities, trade cooperative associations and industry in the matter of safety engineering. This is done by means of expert opinions and discussions and by cooperation in technical committees which are entrusted with the establishment of safety regulations.

To enable the Bundesanstalt to carry out the relevant tests and to advise on questions of safety engineering, to make it possible to further the development of safety provisions for workers and the protection of the civil population, it is necessary that the Bundesanstalt engages in a program of intensive scientific work in the field of explosion protection. The formation, propagation and explosion of large clouds of explosive gas/air mixtures and their properties at higher pressures and temperatures, safety devices on tanks for flammable liquids, explosion protection of electrical equipment, are all investigated.

Industry is also strongly interested in having those instruments tested and calibrated which are not subject to the regulations of legal metrology, and in obtaining a certificate for these tests. This certificate has the significance of a quality mark and demonstrates that the device has been linked up with national standards of the highest precision and that it has specific metrological properties. These certificates are in demand to an ever increasing extent whithin the framework of quality assurance measures during manufacture and as a result of new provisions for product liability, and they are of great importance to industry in preserving its competitive capacity.

This task has been taken on by the "Deutscher Kalibrierdienst" (DKD, German Calibration Service) founded and operated by the state - represented by the Ministry of Economics and the PTB - and industry. The basic elements of the DKD are officially accredited calibrating laboratories and the state institute which disseminates the national standards is the PTB. Industrial laboratories and other institutes (universities, TÜV/Technical Control Board, technical authorities of the federal states) which, due to their trained personnel and equipment, are able to perform measurements with the required accuracy and whose standards have been linked up with the national standards of the PTB, are accredited as calibrating laboratories. Accreditation is granted by the PTB after the metrological efficiency of the laboratories in question and the formal prerequisites have been examined. The calibration laboratories then carry out the desired calibrations on the instruments submitted to them and issue a certificate containing the results. Neutrality is guaranteed, as the PTB supervises the laboratories and as the laboratories themselves are interested in preserving the credibility of the certificates granted on the market. Cooperation with other calibration services in Europe ensures the recognition of the certificates across borders. At present, there are about 90 accredited calibration centers for electrical and mechanical measurands, as well as for pressure, temperature and ionizing radiation. The PTB's metrological knowledge and the benefit of its experience are also passed on to industry via these calibrating laboratories.

Organization

The PTB comes under the auspices of the Federal Minister of Economics and has about 2 000 employees, approximately a quarter of whom are university educated. The Bundesanstalt consists of 10 divisions which are subdivided into groups and laboratories or sections (Fig. 7). Divisions 1 to 4 and 6 to 7 are technical divisions engaged in the main fields of physics. Work of Division 5 is orientated towards the needs of industry; it deals with questions of precision engineering. Division 8 comprises the groups furnishing technical and scientific services to the Bundesanstalt. The headquarters of the PTB with the presidential board and these divisions are in Braunschweig (Fig. 8). Divisions 9 and 10 handle special tasks in the fields of temperature, synchrotron radiation, medical physics and information technology. They comprise more than 400 employees and are situated in Berlin (Charlottenburg and Friedrichshagen) (Fig. 9).

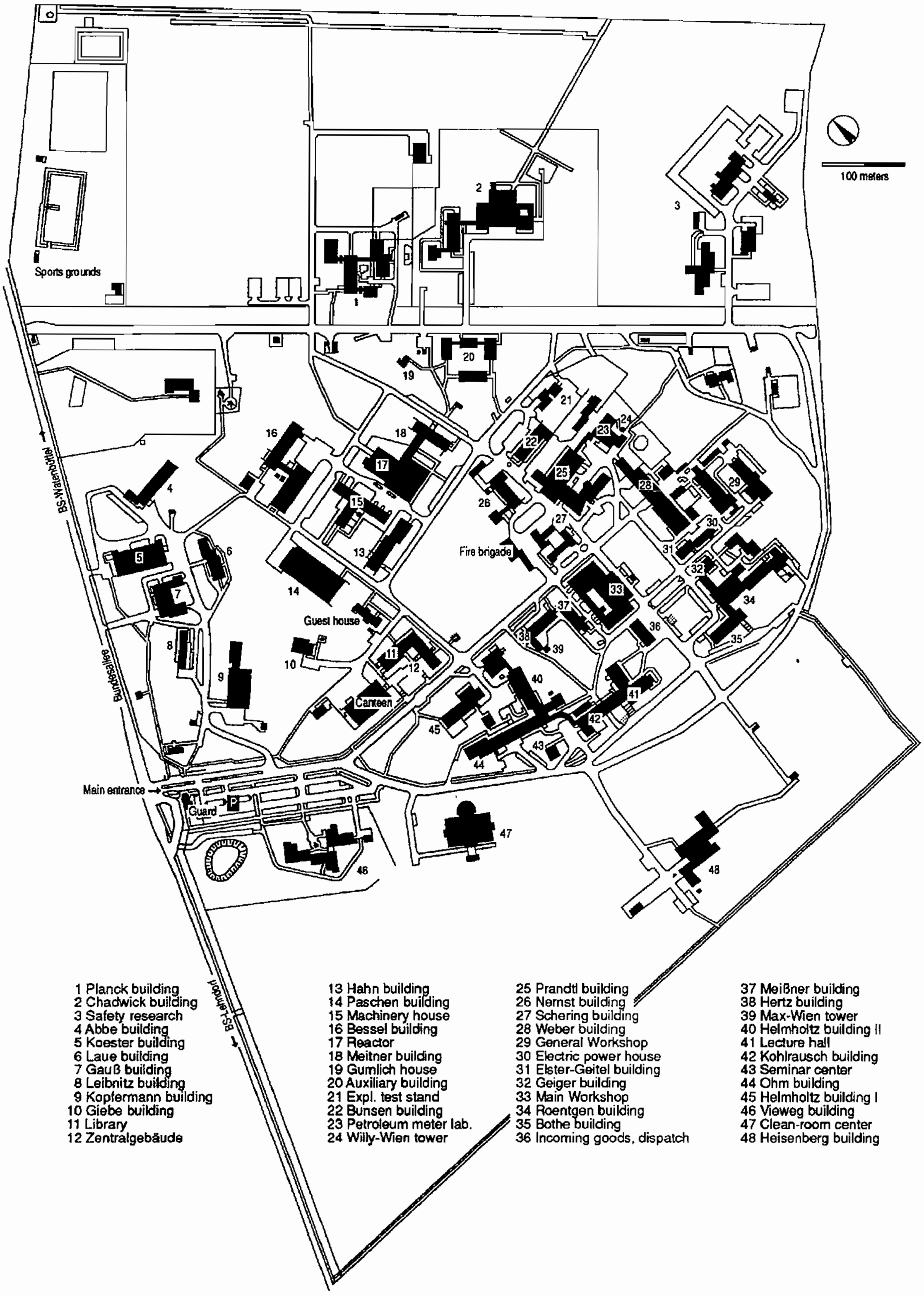
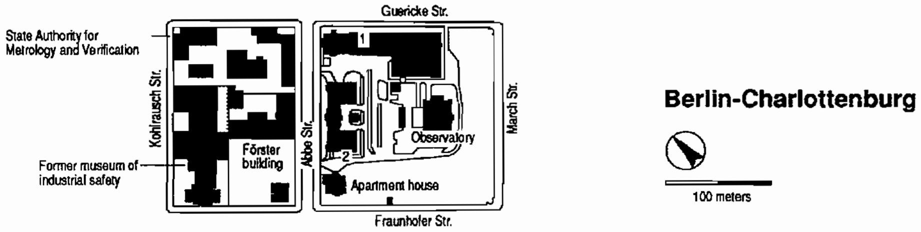
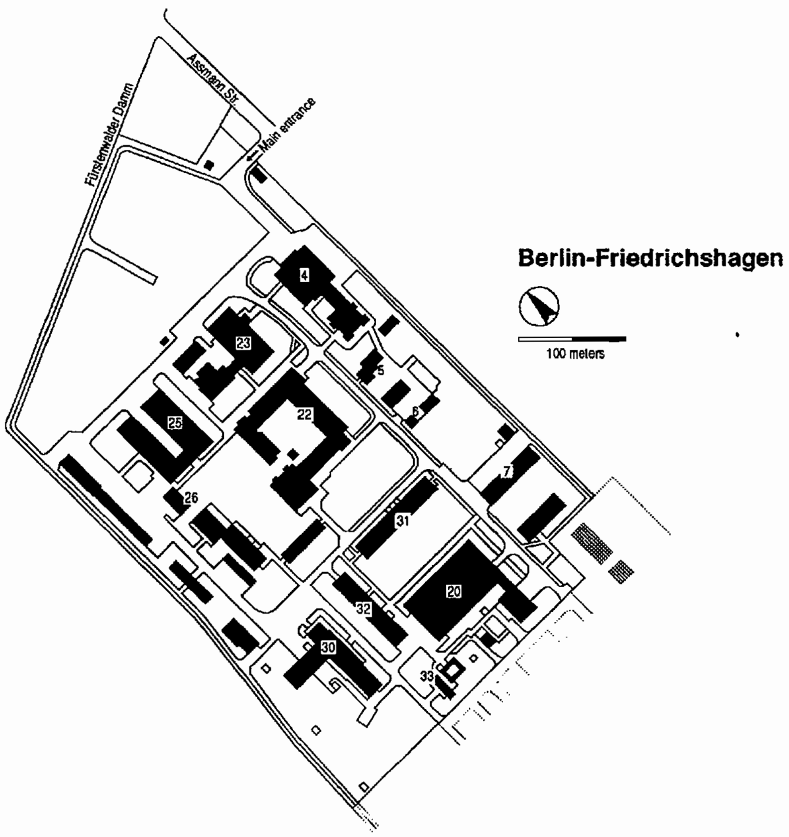


Fig. 8 – Layout of buildings in Braunschweig.



1 Warburg building
2 Siemens building



Laboratory buildings	**Instrument manufacture**	**Technical services**	**Administration**
Building 4	Building 25	Building 5	Building 22
Building 20	Building 26	Building 6	
Building 22		Building 7	**Canteen**
Building 23		Building 31	Building 32
Building 30			
Building 37			

Fig. 9 – Layout of buildings in Berlin.

International cooperation

Units in metrology best serve their purpose as measures in science, technology and commerce if they are internationally recognized and coordinated and if they are regularly and harmoniously adapted to scientific progress in their realization and range of application. As cooperation is indispensable in these basic tasks, the PTB collaborates in numerous international committees, above all in the Metre Convention and its International Committee of Weights and Measures (CIPM) and in the International Organization of Legal Metrology (OIML).

Scientists and technicians of the PTB are members of commissions and working groups of numerous European and national technical committees and in legislative bodies which deal with questions of metrology, safety engineering, standardization and quality control. In all these institutions, the knowledge of metrology and safety engineering and the benefit of the PTB's experience in these fields, are translated into regulations and laws. Within the framework of the harmonization of technical specifications and regulations for the realization of the single European market by the end of 1992, this work is now of particular importance and urgency. The PTB closely cooperates with the metrological state institutes of other countries. Comparison measurements of the national standards of the state institutes are carried out at regular intervals.

Just as the technical and scientific progress of the industrial nations in the last hundred years would not have been possible without the metrological state institutes, so is the establishment of central metrological institutes of appropriate capacity the basis of an organized legal and industrial metrology system as a prerequisite for trade and industry for the developing countries. The PTB passes on the benefit of its experience to the developing countries within the scope of technical cooperation and helps in the establishment and development of metrological organizations with regard to personnel and equipment, especially of central national institutes, usually on behalf of the Federal Minister for Economic Cooperation. If necessary, this is done with the aid of German institutes engaged in the field of verification, standardization, testing and quality assurance. At present, about 30 projects are being implemented, covering the procurement and calibration of measuring instruments, advice and training, and the secondment of experts.

Summary and outlook

The Physikalisch-Technische Reichsanstalt, the predecessor of the Physikalisch-Technische Bundesanstalt, was founded one hundred years ago, in conjunction with the industrial development in Germany. In the beginning, the research work and tests carried out by the Reichsanstalt served above all the development of science, technology and trade and commerce. It is just this task which the Physikalisch-Technische Bundesanstalt still fulfills today. With the development of physics and technology, to an increasing extent tasks have been assigned to the Reichsanstalt - and later to the Bundesanstalt - which are aimed at protecting man against the impacts of technology on his living space. Today, when natural sciences and technology largely determine human life, the work accomplished by the Physikalisch-Technische Bundesanstalt is of equally great importance for all spheres of society, as scientific findings, technical capabilities and man's personal safety are no longer imaginable without a highly developed measuring technique.

Literature

The BIML takes the opportunity to mention two recent books related to the content of the preceding article:

- An extensive publication on the application of legal metrology in Germany including the role of PTB is since a few months available in an English edition :

  W. Schulz - Legal Metrology in the Federal Republic of Germany
  reference : PTB - TWD - 36e
  Braunschweig, January 1992

- The history of the start of PTB when it was called Physikalisch-Technische Reichsanstalt (PTR) and up to 1918 has been subject to a doctorate thesis by an American. This very documented work on the scientific and industrial background, the development of the buildings and the role of the Presidents of PTR during this period, not to forget the calibration services supplied to the industry of that time, has now been published in German language :

  David Cahan: Meister der Messung
  Die Physikalisch-Technische Reichanstalt im Deutschen
  Kaiserreich, 374 pages, 31 fig., 1992
  published by VCH Verlagsgesellschaft mbH
  D – 6940 Weinheim, Germany

The author mentions in the foreword that an English edition will be available in a near future.

DEVELOPMENT OF THE CAPACITANCE TYPE ELECTRONIC CRANE SCALE*

by **XU PINGJUN**
China Zhengshou Electronic Scale Factory

SUMMARY – The capacitance type electronic crane scale is characterized by the introduction of the capacitance type load cell and coding circuits, and the success in application of a microprocessor system.

Resolutions can be chosen conveniently to be 0.1, 0.2, 0.5, and 1, 2, 5 kg. The accuracy requirements of OIML class III scale can be met. Radio transmission makes operation of the scale convenient and flexible to satisfy entirely operation requirements under various conditions.

1. General description

The capacitance ORS type electronic crane scale was developed by China Zhengshou Electronic Crane Scale Factory and granted China national patent. The pattern of the scale has been approved by the metrology service of China, and its weighing accuracy can meet the requirements of OIML class III.

2. Structure and Composition

The ORS type electronic crane scale is composed of two parts: the scale body and the weighing indicator. Its system framechart is shown in Figure 1.

The scale body structure, showed in Figure 2, comprises hanging parts (such as hanging ring and hook), outer cover, capacitance type load cell, temperature sensor, coder, radio transmitter, power supply, etc.

The capacitance type load cell consists of a proving ring, a variable gap capacitance sensor, a LC oscillating circuit with stable features. The proving ring has the shape of an oblate with the plates of the capacitance sensor fixed in the internal cavity with the oscillating circuit board on one side. The effects of wire parametric variation upon the performance of the load cell was eliminated since the wire which connects he capacitance sensor with the oscillating circuit is very short. The load cell is incorporated in a sealed metal hood that is filled with dry nitrogen gas in order to maintain its long-term stability.

The load cell is mounted in the outer cylindrical cover through higher and lower joining parts. There are shear diaphragms fixed in the lower part of the outer cover to deliver side force and torque onto the outer cover. The sealed outer cover not only provides mechanical pro-

(*) Abridged version of a paper presented at the OIML seminar Weighing in Braunschweig, 15-18 May 1990.

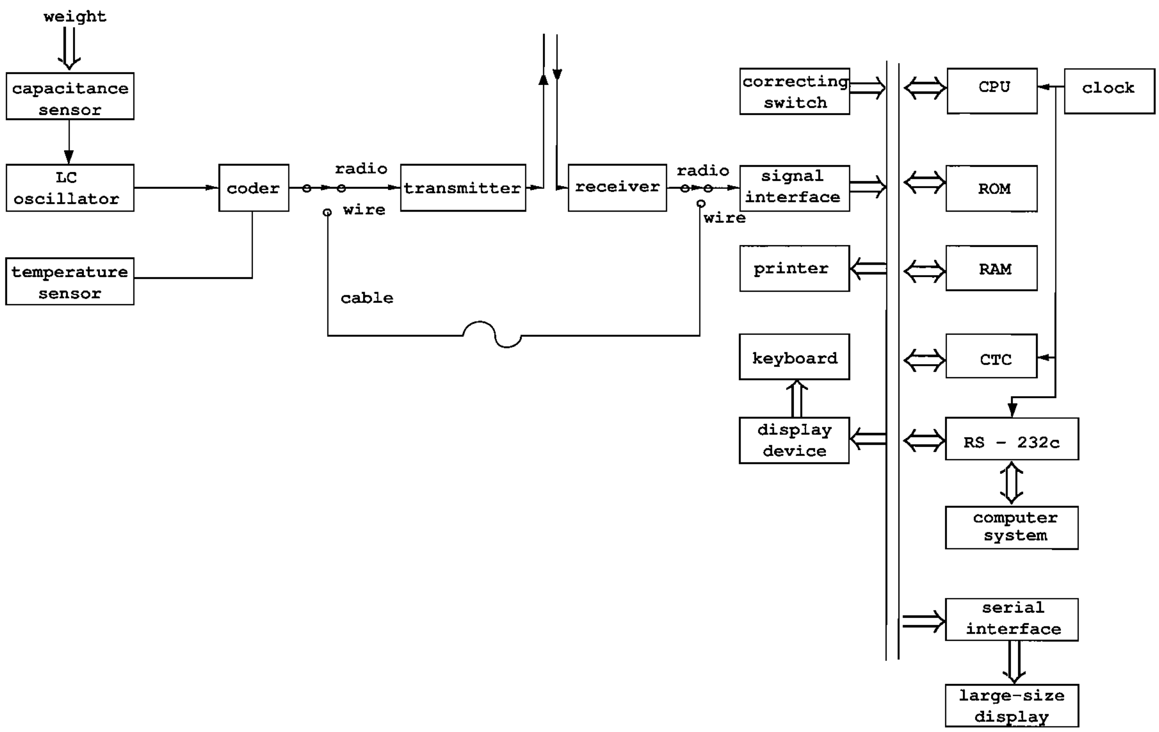


Fig. 1 – Principle framechart.

tection, but also exempts the load cell from direct effects by adverse surroundings. The higher joining part is joined with a hanging ring by means of a hinge that has a needle bearing. The lower part is joined with the hanging hook using a universal joint with a needle bearing. The effects of interference force moment, torque and side force upon the load cell is abated to a negligible extent by such a structure.

The weighing indicator consists of a radio receiver, a microprocessor, a display device, a printer, a key-board, a calibration switch, etc. A RS-232c interface also can be provided if required. In essence, it is a small and exquisite microcomputer for special use with perfect functions and various supplementary devices.

3. Operation Principle

A certain deformation KP (K is the coefficient determined by the structure of the proving ring and the elastic modulus of material) will be generated when the load (i.e. weight) P of the object is applied. A corresponding air gap length $\delta_0 + KP$ will be formed between the two plates of the capacitor (δ_0 is the initial air gap length of the capacitance sensor). Then the capacity of the sensor will be:

$$C = \frac{\varepsilon_0 \varepsilon A}{\delta_0 + KP}$$

ε_0 is the vacuum permittivity, $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
ε is the relative permittivity and $\varepsilon = 1.00068$ when the medium is dry nitrogen
A is the effective area of the plates of the capacitance sensor.

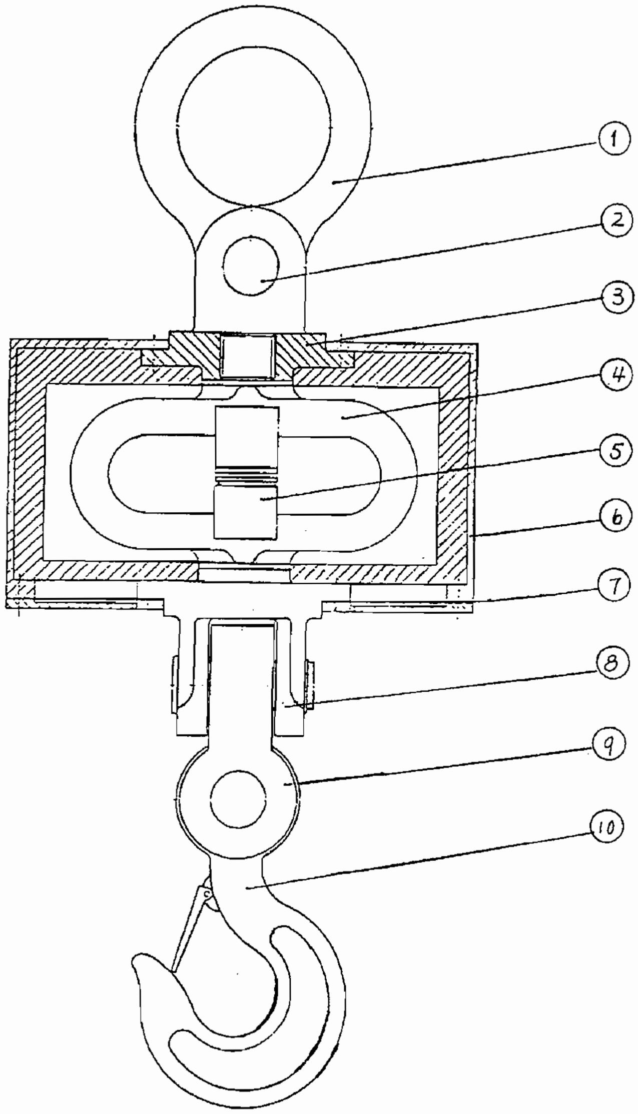


Fig. 2 – The scale body structure.

1 - hanging ring, 2 - axle, 3 - joining part, 4 - proving ring, 5 - capacitance sensor, 6 - outer cover, 7 - bearing diaphgragm, 8 - joining part, 9 - universal joint, 10 - hanging hook.

The frequency generated in an *LC* oscillating circuit which is comprised by the capacitor *C* and inductor *L* will be

$$f = \frac{1}{2\pi\sqrt{L(C' + C)}} = \frac{1}{2\pi\sqrt{L\left(C' + \dfrac{\varepsilon_0 \varepsilon A}{\delta_0 + KP}\right)}}$$

where *C'* is the distributed capacity of the sensor.

The influence of electric field distortion around the capacitance sensor has been omitted here.

As $P \geq 0$, f will obviously be a single-valued monotone function of *P*. The frequency signal and the scale body temperature signal from the temperature sensor are converted into binary and serial digital signals by a coder, then transferred into the microprocessor in the weighing indicator via the radio transmitter and receiver or the signal cable. The linearization for the weight signals, the compensation for the temperature according to the temperature signals, the offset and digital filtering for the creep of load cell and other mathematic treatment are done by the microprocessor. The output for actual and accurate weight value of the object will be processed by the weighing indicator on to the display, printer or RS-232c interface. The operation program flowchart of weighing indicator is shown in Figure 3.

4. Error Analysis of the Load Cell

The main error source of the ORS capacitance type electronic crane scale is concentrated in the load cell itself. Such errors are typically due to creep, hysteresis and non-repeatability.

The main external factor which can affect the characteristics of the capacitance type load cell of the ORS electronic crane scale is the environment temperature. The variations of the elastic modulus of the proving ring and of the distributive capacitance as well as the inductance caused by the temperature will be corrected by the microprocessor according to the temperature signal. Therefore, the long-term stability of ORS capacitance type electronic crane scale depends on the stability of all parameters in the oscillating circuit of the load cell.

To maintain the long-term stability of the load cell it is very important to manufacture stable inductors by all means of technology.

5. Summary of the features of the ORS crane scale

(1) Wide output range, high resolution and excellent repeatability of the capacitance type load cell. The scale has a resolution better than 1 part in 100 000. Its repeatability is better than 0.01 %. Software can be used to compensate the system errors that might be described by the mathematics.

(2) The LC signal conversion circuit allows frequency modulation and the signals of the load cell can be transmitted in frequency and digital form. The transmitted data are not influenced by the decay and the wave-form distortion of the signals.

(3) The ability of antijamming and the accuracy are improved as no linear operational amplifier or analog-digital converter are employed in the system.

(4) The system is easy to operate. The ORS type electronic crane scale can be connected to different types of weighing indicators to meet the users' requirements.

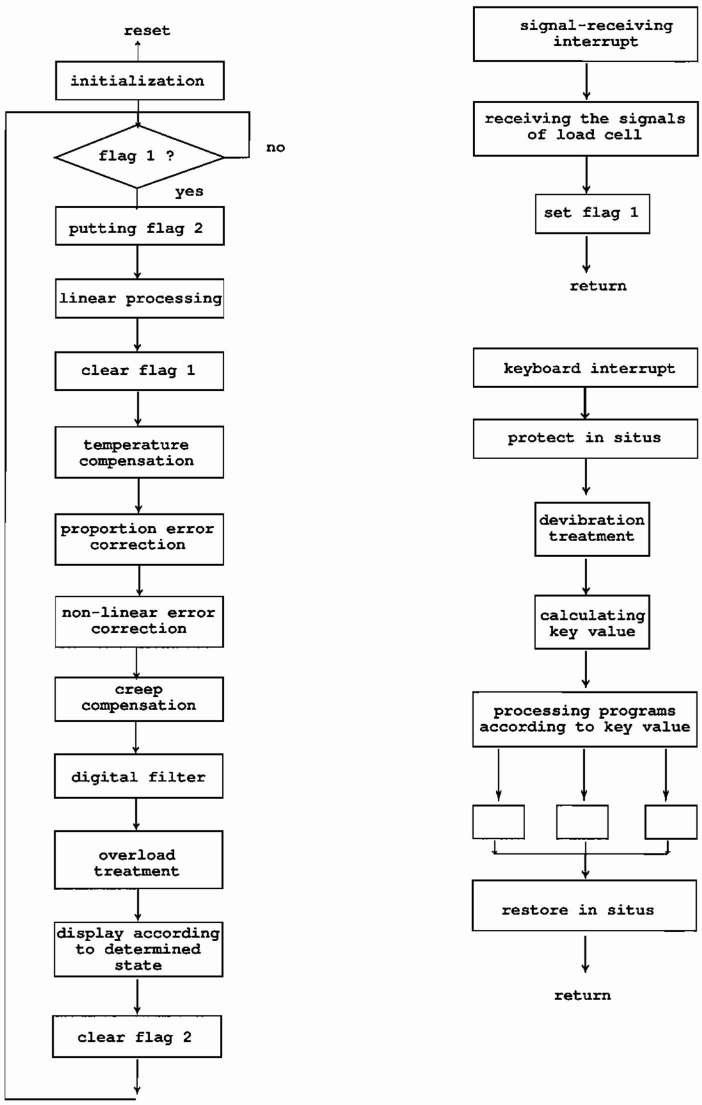


Fig. 3 – The flowchart of the meter's operational sequence.

The desk-top weighing indicator, AC powered, is applicable at fixed locations such as office or crane control-room, and a bright display using fluorescent digital tubes is normally adopted. Generally a liquid crystal display is used in the portable weighing indicator which is supplied by a cadium-nickel battery and can be operated continually for 15 hours after being charged. Both indicators are capable of recording 990 times weighing results for 10 kinds of goods, and the weighing results can be printed out at time by the micro-needle printer of 16 rows that is supplied in the indicator. The indicator has a negative-weighing function to display the weight of the object taken off from the hanging hook directly. It is very convenient to control the casting weight while casting. The resolution interval *d* or the verification interval *e* of the scale can be chosen by the weighing indicator automatically. The interval *d* can also be set to 0.1, 0.2, 0.5, 1, 2 and 5 kg by use of the keyboard conveniently in order to offer enough high resolution while weighing minor objects and retain measuring accuracy.

The weighing indicator with a RS-232c interface can communicate with a computer system to transfer weighing results into computer-aided control systems or to make it possible that the computer controls the electronic crane scale. The large-size display interface on the weighing indicator can be connected with a giant LED display with words being 200 mm high, which is applicable to large workshops. The pocket-size weighing indicator, weighing only 1 kg, has the dimensions of 200 × 80 × 40 mm, an 8-digit LCD display with accumulation possibility and is suitable for out-door operation.

The radio communication frequency of the ORS type electronic crane scale conforms to the stipulations formulated by National Radio Supervision Committee of China. The emission power is less than 0.5 W and allows a transmission distance of more than 300 metres.

R.P. CHINE

A SURVEY OF THE PROGRESS IN IN-MOTION RAIL-WEIGHBRIDGES

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SUMMARY – This paper makes a survey of the progress in weighing accuracy, wagon identification, weighing velocity and new structures of the in-motion weighing rail-weighbridges in China. To better understand the progress so far, the paper will begin by introducing the method used to verify a weighing machine of this kind.

1. Review

In 1976, the first in-motion weighing rail-weighbridge(IWRW) was successfully put into use in China. In the beginning of the 1980's, the country began to develop micro-computer controlled IWRWs. In the mid-1980's Chinese-made IWRWs can accurately weigh wagons in motion as well as, or even better than some developed countries. Since then China has become increasingly more involved in the spread of applications for IWRWs.

With the use of the large-scale integrated circuits, the IWRWs have entered a new era of micro-computer controlled IWRWs which are much better than the previous electronic ones. For example, the failure rate of weighing systems is decreasing, at the same time the stability and reliability are increasing. Under the same condition of the railroad bed and platform, the accuracy of the IWRWs can be improved by 0.1 % to 0.2 %.

To better understand this paper, we will begin by briefly introducing the method of verification of the IWRWs.

2. The Method of Verification of the IWRW

The National Railway Weighbridges Metrology Centre is responsible for the initial verification and in-service inspection of the IWRWs for the whole country in accordance with *China national measurement and verification regulation (JJG 234-90): in-motion weighing rail-weighbridge.*

Each IWRW shall be designated one of the following accuracy classes: class 0.2, and class 0.5. In the regulation JJG 234-90, the accuracy class and corresponding scale interval used in testing is shown in Table 1. The maximum permissible errors for in-motion testing is shown in Table 2.

TABLE 1 – ACCURACY AND TESTING SCALE INTERVAL

Accuracy Class	Testing Scale Interval e
0.2	50 kg
0.5	100 kg

TABLE 2 – MAXIMUM PERMISSIBLE ERRORS FOR IN-MOTION TESTING

Mass Weighed	Accuracy Class	
	0.2	0.5
m = 0	± 0.5 e	
0 < m ⩽ 500 e	± 2 e	
500 e < m ⩽ 2 000 e	± 3 e	± 4 e

The normally used standard test wagons are the T6F model test wagons described in the Appendix which have an accuracy superior to 1×10^{-4} and the T6D model test wagon set (Fig. 1) in which there are 5 test wagons each with an accuracy superior to 2×10^{-4}.

For in-motion weighing testing, the five T6D wagons which are 84 t, 76 t, 68 t, 50 t and 20 t of nominal weight should be grouped according to the following two series:

1) Locomotive – 84 t – 50 t – 76 t – 68 t – 20 t, and
2) Locomotive – 68 t – 76 t – 50 t – 84 t – 20 t.

For each group, the test wagon set will run over the weighbridge and back 10 times with the allowed weighing speed, and every reading shall be in conformity with the specification in Table 2. It will be considered failure to pass the verification if any reading not in conformity with the Table 2 appears or any mistake occurs during the test performance.

After the in-motion test has finished, we can obtain 20 groups of test readings. For each group of readings x_i, i = 1, 2, 3, ... 10, we know the standard value x_0 of the corresponding test wagon, so we define the equivalent accuracy (δ) of the in-motion weighing of the IWRW according to the following procedure:

mean value of test readings $\bar{x} = \sum_{i=1}^{10} x_i$

systematic error $\Delta = \bar{x} - x_0$

the standard deviation $\sigma = \sqrt{\frac{1}{10-1} \sum_{i=1}^{10} (x_i - \bar{x})^2}$

Fig. 1 – Standard test wagons set model T6D

Nominal mass: 20 t, 50 t, 68 t, 76 t and 84 t

Accuracy superior to $\pm 2 \times 10^{-4}$

Mass stability during a verification cycle better than $\pm 2 \times 10^{-4}$

Rated speed: 100 km/h

This equipment was developed by Cheng Wei, Guo Lili and Guo Ruilin.

relative error at the weight equivalent $\delta = \dfrac{|\Delta| + 2\sigma}{x_0}$

Among δj, j = 1, 2, 3, ..., 20, the biggest figure is defined as the weighing accuracy of the IWRW.

3. Progress in Accuracy

The statistical figures shown in Table 3 are obtained according to the method explained above. From the table we can notice the in-motion weighing accuracy of Chinese-made IWRWs tends to be better from one year to another. There are 16 imported IWRWs in China. Both imported and Chinese-made IWRWs are tested according to the regulation JJG 234-90. The accuracy of the Chinese-made IWRWs have proved to be very good. According to statistics in November 1991, about 30 % of Chinese-made IWRWs correspond to the accuracy of class 0.2, while there are 11 IWRWs which can only reach class 0.5 among the 16 imported ones.

TABLE 3 – THE NUMBER OF HIGH ACCURACY IWRWs IN IN-MOTION TEST RESULTS

Annuals	1985	1986	1987	1988	1989	1990	to Nov. 1991
$\delta \leqslant 0.1\ \%$			1	1		3	4
$0.1\ \% < \delta \leqslant 0.2\ \%$		1	9	16	22	32	33
Total	0	1	10	17	22	35	37

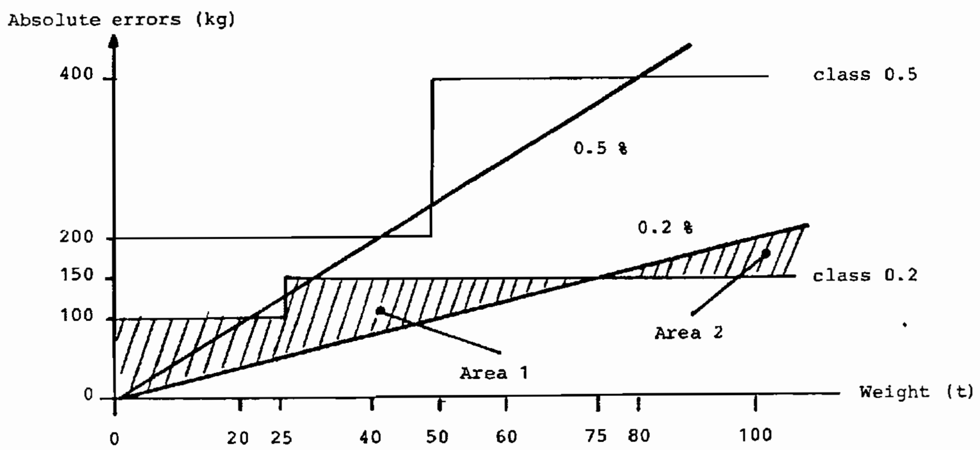

Fig. 2 – The relationship between accuracy class and accuracy.

In China, the accuracy class is only used to decide whether an IWRW can be used to weigh expensive materials such as grain, chemical products, etc. Please note, class 0.2 is not a name synonymous with the accuracy superior to 0.2 %, neither does class 0.5 and the accuracy inferior to 0.2 % have the same meaning. For example, in Fig. 2 if the maximum tolerance is in area 1 after the verification performance, the IWRW can certainly reach class 0.2, but the accuracy of the IWRW would be worse than 0.2 % according to the Chinese method. In contrast, if the maximum tolerance is in area 2, the accuracy of the IWRW would be superior to 0.2 %, but unfortunately the IWRW can only be classified to class 0.5. As explained in the last part of this paper, even if every reading in a group of test data has an accuracy superior to 0.2 %, the relative error at the equivalent weight may be inferior to 0.2 %. The weighing accuracy of an IWRW is defined in a different way in China compared to most western countries. Although the Chinese method results in a more conservative estimate, both the reliability and confidence are higher. Because there is a probability forecasting factor in the Chinese method, it is very difficult for an IWRW to be defined to an accuracy superior to 0.2 %. Without this background knowledge, many traders fell into a difficult position after an IWRW trade contract was signed with China.

4. Progress in Wagon Identification

As we know, track switches operate up and down very frequently when the train being weighed is running over the weighbridge, so they are easily damaged. Once there is something wrong with the track switches, logical errors will occur when the IWRW tries to identify the wagons, so the weighing would be failure.

All Chinese-made IWRWs have no so-called track switches or wheel sensors now. They automatically identify the wagons with analog signals of axles' weight. The hardware of the IWRWs used for wagon identification is avoided. There is almost no maintenance work on the track logic of the Chinese-made IWRWs. Its reliability is also very good.

Although there are so many types of locomotives and wagons in China, the Chinese method of wagon identification can distinguish each wagon in-motion with a reliability of up to 100 %.

The method is based on the different distances between the adjacent axles of rolling stocks. When a weighing train is passing the weighbridge, the output signals of the load cells are in proportion to the weight of the wagon axles, and the output waveforms of the load cells are periodically changed. So the computer can calculate every distance between adjacent axles (DBAA) simultaneously. The software can also detect the direction, the sequence number, type and roll back of the axle passage, these data ensure weighings are made at the correct time. Non-essential data (i.e. axles comprising locomotives and guards' wagons) can be automatically eliminated from the weighing cycle.

The DBAAs are the criterion used for wagon identification in the Chinese mèthod, so the precision of the distances measured is the key to reliable wagon identification. Here, the main problem is that the velocity of the train being weighed may be unstable to a great extent, so a suitable formula for calculating the DBAAs must include the factor of the speed variation. The measurement offsets should be set to obtain accurate DBAAs.

5. Progress in Weighing Velocity

The maximum weighing speed of Chinese-made IWRWs can reach as high as 12 to 18 km/h, and the minimum weighing speed can go as low as possible. Because the weighing speed can be varied within a wide enough range, the weighing efficiency has been raised greatly. The driver finds it easy to operate the train being weighed.

The faster a weighing train runs, the less the period is during which a wagon passes the weighbridge and the shorter is the sampling time. Because there is no multi-section filter circuit in Chinese-made IWRWs, the task of automatic elimination of dynamic suspension elements from weight processing calculations is finished by the micro-computer. This makes it possible to do fast and accurate weighing. While wagons are being weighed, the IWRWs can display and print the readings almost simultaneously.

6. Progress in Structure

Besides the traditional IWRWs (i.e., deep pit or low profile in-motion weighing systems), a few kinds of new products have been developed in recent years (as shown in Table 4).

TABLE 4 – NEW KINDS OF IWRWs IN CHINA

N°	Name of New Kind of IWRW	Special Characteristics
1	Pitless In-motion Weighing Rail-Weighbridge	– rapid and high accuracy weighing – short construction time – low investment
2	Pitless In-motion Weighing Rail-Weighbridge on Curved Track	– suitable for the enterprises with difficulty in locating the IWRW on straight lines long enough – radius of curved track ⩾ 200 m
3	Dual Purpose Static Rail-Weighbridge for Highway Trucks and Railway Wagons	– save construction area – save investment
4	The Rail-Weighbridge for Monitoring the over load and eccentric load of wagons in-motion	– ensure safe transportation – pitless and no platform – easy to maintain – fast weighing and low cost
5	The In-motion Weighing Rail-Weighbridge for Artery Rail-line	– no platform and pitless – easy to maintain – fast weighing and low cost – business as usual while constructing – no influence to track circuit

7. Concluding Remarks

Besides the benefits realised in hundreds of railway in-motion weighing installations world-wide, such as improved freight turnround times, reduced operating costs, optimum manpower utilisation and improved marshalling yard safety, etc., the Chinese-made IWRWs have some added features especially convenient for the users. For example, fast and accurate weighing, without any mechanical wagon identification device, reliability, several kinds of new structural designs for a particular application, etc. Furthermore the Chinese-made IWRWs are tending towards being more reasonable and simplified in structure, more convenient to users, much easier and faster in installation and adjustment, much lower in cost, and so on.

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RAIL-WEIGHBRIDGE TESTING WAGON MODEL T6F

Equipment developed by **JIN ZUOKANG**

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The T6F rail-weighbridge testing wagon is a specialized wagon for the verification of the static weighbridges with heavy test weights. It can also be used to test in-motion weighbridges while coupled with the standard wagon set. As a vital equipment with the characteristics of high accuracy, rational structure and easy operation, it is widely used for the rail-weighbridge testing in railways, harbours, mines, etc.

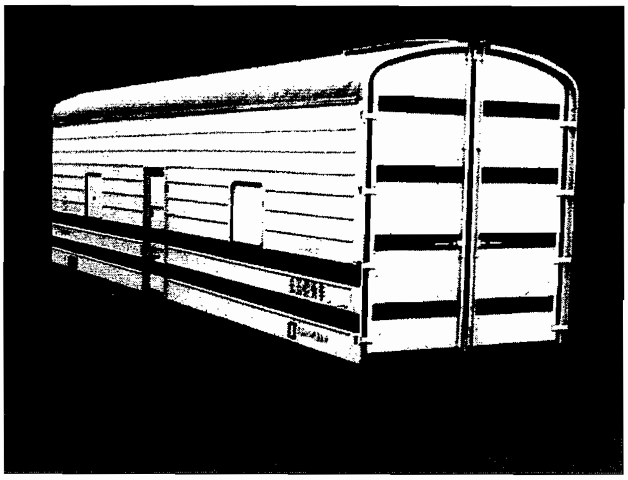
The wagon consists of a body, weights conveyor, lifting device, heavy mass standards and electric installations. It can carry out the full load testing, the eccentric load testing, the support testing and the multiple weighing points testing.

CHARACTERISTICS

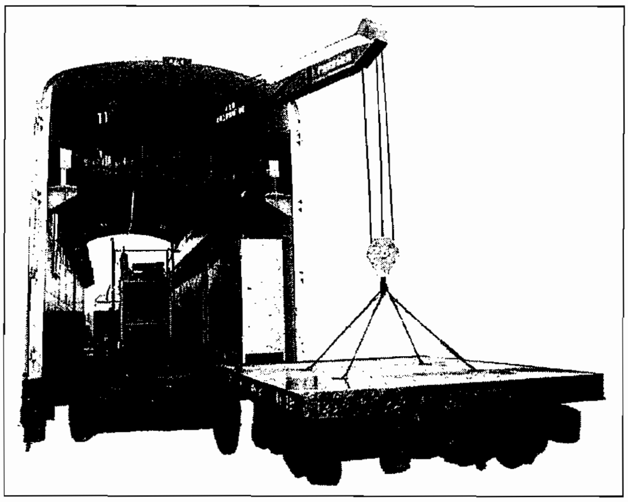
1. The telescopic lifting boom can work in both directions
2. The wagon can be towed by the weights conveyor
3. The range of swing angle of the wagon boom is 0° to 260 °
4. Anti-skid device is provided for the heavy test weights
6. The stability of the gross weight permits the wagon to be used as a reference weight for the rail-weighbridge testing.

MAIN TECHNICAL SPECIFICATIONS

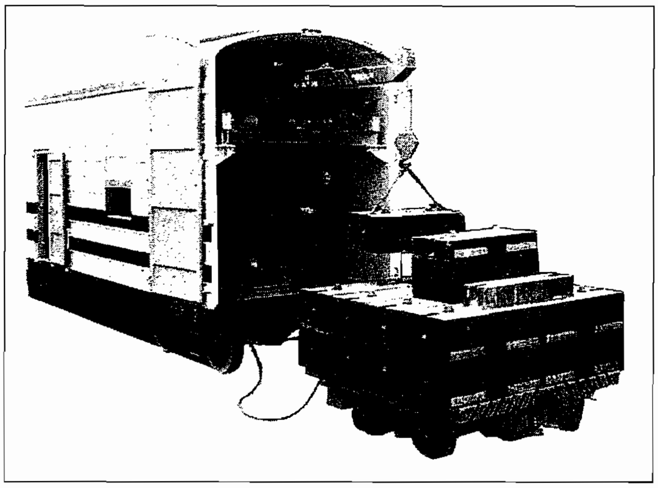
1. Gross weight:	82	t
2. Rail gauge:	1 435	mm
3. Rated speed:	100	km/h
4. Maximum height of the empty wagon:	4 620	mm
5. Maximum width of the wagon:	3 014	mm
6. Rated lifting capacity:	2.5	t
7. Maximum boom reach from the wagon:	2.8	m
8. Maximum lifting height:	3.2	m
9. Weights conveyor		
Maximum carrying capacity:	40	t
Tare weight:	2.5	t
Wheel base:	1 000	mm
Rail gauge:	1 435	mm
10. Number of the standard weights:	22 of 2 t, 2 of 1 t, 2 of 0.5 t.	



The T6F rail-weighbridge testing wagon.



The boom can be put outside of the wagon to lift the weights conveyor.



A standard weight of 2 t can be lifted by the telescopic lifting boom.

ADJUSTMENT OF STANDARD WEIGHTS (Ni-Cr alloy) BY ELECTRODEPOSITION OF RHODIUM

by **M.L. DAS** and **S.V. GUPTA**
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SUMMARY – A technique was developed to increase the mass of the Ni-Cr alloy standard weights by electroplating them with rhodium. To get a low stressed bright deposit, the deposition was carried out by using an aged sulphate electrolyte at low temperature. Degreasing in an ultrasonic cleaner which contained trichloroethylene and hot alkaline electrolytic cleaning of the surfaces were found essential for good adhesion. The adhesion was tested by a heat-quench method. The cleaning and electroplating methods are described in detail.

Introduction

Weights made from 80 % Ni 20 % Cr alloy are used as secondary standards of mass at NPL of India. Due to frequent use, some of them have lost a significant amount of mass. Sometime back we got four Ni-Cr alloy standard weights (1 kg) from the manufacturer (India Government Mint, Bombay), which were found much below their nominal values. These four weights and some other weights were adjusted by electroplating them with rhodium. Electroplated rhodium has some unique properties suitable for standards of mass [1, 2]. It is highly corrosion and wear resistant. Its colour is silver-white and its reflectivity to visible light is excellent.

It is difficult to get adhesive and crackfree deposit of rhodium on nickel [3]. In our case the problem became more acute as the substrates contained a substantial amount of chromium. For good adhesion, great care was taken to ensure thorough cleaning of the surfaces of the weights. Cracking in rhodium deposit occurs due to excess internal stress [4, 5]. To get lower internal stress in the deposit and higher cathodic efficiency, an aged (about 5 years) rhodium-sulphate electrolyte was used. During electrodeposition the electrolyte was kept at rather low temperature which helped in reducing the internal stress further.

Experimental

1. CLEANING OF THE SURFACES OF THE WEIGHTS

The weights were first degreased by ultrasonic solvent cleaner containing trichloroethylene for five minutes. Then they were cleaned electrolytically by the following alkaline solution:

Sodium hydroxide: 35 g/L
Sodium carbonate: 25 g/L.

The cleaning was cathodic and for a duration of two minutes. The temperature of the bath was maintained at 80 °C and a current density of 1 000 A/m^2 was applied.

A stainless steel bar was used as anode. After alkaline cleaning, the weights were rinsed in distilled water and then dipped in a solution containing ten percent sulphuric acid by volume.The weights were then transferred into the rhodium plating solution without any delay.

2. RHODIUM PLATING

A 10 g/L solution of rhodium had been prepared earlier (5 years back) by dissolving anhydrous sulphate salt in distilled water. The temperature of the solution was maintained at 25 °C. A current density of 100 A/m^2 was applied. A platinum sheet was used as anode. The deposition time was fixed by taking into account the amount of rhodium required to be deposited on the weights. Two of the rhodium plated standards are shown in Fig. 1.

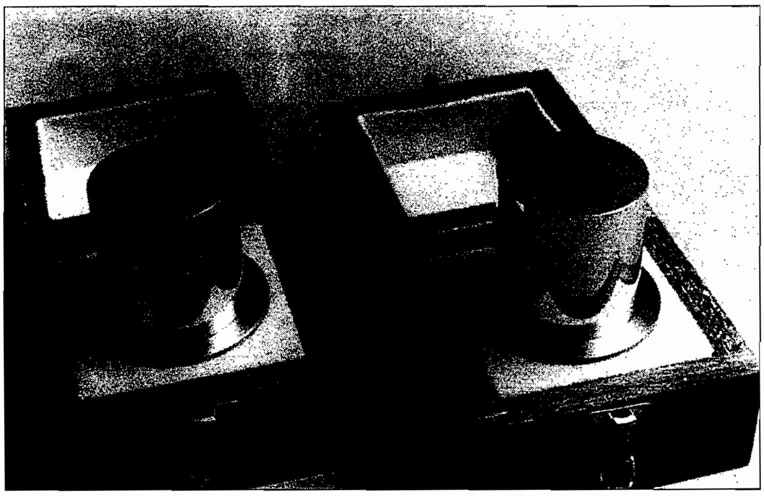

Fig. 1

3. ADHESION TEST

For the adhesion test, samples were prepared by plating small pieces of Ni-Cr alloy with rhodium by following the same cleaning and plating procedure as for the standard weights. The samples were heated to 150 °C for one hour in air and then quenched into cold water (ASTM B571). The operation was repeated several times. No degradation, such as blisters, cracks or patches of discoloration was observed.

Conclusion

Chemically stable and very hard rhodium can be electrodeposited on Ni-Cr alloy weights and the mass of the weights can be increased according to requirement.

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WECC

INTERNATIONAL INTER-LABORATORY COMPARISONS - A TOOL FOR GAINING MUTUAL CONFIDENCE IN CALIBRATION AND TEST RESULSTS

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1. Introduction

At its meeting in 1990, the International Committee of Legal Metrology approved, after several years of discussion, a document on an OIML certificate system for measuring instruments [1]. The system aims inter alia to facilitate, accelerate and harmonize the work of national or regional bodies that approve patterns of measuring instruments. It is limited to those categories of measuring instruments for which existing OIML Recommendations specify the metrological and technical requirements, suitable test methods and the format of the test report thus providing a sound basis for conformity tests to be carried out. Nevertheless, some doubts were raised during the process of development of this system whether there was enough evidence to suppose that tests performed on the same instrument in laboratories of different OIML member states would lead to the same test results. It appeared that only little experience on the international equivalence of tests and test reports is available in the field of legal metrology up to now. It was, therefore, suggested to consider in the future any means to improve the situation and to initiate international inter-laboratory comparisons wherever appropriate.*

In the field of laboratory accreditation, however, proficiency testing has for many years been regarded as an effective means for the demonstration of the technical competence of a calibration or testing laboratory. Recent normative documents [2] explicity recommend participation in proficiency tests and within the framework of calibration laboratory accreditation proficiency testing by inter-laboratory comparisons is standing practice.

At an international level, inter-laboratory comparisons are recognized as the most important element in a programme for building up and maintaining mutual confidence between calibration or testing laboratories in different countries and between national laboratory accreditation bodies.

Especially, the Western European Calibration Cooperation (WECC), that is the collaboration of national calibration services in Europe has an ongoing programe of inter-laboratory comparisons since 1975. At present nearly 800 calibration laboratories are accredited by the national accreditation bodies of the 17 WECC member countries. Through the programme of inter-laboratory comparisons, the equivalence of certificates issued by these laboratories has been permanently demonstrated. A number of bilateral and multilateral agreements on mutual recognition of calibration certificates have been signed on this basis. The first was concluded in 1981, the last one concluded in 1990 is a multilateral agreement between 9 out of 17 WECC members.

(*) Note by BIML: Intercomparison tests of nonautomatic weighing instruments in accordance with the first edition of OIML R 76 were undertaken at an early stage by the EFTA countries. The results were reported in Bulletin de l'OIML. n° 117, Dec. 1989. Simular intercomparisons were later initiated by other legal metrology services of countries belonging to EEC.

TABLE 1 – DEVICES SUBJECT TO WECC INTER-LABORATORY COMPARISONS

Field of measurement	Desig-nation	Start year	Devices
Dimensional	M1	1976	end gauges, plug and ring gauge, screw gauge
	M2	1976	length bar, polygon, angle gauges, ring gauge
	M3	1976	end gauges, plug and ring gauge, screw gauge
	M4	1978	end gauges, plug and ring gauge, line scale
	M5	1979	end gauges
	M6	1979	end gauges, plug and ring gauge, surface texture standards
	M7	1983	long end gauges
	M8	1983	end gauges
	M9	1983	line scale
	M10	1985	screw gauges
	M11	1987	balls and rollers
	M12	1989	angel gauge blocks
	M13	1989	surface roughness
	M14	1990	internal diameter, roundness, cylindricity
Electrical	El1	1976	resistors, capacitors, inductors, attenuator
	El2	1976	resistors, capacitors, inductors, attenuator
	El3	1976	DC transfer standard
	El4	1976	resistors, capacitor, attenuator
	El5	1976	capacitors, inductors
	El6	1977	resistors, capacitors
	El7	1978	directional coupler, power heads
	El8	1979	resistors
	El9	1979	resistors, capacitors
	El10	1980	coaxial attenuator
	El12	1983	capacitors
	El14	1988	semiconductor voltage standard
	El15	1988	AC/DC transfer
	El16	1989	resistors
	El17	1990	inductance standards
	El18	1990	RF power
Force	F1	1985	load cells
	F2	1990	force transducers
Torque	T1	1991	torque transducers
Pressure	Pr1	1976	pressure balance
	Pr2	1988	pressure balance
Photometry	P1	1979	incandescent lamps
Thermometry	Th1	1976	platinum thermocouple
	Th2	1978	resistance thermometer
	Th3	1979	thermocouple
	Th4	1982	liquid-in-glass thermometers
	Th5	1991	thermocouples

TABLE 2 – PARTICIPATION IN WECC INTER-LABORATORY COMPARISONS

Start year	Designation	Report year	Participating countries														
1976	El1	1977					DK				**GB**				NO		SE
1976	El2	1977				DE					**GB**		IT	NL			
1976	El3	1977	AT								**GB**			NL	NO		
1976	El4	1977	AT			DE				FR	**GB**						
1976	El5	1977	AT			**DE**				FR	GB						
1976	M1	1977					DK				**GB**		IT		NO		
1976	M2	1977				DE					**GB**			NL	NO		
1976	M3	1977				DE					**GB**			NL			SE
1976	Pr1	—	AT			**DE**					GB						
1976	Th1	1977	AT								**GB**		IT		NO		
1977	El6	1979					DK					IE	IT	**NL**			
1978	El7	1979				**DE**					GB			NL			SE
1978	M4	1979	AT								GB		IT	NL			**SE**
1978	Th2	1979					DK				GB		**IT**		NO		SE
1979	El8	1981	AT			**DE**							IT		NO		
1979	El9	1981				DE			FI					**NL**			SE
1979	M5	1981				DE	DK			FR	**GB**			NL			
1979	M6	1981				**DE**				FR					NO		SE
1979	P1	1981				DE					**GB**		IT	NL			
1979	Th3	1981	AT				DK				GB		IT		NO		**SE**
1980	El10	1988				DE					**GB**		IT	NL	NO		SE
1982	Th4	1986				**DE**	DK		FI						NO		SE
1983	El12	1987				**DE**	DK		FI	FR	GB	IE	IT	NL	NO		SE
1983	M7	1987	AT			DE	DK		FI	FR			**IT**	NL			SE
1983	M8	1988	AT			DE	DK		FI	FR	GB		**IT**	NL	NO		SE
1983	M9	—				DE	DK			FR			**IT**	NL	NO		SE
1985	F1	1987				DE	DK				GB			NL			**SE**
1985	M10	1987				DE	DK		FI		**GB**	IE	IT	NL	NO		SE
1987	M11	1991			CH	DE	DK		FI		**GB**			NL	NO		SE
1988	El14	1989	AT	BE	CH	DE	DK	ES	FI	**FR**	GB	IE	IT	NL	NO	PT	SE
1988	El15	—	AT	BE	CH	DE	DK	ES	FI	**FR**	GB	IE	IT	NL	NO	PT	SE
1988	Pr2	—				DE	DK		FI		**GB**		IT	NL	NO		SE
1989	EL16	—	AT	BE	**CH**	DE	DK	ES	FI	FR	GB	IE		NL	NO	PT	SE
1989	M12	—			CH	**DE**	DK		FI	FR	GB		IT	NL	NO	PT	SE
1989	M13	—			CH	**DE**	DK	ES	FI	FR	GB		IT	NL	NO	PT	SE
1990	M14	—			CH	DE	DK		FI		GB		IT	**NL**	NO		SE
1990	El17	—		BE	CH	**DE**				FR	GB	IE	IT	NL	NO		SE
1990	El18	—		BE	CH	DE	DK	ES	FI	**FR**	GB			NL	NO		SE
1990	F2	—				**DE**	DK		FI	FR	GB			NL	NO	PT	SE
1991	T1	—				**DE**	DK				GB		IT			PT	SE
1991	Th5	—			CH	DE	DK	ES	FI		**GB**	IE	IT	NL	NO		SE

Country codes: AT Austria, BE Belgium, CH Switzerland, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, IE Ireland, IT Italy, NL Netherlands, NO Norway, PT Portugal, SE Sweden.

Reference laboratory marked with bold letters.

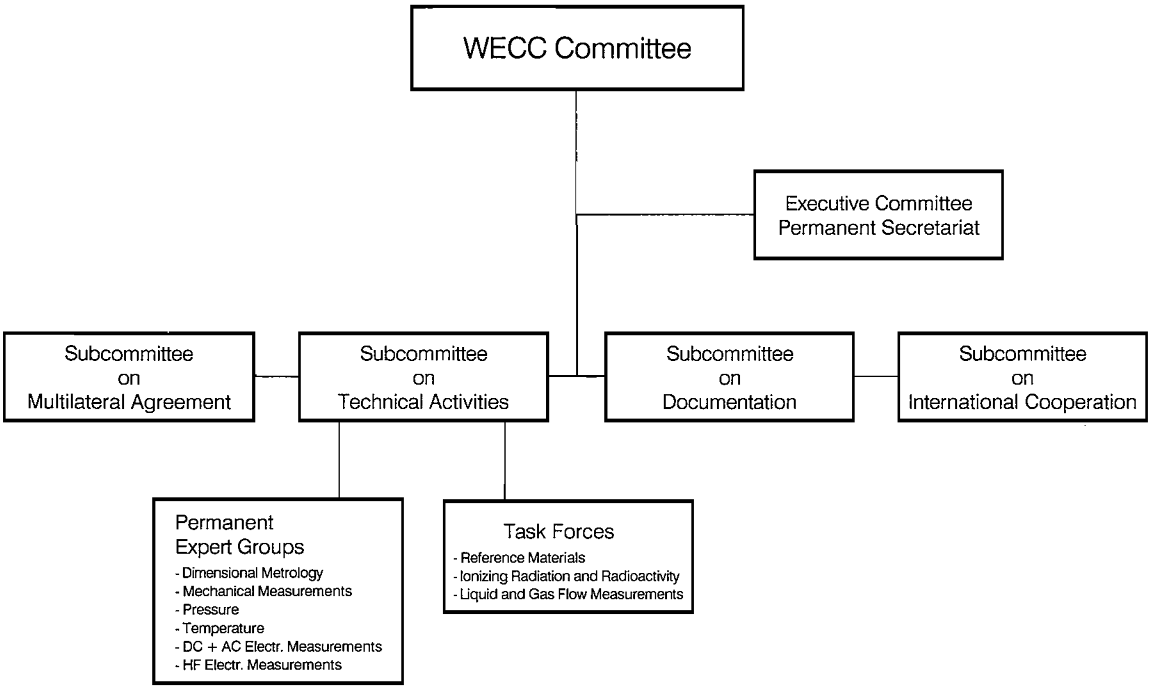

Fig. 1

The gathered expertise of WECC in the field of inter-laboratory comparisons may serve as a model for other organizations faced with similar problems. Therefore, the main technical and organizational aspects of WECC inter-laboratory comparisons will be described. This will cover the whole procedure, i.e. starting off from an analysis of needs and ending up with the approval of the final report. Emphasis is laid on some practical experience.

2. Programme and administration of WECC inter-laboratory comparisons

The series of WECC inter-laboratory comparisons started in 1975. Since then, a total number of 41 comparisons have been initiated, 14 of them running at present. Table 1 gives a survey of the fields of measurement and quantities covered. The main activities apparently lie in the classical areas of metrology, i.e. dimensional and electrical measurements but other fields such as force, torque, pressure, photometry and thermometry are covered as well.

Table 2 shows the chronological sequence and the participation of member services indicated by their country codes. Reference laboratories are marked by bold letters. It may be noted that the number of participating countries is continuously increasing and that a total number of 15 countries participated in some of the recent comparisons, each of them being represented by several accredited laboratories. 7 member services shared the burden of organizing all these comparisons.

A continuous programme of this kind requires a proper administrative structure. To provide easy understanding of the development of WECC inter-laboratory comparisons, a sketch of the WECC structure is shown in Fig. 1.

The highest authority of WECC in all questions including those of technical nature is the WECC Committee. It establishes subcommittees, technical expert groups and task forces, receives their reports and, apart from many other things, decides on the performance of inter-laboratory comparisons. At present, 6 permanent expert groups and 3 temporary task forces deal with specific measurement fields.

While the conveners of expert groups are appointed by the Committee for a four year period, their members are nominated by the member services. The membership may vary depending on the subjects to be discussed thus guaranteeing an utmost technical expertise in the group. It is the special responsibility of these groups to agree on the details of comparisons and to discuss their results. Task forces have similar responsibilities and follow the same principles of membership on a temporary basis.

The Subcommittee on Technical Activities forms the link between the Committee and the expert groups and task forces. It mainly comprises their conveners and was set up to harmonize the technical work, to make long-term planning of comparisons, to monitor their progress and to advise the Committee in all technical questions. The responsibilities of all the parties concerned with technical work are well specified in related documentation [3, 4].

TABLE 3 – DEVELOPMENT OF WECC INTER-LABORATORY COMPARISONS

Stage	Responsibility	Action
Analysis	SC "Technical Activities"	Long-term planning
Proposal	Expert Group Task Force Accreditation Body	Physical quantity Equipment Reference Laboratory Organ. Accr. Body Circulation type Schedule
Decision	WECC Committee	Registration
Preparation	Organizing Accreditation Body	Measuring instruction Invitation, Schedule Transportation Reference calibration
Execution	Participating Accreditaiton Body Organizing Accreditation Body SC "Technical Activities"	National loop Summary report Corrective actions Supply of ref. values progress control Management control
Report	Organ. Accr. Body Part. Accr. Bodies Expert Gr., Task Force	Draft report Corrective actions Final report
Approval	WECC Committee	Registration

3. The development of WECC inter-laboratory comparisons

The development of WECC inter-laboratory comparisons is explained in Table 3. It contains the main stages of a comparison, the responsibilities of the various parties concerned and the actions to be taken at each level.

(1) Any comparison originates from an analysis of the needs. This is based on an evaluation of the measurement capabilities offered by accredited laboratories in the WECC member countries. A permanent comprehensive analysis is carried out within the Subcommittee on technical activities. It results in a long-term planning and may lead to the establishment of further expert groups and task forces from time to time. It is the goal of this analysis to include all main physical quantities in the long-term programme for which some common interest exists, especially those representing new fields of technology.

(2) The next stage is the proposal stage. A proposal for a certain comparison will usually be presented by an expert group or task force. It shall contain details on the physical quantity to be measured, the equipment to be circulated, the reference laboratory, the organizing accreditation body, the type of circulation, and a preliminary time schedule.

At present the classical round robin type of circulation dominates. But with the increasing number of participating countries the total circulation time is considerably extended resulting in more severe requirements on the stability of the circulated equipment and/or more frequent recalibration by the reference laboratory. Therefore, other types of circulation are considered, e.g. a startype where a number of equivalent devices are calibrated by the reference laboratory and circulated in parallel to participating services.

The reference laboratory usually is the national standards laboratory in the country of the organizing accreditation body which often provides a measurement uncertainty considerably lower than that of most participating laboratories. Knowing a good estimate of the true value obviously facilitates the evaluation of results.

(3) Final decisions on comparisons are up to the WECC Committee. A registration number as indicated in the lists shown in Table 1 and Table 2, is applied for identification purposes.

(4) The following stage is the preparatory stage. The organizing accreditation body is responsible for drafting the preliminary and editing the final measuring instructions, for inviting member services to participate, for preparing of a detailed time schedule on the basis of responses received, for preventing problems concerning equipment transportation and customs and for having the equipment calibrated by the reference laboratory.

The measurement instructions should allow the participants to follow the measurement procedures usually applied and to issue a normal certificate of calibration. The time needed for calibration should generally not exceed one man day.

WECC member services are requested to participate in a comparison whenever they have accreditaiton activities in measurement fields covered by the scope of a certain comparison. In the case of a classical round robin circulation, however, the number of participating laboratories in each country has to be limited and the time for transportation has to be minimized by proper sequence of participants.

Obviously, a realistic but tight time schedule is very important from the very beginning. In the past, there was a tendency of an extension of the total time needed to several years both due to the increasing number of participants and due to some kind of lacking discipline of the participants. Inevitably, such exercises then bear the risk in themselves that the results might be obsolete by any reason when they will finally have been derived.

Moreover, it is quite important to have some knowledge of the history and the stability of the circulated equipment and to provide intermediate recalibrations in the reference laboratory, if necessary, by separating the comparisons into different subsequent loops.

(5) During the execution stage, participating accreditation bodies are responsible for organizing the national loops within their countries, for collecting the calibration certificates from the participants and to provide a brief summary report. They are allowed to take immediate corrective actions if some of the results are obviously wrong.

Each participating accreditation body is responsible for its own budget: unless another formal agreement has been made for a specific inter-laboratory comparison, there are no financial interactions between accreditation bodies. The costs for the organization as a whole are, however, to be covered by the organizing accreditation body.

After having received the summary report the organizing accreditation body submits the preliminary reference values for the equipment thus enabling quick actions if one of the participating laboratories obviously has failed to meet its specified measurement uncertainty.

The organizing accreditation body has to maintain a permanent progress control and - in close cooperation with the convener of the expert group or task force concerned - to take appropriate actions, if necessary. Forms confirming arrival of the equipment in a certain country and departure from it are extremely useful.

Even if this is properly performed, an overall management control by the Subcommittee on technical activities has been found to be necessary. A status report on all running comparisons is prepared half-yearly and circulated to all member services showing deviations from original time schedules and actions taken.

(6) A draft report on the inter-laboratory comparison is prepared by the organizing accreditation body combining the complete course of the comparison including any deviations from the originally agreed schedule and all results received including the final reference values.

Having received the draft report it is up to the participating accreditation bodies to take final corrective actions, if necessary, and to report on them to the organizer for inclusion in the final report.

At the end of the reporting stage, the draft report is discussed by the expert group or task force concerned and the final report is prepared on the basis of comments received.

(7) This final report is circulated to all WECC member services. The Committee approves it and may draw conclusions, if necessary.

4. Evaluation of calibration results

Fig. 2 shows an extract from a round robin test on a standard 1 μF capacitor. At the left-hand side, a selection of participating laboratories is given, identified by the country code and a confidential code number. On a scale showing the relative deviation of the measurement results from the nominal value, the individual result of each laboratory is given together with the stated uncertainty

In this case, the Physikalisch-Technische Bundesanstalt (PTB), Germany, acted as the reference laboratory. The total intercomparison had been divided into various loops with intermediate recalibrations at the PTB. By this means a slight time shift of the capacitance standard could be detected and taken into account.

Extract from report on WECC inter-laboratory comparison

EL 12 (capacitance standard 1 μF)

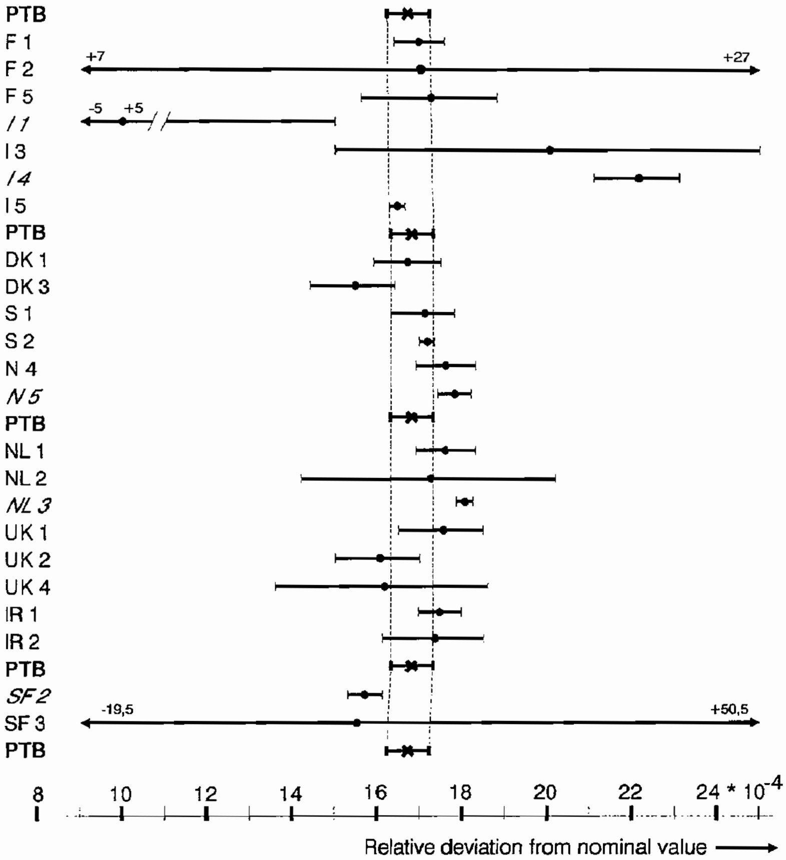

Fig. 2

It is emphasized that the claimed best measurement capability of a laboratory is evaluated during the national accreditation procedure and is finally fixed in the accreditation certificate. The basis for the calculation and the expression of measurement uncertainties using calibration is now laid down in a WECC document [5], which is to be uniformly applied by all WECC member services from 1 January 1992, especially with respect to a stated interval of confidence of 95 %.

Though a high degree of accuracy is certainly a goal aimed at by each laboratory, it is principally free to specify any uncertainty which it is able to achieve during routine work and which serves the needs of its customers.

The uncertainty stated by a laboratory for a special calibration may exceed the best measurement capability specified during accreditation, but must never be lower.

In Fig. 2 a large range of uncertainties of the various laboratories is shown. A measurement result was considered satisfactory in this comparison if the uncertainty bar of the participating laboratory overlapped the uncertainty bar of the reference laboratory.

With respect to their results, several groups of laboratories might be distinguished, the most interesting in our context being

- those stating a small uncertainty and reporting a mean value in close agreement with the result of the reference laboratory (e.g. F1, I5, S2),
- those stating a large uncertainty but reporting a mean value close to the "true value" (e.g. F2, NL2),
- those stating a small uncertainty but deviating too much from the "true value" (e.g. I4, N5, NL3, SF2) and
- those stating a large uncertainty without including the correct result in their confidence interval (e.g. I1).

Corrective actions have to be taken in the latter two cases. They may consist of a thourough evaluation of possible systematic errors and their removal, a withdrawal of the accreditation or merely of an increase of the specified best measurement uncertainty. This latter consequence may, at first sight, be considered as of minor importance. However, the important role of measurement uncertainty must not be forgotten. It is not only that some kind of competition between calibration laboratories and member services will be based on stated uncertainties which might be distorted by lacking equivalence but there is also the risk of wrong and costly decisions in industrial production processes based on wrong estimates of uncertainties.

4. Conclusions

As operated by WECC, international inter-laboratory comparisons considerably increase the transparency of performance of different accreditation bodies and provide an excellent basis for mutual confidence. Within WECC, they are therefore considered an essential element of any multilateral agreement on the recognition of technical equivalence of the parties concerned.

The ongoing WECC programme of inter-laboratory comparisons is based on a 15 year experience, well structured in each detail and properly documented [6, 7]. Some of these documents are under revision at present to incorporate most recent experiences, the principles will, however, be kept unchanged.

There are no reasons for any discontinuity in future developments of any follow-up programmes. However, there is a gradual development which has to be carefully considered and procedural modifications have to be adapted accordingly. A first issue is the number of countries expressing their wishes to participate in this programme. Recently, WECC has been approached both by Eastern European countries and by countries far outside Europe asking for participation. The inclusion of countries from other continents apparently creates special organizational problems. Since international comparisons are considered a good tool for national surveillance of accredited laboratories, the number of laboratories nominated for participation by each service also increases permanently. Both tendencies raise problems concerning the total circulation time needed together with equipment stability and concerning transportation and financial aspects. New forms of circulation have to be developed and external financial support has to be sought. Other problems arise from the increasing complexity of measurements and related equipments.

Though some modifications might be necessary the general concept of WECC inter-laboratory comparisons is not questioned. The well-established experience of WECC in the field of calibration may easily be transformed to other areas. It is, therefore, offered to other related organizations as a model and may help to harmonize corresponding procedures between organizations active in the field of calibration, testing and accreditation.

References

[1] OIML Certificate System for Measuring Instruments. First edition, 1991.

[2] ISO/IEC Guide 25: 1990: General requirements for the competence of calibration and testing laboratories.

[3] WECC-Doc. 18-1989. Guidelines for the Expert Groups of WECC (at present under revision).

[4] WECC-Doc. 15-1987. WECC International Measurement Audits (at present under revision).

[5] WECC-Doc. 19-1990. Guidelines for the Expression of the Uncertainty of Measurements in Calibrations.

[6] WECC-Doc. 04-1990. Circulation Audits.

[7] WECC-Doc. 06-1990. Expert Meetings.

A "STANDARDIZED" GRAVITY FORMULA

In a paper with the title "The Local Value of *g*" (Bulletin de l'OIML n° 94, March 1984) the author indicated a simplified formula for the approximate computation of the local value of the acceleration due to gravity. The coefficients stated were those adopted by the International Union of Geodesy and Geophysics in 1967.

A metrologist draw some time ago my attention to the fact that the constants of this geophysical formula were changed again by the introduction of the Geodetic Reference System 1980, a description of which was published much later in a paper by Professor H. Moritz in Bulletin Geodesique Vol. 62, n° 3, 1988.

Some recent physical handbooks reproduce in fact a similar formula using the new coefficients of the Geodetic Reference System 1980.

A more careful reading of the various publications and correspondence with Professor Moritz indicated however that the geodesists remove the influence of the atmosphere above the earth so that their so-called γ-values are not fully identical to the *g*-values but include the earth's atmosphere just like it was condensed on the earth's surface.

The difference is very small and amounts at sea level to 0.87 mgal or $8.7 \cdot 10^{-6}$ m/s^2.

By pure coincidence it thus happens that the goedesist's γ_e-value for the latitude of the equator in the 1967 system and the corresponding computed value of g_e at the equator in the 1980 system are identical at sea level.

The result is that we may for approximate computations of *g* standardize upon the following simplified formula which is in conformity with the Geodetic Reference System of 1980

$$g = 9.780\,318\,(1 + 0.005\,3024 \sin^2 \varphi - 0.000\,0058 \sin^2 2\varphi) \qquad \text{m/s}^2.$$

Our readers will notice that this formula is, except for a very slight modification of the third coefficient, identical to that published for γ in Bulletin de l'OIML n° 94.

The estimations of the altitude correction given in the previous paper are not affected by the above considerations and remain the same, i.e. about $-2 \cdot 10^{-6}$ m/s^2 per meter altitude within the (flat) earth to about $-3 \cdot 10^{-6}$ m/s^2 per meter altitude in free air.

Finally remember that the absolute value of *g* can hardly be computed to better than 0.01 % by the simple use of formulas whatever the coefficients are.

Åke Thulin
BIML

A SHORT HISTORY
OF WESTERN EUROPEAN METROLOGY ORGANISATIONS*

Bilateral collaboration in metrology in Western Europe goes back over many decades, but it is only in the past twenty years or so that a wider approach has emerged. The Western European Metrology Club (WEMC) played a major part in this development.

The "Club" came into being following a conference on metrology in Western Europe held at the NPL in April 1973. It was felt that there was a need for those with national responsibilities for metrology to come together from time to time. Issues of common interest could be considered and actions and initiatives agreed.

In 1974 the first meeting of the "Club" took place at the PTB. Some twenty participants, representing the major national metrology institutes and services in Western Europe, were present. The atmosphere was business-like, but friendly and informal, and agreement was reached on a number of aspects. The Club would meet at intervals of between one and two years and detailed work in specified areas would be carried out between meetings through a number of working groups. It was agreed also that every few years a booklet on national metrological services and facilities in Western Europe, broadly similar to one provided by the 1973 conference, should be produced.

One of the working groups established by WEMC in 1974 was in the area of calibration. As we shall see, this group was eventually to become WECC, an important body in Western Europe in its own right. Other groups, on nomenclature, information exchange and thermal properties, were to be more limited in attainment but they played some part in later developments.

The Club met nine times in the period 1974 to 1986. The meetings took place at different venues and settled into an agreed format. Developments in metrology in the various states were described, and discussions took place on working group activities and matters such as specification standards, legal metrology and laboratory accreditation. Reports were presented on aspects of the work of major international organisations, and the meetings benefitted from the presence by invitation of the Directors of BIPM and BIML.

The meeting in Paris 1986 proved to be something of a watershed for WEMC, for it was then that the concept of EUROMET was proposed. This initiative, which followed discussions involving Germany, France and the UK, initially received a somewhat mixed response. However, the delegates were to become much more enthusiastic in the following months and, following discussions on the concept at Frankfurt in December 1986 and Teddington in April 1987, the EUROMET Memorandum of Understanding was signed at Madrid in September 1987. EUROMET formally came into being on 1 January 1988.

Whereas WEMC had been informal and a means primarily of ensuring contact between those responsible for metrology in Western Europe, EUROMET was a more formal arrangement between states for collaboration on measurement standards. Initially all the EC and EFTA states, excepting Iceland, became members along with the European Commission. The first meeting of the EUROMET Committee took place at PTB in Braunschweig in January 1988, a second in August of that year at Helsinki, and a third, in May 1989, in Boras, Sweden. It was agreed that subsequent meetings should take place at approximately yearly intervals, and later meetings occured at Lisbon in March 1990 and Berne in April 1991. Iceland joined as a member for the 1990 Committee meeting.

(*) This article and the following pages containing information on EUROMET, WECC and WELMEC are reproduced from the directory "Metrology in Western Europe" printed by PTB (editor P. Drath).

EUROMET initially made rapid progress, various projects being agreed at an early stage between member states. At the end of 1991 there were 81 agreed projects underway with 46 other proposals for collaborative work on measurement standards. The structure of national delegates, rapporteurs for each of nine areas of metrology, and national contact points for each of these areas worked well. At the outset close relations were established with the European Commission's BCR programme on Applied Metrology.

With the coming of EUROMET, the need for WEMC as a forum for maintaining contact clearly diminished. A short meeting of the Club was held in Madrid in September 1987 following the signing of the EUROMET Memorandum of Understanding, and others followed the early EUROMET Committee meetings. Boras in 1989 was to be the final meeting-place for WEMC. It was agreed then that with the successful establishment and clear progress of EUROMET there was no longer a sufficiently strong case for a separate focus for metrology in Western Europe and therefore that WEMC should be wound up.

Inevitably there were some concerns at the demise of WEMC. It had been a useful forum in which to discuss matters wider than the purely scientific and industrial aspects of metrology. Most particularly, a number of those with responsibilities for legal metrology were concerned. Soundings suggested that there was probably a case for the establishment of a new body specifically concerned with legal metrology in Western Europe. A meeting at PTB held in the autumn of 1989 indicated strong and enthusiastic support for this idea. Thus the concept of WELMEC, the Western European Legal Metrology Cooperation, was born.

WELMEC was formally established by a Memorandum of Understanding in June 1990 between bodies responsible for legal metrology in the EC and EFTA states. Its objectives include the development of mutual confidence between the various services, the harmonisation of legal metrology activities, and the removal of technical or administrative barriers to trade for measuring instruments. The WELMEC Committee meets at least once a year and a good deal of work is inderway through its eight Working Groups.

As mentioned earlier, the Western European Calibration Cooperation (WECC), now a formal vehicle for collaboration between the national calibration services of Western Europe, had its origins at the WEMC meeting at PTB in 1974. The calibration Working Group established there, after a hesitant beginning, was to go from strength to strength over the years. It became somewhat separate from WEMC itself in the late 1970's, although its members were either themselves delegates to WEMC or colleagues of delegates. It continued to report on its activities at WEMC meetings.

WECC played an important part over the years in stimulating the establishment of a number of the national calibration services in Western Europe. It has been involved in the development of published standards for calibration laboratory accreditation and has played an important part in the growth of bilateral agreements of mutual recognition between services. Late in 1989 it established a multilateral agreement, now involving nine countries, which became in 1991 the first Agreement Group of the European Organisation for Testing and Certification (EOTC). Strangely enough, WECC was itself formalised by a Memorandum of Understanding between Western European states only as recently as June 1989.

EUROMET, WECC and WELMEC now cover the field of metrology and calibration in Western Europe and undoubtedly will be influential in the future. It is interesting that all three can be traced back to the informal gatherings of WEMC and the simple initiating thought that those responsible for metrology in Western Europe should maintain contact.

Dr Paul DEAN

EUROMET

Established by the signing of a Memorandum of Understanding by representatives of participating States and the EC Commission in Madrid on 23 September 1987 to become operative from 1 January 1988.

The main purposes of EUROMET are

- to coordinate research into the development of new and improved measurement standards in a shorter time scale and without unnecessary duplication;
- to allow EUROMET Members access to measurements standards of the others;
- to allow Members to cooperate in the provision of measurement standards on a European basis for the small number of physical quantities where demand for traceable calibration does not justify facilities being provided in every Member State;
- to support work in the fields of legal metrology and calibration services, observing the exclusively recommendatory nature of EUROMET.

Members: the EUROMET Committee is composed of

- 18 Delegates from organisations responsible for maintaining measurement standards in EC and EFTA countries and one Delegate from the Commission of the European Communities;
- 2 observers from Western European Calibration Cooperation (WECC) and Western European Legal Metrology Cooperation (WELMEC);
- invited observers for specified meetings.

EUROMET has no permanent seat. The chairman is elected for a period of two years, his term of office is renewable once. EUROMET has no budget of ist own. The funds required come from the member countries' normal budget.

To make cooperation practicable and ensure transparency of the work being done, the field of metrology has been divided into the following areas: Mass - Electricity - Length - Time and Frequency - Thermometry - Ionizing radiation and radioactivity - Photometry and radiometry - Flowrate measurements - Acoustics. The EUROMET Committee elects a rapporteur for each of these areas, who coordinates cooperation in this area in Europe.

There is a contact person for each special field in each country, who submits project proposals to the respective rapporteur and discusses these proposals with him. There are at present 54 agreed EUROMET projects, and another 106 have been proposed.

The addresses of all committee members, rapporteurs and contact persons have been compiled in the EUROMET DIRECTORY which is newly published every year and can be obtained from the EUROMET Secretary. This directory also contains the Memorandum of Understanding.

Chairman: Prof. Dr.-Ing. Dieter Kind, President, Physikalisch-Technische Bundesanstalt,
Bundesallee 100, W-3300 Braunschweig
Phone: + 49 531 592 1000.

Secretary: Dr. Peter Drath, Physikalisch-Technische Bundesanstalt,
Bundesallee 100, W-3300 Braunschweig
Phone: + 49 531 592 8103 FAX: + 49 531 592 4006.

WECC

The Western European Calibration Cooperation (WECC) denotes the collaboration of the national calibration services. The national calibration services comprise, apart from the national calibration laboratory accreditation body (hereafter called accreditation body), its accredited laboratories and their activities. The cooperation started in 1975 and is based on a Memorandum of Understanding signed by representatives of the participating calibration services in Copenhagen on 9 June 1989.

The purpose of the WECC is to build up and maintain mutual confidence between national calibration services in order to reach a state of mutual agreement on the equivalence of the operation of the accreditation bodies and of the certificates issued by accredited laboratories. This supports the removal of technical barriers to trade related to calibration.

A further goal of WECC is to open and maintain channels for a continuous flow of know-how between the participating accreditation bodies in order to establish a common high level of measuring capability.

One of the means for WECC to reach these goals is the publication of the criteria accredited laboratories have to meet and criteria for the operation of the accreditation bodies. These criteria, while being harmonised with the European standards on laboratory accreditation, in particular with EN 45001, EN 45002 and EN 45003, lay down the detailed requirements for calibration laboratories, their assessment, accreditation and surveillance. They also contain procedures to keep Member Bodies informed about each other's activities.

Members: the WECC Committee is composed of

- delegates from the participating calibration services;
- observers from EUROMET, WELAC, WELMEC, EURACHEM and EUROLAB;
- invited observers for specified meetings.

WECC has no permanent seat. The chairman is elected for a period of four years.

WECC has no budget of its own. The funds required come from the calibration services' own budget, with exception of the secretariat which is paid by the member services.

Apart from the WECC Committee, WECC consists of the following groups:

- Executive Committee, to prepare the plenary meetings and to conduct the daily operations;
- four Subcommittees: SC1 on Multilateral Agreements, SC2 on Technical Activities, SC3 on Documentation and SC4 on International Cooperation;
- six expert groups: on low-frequency electrical measurements, high-frequency electrical measurements, dimensional metrology, pressure, temperature, and mechanical measurements;
- three Task Forces: on ionizing radiation & radioactivity, on reference materials, and on liquid & gas flow measurements.

The addresses of contact persons are compiled in WECC Doc. 3, which is newly published every year and can be obtained from all calibration services.

Chairman: Ir. R. Kaarls, Director Van Swinden Laboratory, P.O. Box 654, NL-2600 AR Delft.

Secretary: Dr. O. Mathiesen, SWEDAC, Box 878, S-501 15 Borås.

WELMEC

The Western European Legal Metrology Cooperation (WELMEC) is a cooperation between the bodies responsible for legal metrology in the Member States of the European Community and the countries of EFTA. It was established by the signature of a Memorandum of Understanding in June 1990.

The objectives of WELMEC include

- the development and maintenance of mutual confidence between legal metrology services in Europe;
- the equivalence and harmonisation of legal metrology activities;
- the removal of technical or administrative barriers to trade in the field of measuring instruments.

The WELMEC Committee, which meets at least once a year, consists of one delegate from each of the signaroty bodies as well as observers from the European Commission, the European Free Trade Association (EFTA) Secretariat, the International Organisation of Legal Metrology (OIML), the European Organisation for Testing and Certification (EOTC), EUROMET and WECC. The Chairman of the Committee is elected for a period of two years.

WELMEC has established eight Working Groups as follows

1 STRATEGY (Secretariat: UK)
2 DIRECTIVE IMPLEMENTATION (Secretariat: UK)
3 DATA BASE (Secretariat: Netherlands)
4 EN45000 STANDARDS (Secretariat: Sweden)
5 WELMEC LEGAL METROLOGY REVIEW (Secretariat: UK)
6 PACKAGES (Secretariat: Germany)
7 PERIPHERALS AND COMPUTERS (Secretariat: Germany)
8 MEASURING INSTRUMENTS DIRECTIVE (Secretariat: Netherlands).

Further information about WELMEC and its activities can be obtained from the Chairman or the Secretary.

Chairman: Dr Seton Bennett, Chief Executive, National Weights and Measures Laboratory
Stanton Avenue, Teddington, Middlesex TW11 0JZ.

Secratary: Mr Peter Edwards, National Weights and Measures Laboratory
Stanton Avenue, Teddington, Middlesex TW11 0JZ.

INFORMATIONS

MEMBRES DU COMITÉ – CIML MEMBERS

IRLANDE – Le nouveau représentant de l'Irlande auprès du CIML est Monsieur Seamus MORAN, Secrétaire Adjoint du Ministère de l'Industrie et du Commerce.

IRELAND – The new representative of Ireland in the CIML is Mr Seamus MORAN, Assistant Secretary of the Department of Industry and Commerce.

RUSSIE – Le nouveau représentant de la Russie auprès du CIML est notre ancien Vice-Président Dr L.K. ISSAEV.

RUSSIA – The new CIML representative of Russia is our previous Vice-President Dr L.K. ISSAEV.

MEMBRES CORRESPONDANTS – CORRESPONDING MEMBERS

La MONGOLIE a récemment été admise comme membre correspondant de l'OIML.

MONGOLIA has recently been admitted as corresponding member of OIML.

PUBLICATIONS

		Edition
	Vocabulaire de métrologie légale *Vocabulary of legal metrology*	1978
	Vocabulaire international des termes fondamentaux et généraux de métrologie *International vocabulary of basic and general terms in metrology*	en révision *being revised*
	Dictionnaire des essais de dureté (français, anglais, allemand, russe) *Hardness testing dictionary (French, English, German, Russian)*	1991

RECOMMANDATIONS INTERNATIONALES
INTERNATIONAL RECOMMENDATIONS

R 1 —	Poids cylindriques de 1 g à 10 kg (de la classe de précision moyenne) *Cylindrical weights from 1 g to 10 kg (medium accuracy class)*	1973
R 2 —	Poids parallélépipédiques de 5 à 50 kg (de la classe de précision moyenne) *Rectangular bar weights from 5 to 50 kg (medium accuracy class)*	1973
R 4 —	Fioles jaugées (à un trait) en verre *Volumetric flasks (one mark) in glass*	1970
R 5 —	Compteurs de liquides autres que l'eau à chambres mesureuses *Meters for liquids other than water with measuring chambers*	1981
R 6 —	Dispositions générales pour les compteurs de volume de gaz *General provisions for gas volume meters*	1989
R 7 —	Thermomètres médicaux (à mercure, en verre, avec dispositif à maximum) *Clinical thermometers (mercury-in-glass, with maximum device)*	1978
R 9 —	Vérification et étalonnage des blocs de référence de dureté Brinell *Verification and calibration of Brinell hardness standardized blocks*	1970
R 10 —	Vérification et étalonnage des blocs de référence de dureté Vickers *Verification and calibration of Vickers hardness standardized blocks*	1970
R 11 —	Vérification et étalonnage des blocs de référence de dureté Rockwell B *Verification and calibration of Rockwell B hardness standardized blocks*	1970
R 12 —	Vérification et étalonnage des blocs de référence de dureté Rockwell C *Verification and calibration of Rockwell C hardness standardized blocks*	1970
R 14 —	Saccharimètres polarimétriques *Polarimetric saccharimeters*	1978
R 15 —	Instruments de mesure de la masse à l'hectolitre des céréales *Instruments for measuring the hectolitre mass of cereals*	1970
R 16 —	Manomètres des instruments de mesure de la tension artérielle (sphygmomano-mètres) *Manometers for instruments for measuring blood pressure (sphygmomanometers)*	1970

R 18	—	Pyromètres optiques à filament disparaissant *Visual disappearing filament pyrometers*	1989
R 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*	1973
R 21	—	Taximètres *Taximeters*	1973
R 22	—	Tables alcoométriques internationales *International alcoholometric tables*	1975
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R 27	—	Compteurs de volume de liquides (autres que l'eau). Dispositifs complémentaires. *Volume meters for liquids (other than water). Ancillary equipment*	1973
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R 30	—	Mesures de longueur à bouts plans (calibres à bouts plans ou cales-étalons) *End standards of length (gauge blocks)*	1981
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R 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*	1989
R 33	—	Valeur conventionnelle du résultat des pesées dans l'air *Conventional value of the result of weighing in air*	1973
R 34	—	Classes de précision des instruments de mesurage *Accuracy classes of measuring instruments*	1974
R 35	—	Mesures matérialisées de longueur pour usages généraux *Material measures of length for general use*	1985
R 36	—	Vérification des pénétrateurs des machines d'essai de dureté *Verification of indenters for hardness testing machines*	1977
R 37	—	Vérification des machines d'essai de dureté (système Brinell) *Verification of hardness testing machines (Brinell system)*	1977
R 38	—	Vérification des machines d'essai de dureté (système Vickers) *Verification of hardness testing machines (Vickers system)*	1977

R 39	—	Vérification des machines d'essai de dureté (systèmes Rockwell B, F, T - C, A, N) *Verification of hardness testing machines (Rockwell systems B, F, T - C, A, N)*	1977
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R 44	—	Alcoomètres et aréomètres pour alcool et thermomètres utilisés en alcoométrie *Alcoholometers and alcohol hydrometers and thermometers for use in alcoholometry*	1985
R 45	—	Tonneaux et futailles *Casks and barrels*	1977
R 46	—	Compteurs d'énergie électrique active à branchement direct (de la classe 2) *Active electrical energy meters for direct connection (class 2)*	1978
R 47	—	Poids étalons pour le contrôle des instruments de pesage de portée élevée *Standard weights for testing of high capacity weighing machines*	1978
R 48	—	Lampes à ruban de tungstène pour l'étalonnage des pyromètres optiques *Tungsten ribbon lamps for calibration of optical pyrometers*	1978
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R 55	—	Compteurs de vitesse, compteurs mécaniques de distance et chronotachygraphes des véhicules automobiles - Réglementation métrologique *Speedometers, mechanical odometers and chronotachographs for motor vehicles. Metrological regulations*	1981
R 56	—	Solutions-étalons reproduisant la conductivité des électrolytes *Standard solutions reproducing the conductivity of electrolytes*	1981
R 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*	1982

R 58	—	Sonomètres *Sound level meters*	1984
R 59	—	Humidimètres pour grains de céréales et graines oléagineuses *Moisture meters for cereal grains and oilseeds*	1984
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R 64	—	Exigences générales pour les machines d'essai des matériaux *General requirements for materials testing machines*	1985
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R 68	—	Méthode d'étalonnage des cellules de conductivité *Calibration method for conductivity cells*	1985
R 69	—	Viscosimètres à capillaire, en verre, pour la mesure de la viscosité cinématique *Glass capillary viscometers for the measurement of kinematic viscosity*	1985
R 70	—	Détermination des erreurs de base et d'hystérésis des analyseurs de gaz *Determination of intrinsic and hysteresis errors of gas analysers*	1985
R 71	—	Réservoirs de stockage fixes. Prescriptions générales *Fixed storage tanks. General requirements*	1985
R 72	—	Compteurs d'eau destinés au mesurage de l'eau chaude *Hot water meters*	1985
R 73	—	Prescriptions pour les gaz purs CO, CO_2, CH_4, H_2, O_2, N_2 et Ar destinés à la préparation des mélanges de gaz de référence *Requirements concerning pure gases, CO, CO_2, CH_4, H_2, O_2, N_2 and Ar intended for the preparation of reference gas mixtures*	1985
R 74	—	Instruments de pesage électroniques *Electronic weighing instruments*	en révision *being revised*
R 75	—	Compteurs d'énergie thermique *Heat meters*	1988

R 76 — Instruments de pesage à fonctionnement non automatique
Nonautomatic weighing instruments

Partie 1 : Exigences métrologiques et techniques - Essais — 1992
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R 77 — Ensembles de mesurage de liquides autres que l'eau équipés de compteurs de volumes. Dispositions particulières relatives à certains ensembles — 1989
Measuring assemblies for liquids other than water fitted with volume meters. Provisions specific to particular assemblies

R 78 — Pipettes Westergren pour la mesure de la vitesse de sédimentation des hématies — 1989
Westergren tubes for measurement of erythrocyte sedimentation rate

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R 80 — Camions et wagons-citernes — 1989
Road and rail tankers

R 81 — Dispositifs et systèmes de mesure de liquides cryogéniques (comprend tables de masse volumique pour argon, hélium, hydrogène, azote et oxygène liquides) — 1989
Measuring devices and measuring systems for cryogenic liquids (including tables of density for liquid argon, helium, hydrogen, nitrogen and oxygen)

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Gas chromatographs for measuring pollution from pesticides and other toxic substances

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R 102	—	Calibreurs acoustiques *Sound calibrators*	1992
R 103	—	Appareillage de mesure pour la réponse des individus aux vibrations *Measuring instrumentation for human response to vibration*	1992
R 104	—	Audiomètres à son pur *Pure-tone audiometers*	(*)

DOCUMENTS INTERNATIONAUX
INTERNATIONAL DOCUMENTS

D 1	—	Loi de métrologie *Law on metrology*	1975
D 2	—	Unités de mesure légales *Legal units of measurement*	en révision *being revised*
D 3	—	Qualification légale des instruments de mesurage *Legal qualification of measuring instruments*	1979
D 4	—	Conditions d'installation et de stockage des compteurs d'eau froide *Installation and storage conditions for cold water meters*	1981

D 5 —	Principes pour l'établissement des schémas de hiérarchie des instruments de mesure *Principles for the establishment of hierarchy schemes for measuring instruments*	1982
D 6 —	Documentation pour les étalons et les dispositifs d'étalonnage *Documentation for measurement standards and calibration devices*	1983
D 7 —	Évaluation des étalons de débitmétrie et des dispositifs utilisés pour l'essai des compteurs d'eau *The evaluation of flow standards and facilities used for testing water meters*	1984
D 8 —	Principes concernant le choix, la reconnaissance officielle, l'utilisation et la conservation des étalons *Principles concerning choice, official recognition, use and conservation of measurement standards*	1984
D 9 —	Principes de la surveillance métrologique *Principles of metrological supervision*	1984
D 10 —	Conseils pour la détermination des intervalles de réétalonnage des équipements de mesure utilisés dans les laboratoires d'essais *Guidelines for the determination of recalibration intervals of measuring equipment used in testing laboratories*	1984
D 11 —	Exigences générales pour les instruments de mesure électroniques *General requirements for electronic measuring instruments*	en révision *being revised*
D 12 —	Domaines d'utilisation des instruments de mesure assujettis à la vérification *Fields of use of measuring instruments subject to verification*	1986
D 13 —	Conseils pour les arrangements bi- ou multilatéraux de reconnaissance des résultats d'essais, approbations de modèles et vérifications *Guidelines for bi- or multilateral arrangements on the recognition of test results, pattern approvals and verifications*	1986
D 14 —	Formation du personnel en métrologie légale - Qualification - Programmes d'étude *Training of legal metrology personnel - Qualification - Training programmes*	1989
D 15 —	Principes du choix des caractéristiques pour l'examen des instruments de mesure usuels *Principles of selection of characteristics for the examination of measuring instruments*	1986
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D 20 —	Vérifications primitive et ultérieure des instruments et processus de mesure *Initial and subsequent verification of measuring instruments and processes*	1988

D 21 — Laboratoires secondaires d'étalonnage en dosimétrie pour l'étalonnage des dosimètres utilisés en radiothérapie — 1990
Secondary standard dosimetry laboratories for the calibration of dosimeters used in radiotherapy

D 22 — Guide sur les instruments portatifs pour l'évaluation des polluants contenus dans l'air en provenance des sites de décharge de déchets dangereux — 1991
Guide to portable instruments for assessing airborne pollutants arising from hazardous wastes

D 23 — Principes du contrôle métrologique des dispositifs utilisés pour les vérifications — (*)
Principles for the metrological control of devices used for verification

(*) Publication en cours d'impression/*Publication being printed.*

Note — Ces publications peuvent être acquises au / *These publications may be purchased from* Bureau International de Métrologie Légale, 11, rue Turgot, 75009 PARIS.

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