

The origins and early years of the Metre Convention and the BIPM

Terry Quinn

The Metre and Kilogram of the Archives





Photo TJQ



Photo TJQ

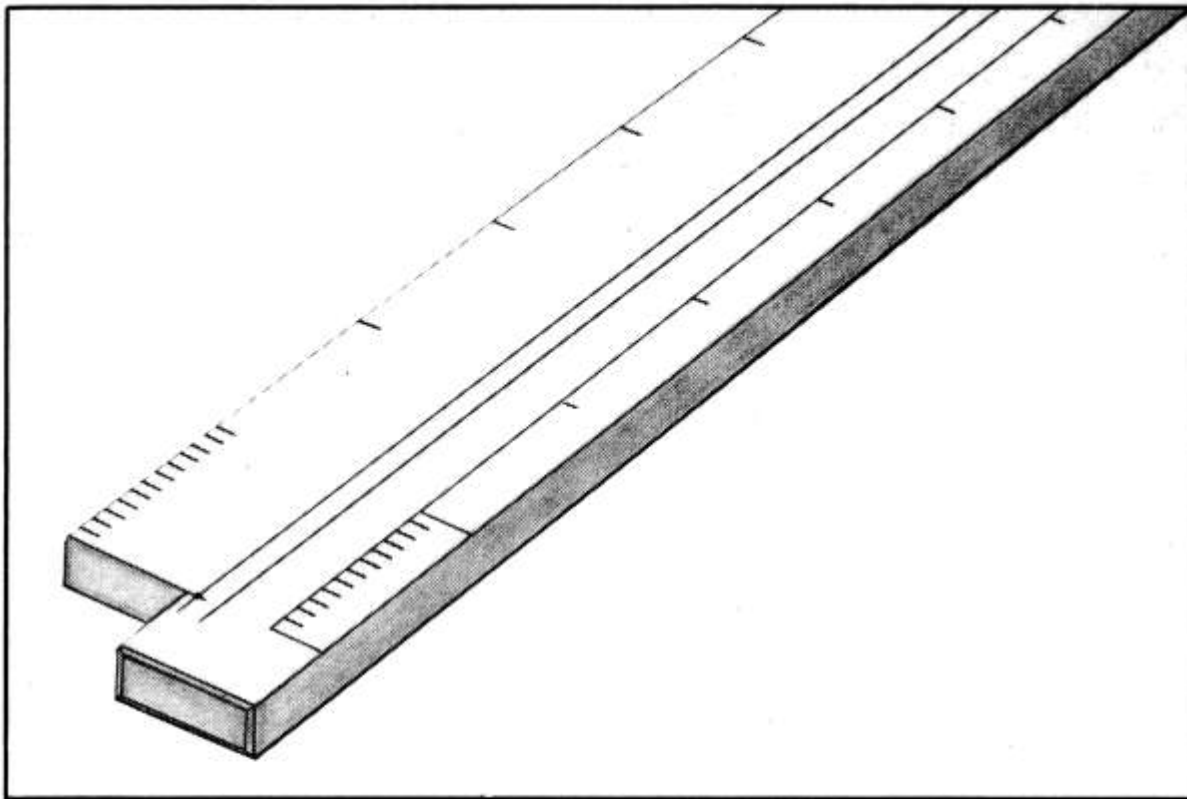
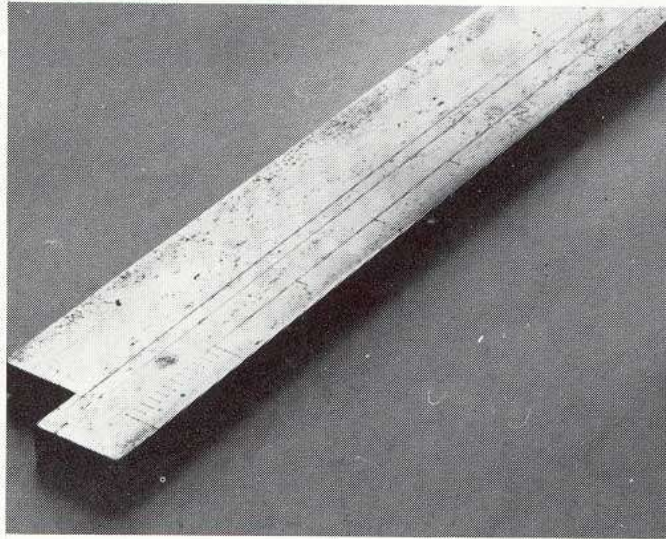


Fig. 1. — L'une des extrémités de la Toise du Pérou ou de l'Académie (1735).

La division comprend un premier intervalle de 1 pouce (27,07 mm) subdivisé en 12 lignes (2,256 mm) puis cinq intervalles de 1 pouce et ensuite des intervalles de 3 en 3 pouces jusqu'à l'autre extrémité. On voit aussi l'un des points de la «Toise à points».

Le couvercle de la boîte de cet étalon porte l'inscription Toise de l'Académie qui a servi à mesurer la grandeur du degré sous l'Equateur et sur laquelle ont été réglées les toises qui ont été envoyées, par ordre du Roy, dans les principales villes du Royaume, précédée d'une gravure d'armoiries avec la devise Invenit et Perficit.

Defined at 13°
Réaumur equal
to 16.25 °C



“Toise du Pérou” from the “Académie,” conserved in the “Observatoire de Paris.” On the right, the plate attached to the case.

The Second International Conference for the Measurement of Degrees in Europe Berlin October 1867 (the first having been in Berlin in 1864)

The Conference made 10 Recommendations:

1. On the need to compare standards of length and obtain new comparators
2. Set up a special commission to oversee this
3. Start research on the time variation of thermal expansion coefficients of standards
4. In everyone's interest to have a single system of weights and measures in Europe
5. Recommends the metric system
6. Recommends the metric system without change, opposes the metric foot
7. **Recommends the construction of a new European prototype of the metre to be based on the Metre of the Archives**
8. Construction to be entrusted to an international commission
9. **Recommends the creation of a European international bureau of weights and measures**
10. Recommends delegates to bring these Recommendations to the attention of their governments

Who initiated all this:

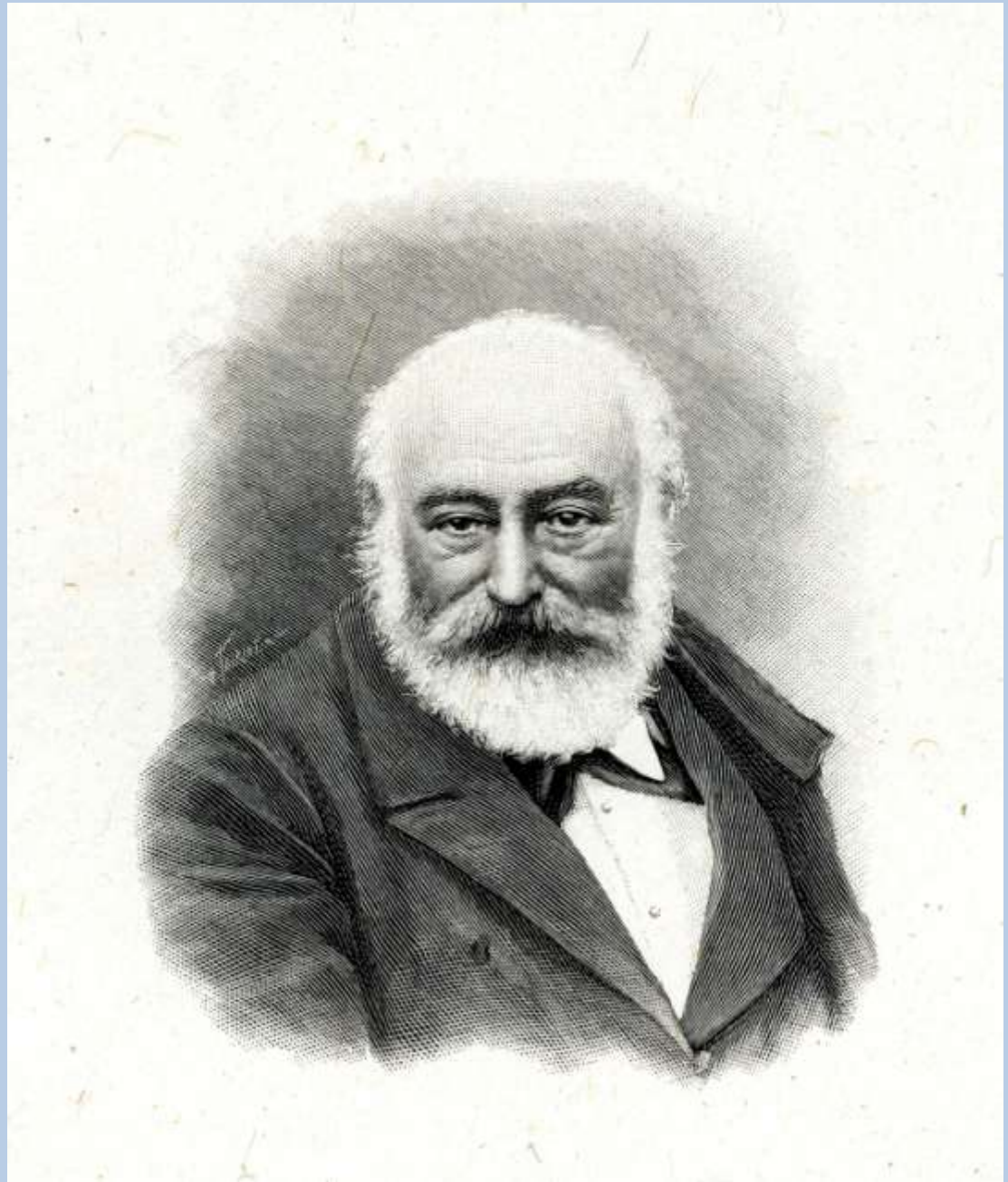
Otto Struve from Saint Petersburg and Adolph Hirsch from Neuchatel who formulated the Recommendations



Otto Wilhelm von Struve (May 7, 1819 – April 14, 1905) was a prominent Russian astronomer, Director of the Pulkovo Observatory (Saint Petersburg) between 1862 and 1889

Adolph Hirsch 1830-1901
Director of the Observatoire
de Neuchâtel

One of the originators of the
Metre Convention and
Secretary of the Comité
international des poids et
mesures from 1875 to 1901



Claude-Louis Mathieu

1783-1875

Member of the Académie des
sciences

President of the International
Metre Commission 1869-1875



Général Arthur Morin 1797-
1880

Member of the Académie des
sciences

Director, Conservatoire Impérial
des arts et métiers, Paris

Member of the Comité
international des poids et
mesures 1875-1880



Wilhelm Foerster 1832-1921
Director of the Berlin
Observatory

President of the Comité
international des poids et
mesures 1891-1920



Jean-Baptiste Dumas
1800-1884

Member of the Académie des
sciences

President of the Special
Commission of the Diplomatic
Conference on the Metre, 1
March to 20 May 1875



J. B. DUMAS

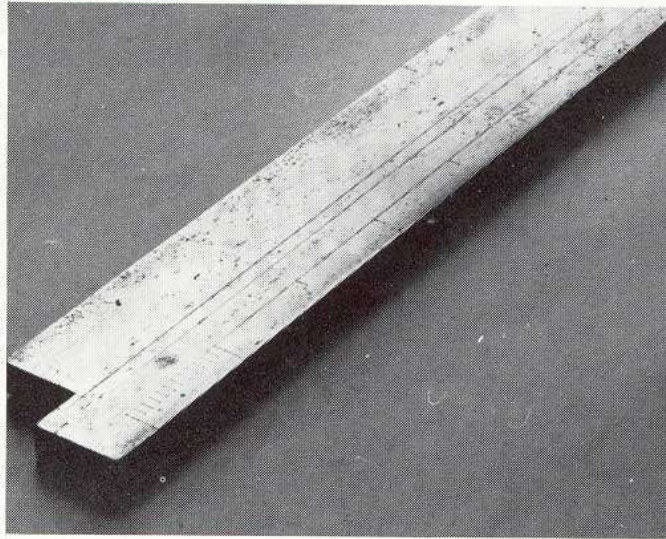
SECRÉTAIRE GÉNÉRAL DE L'INSTITUT IMPÉRIAL DE FRANCE (ACADÉMIE DES SCIENCES)
PRÉSIDENT DE LA SOCIÉTÉ D'ENCOURAGEMENT POUR L'INDUSTRIE NATIONALE.

Carlos Ibañez de Ibero, Marquis de
Mulhacén 1825-1891

Directeur de l'Institut Geographique de
Madrid

1st President du Comité international des
poids et mesures 1875-1891





“Toise du Pérou” from the “Académie,” conserved in the “Observatoire de Paris.” On the right, the plate attached to the case.

The metre is equal to one ten millionth part of the quarter of the terrestrial meridian

The kilogram is equal to the mass of a decimetre cube of water at the temperature of melting ice

The quarter of the terrestrial meridian , deduced from the measurements of Pierre-Francois Méchain and Jean- Baptiste Delambre, was:

5 130 740 toise du Pérou, thus

1 mètre = 443,296 lignes of the toise du Pérou

What was the definition of the metre?

Photo TJQ



The kilogram is the mass of one cubic decimetre of water at the temperature of melting ice.

The kilogram is the mass of the Kilogram of the Archives.

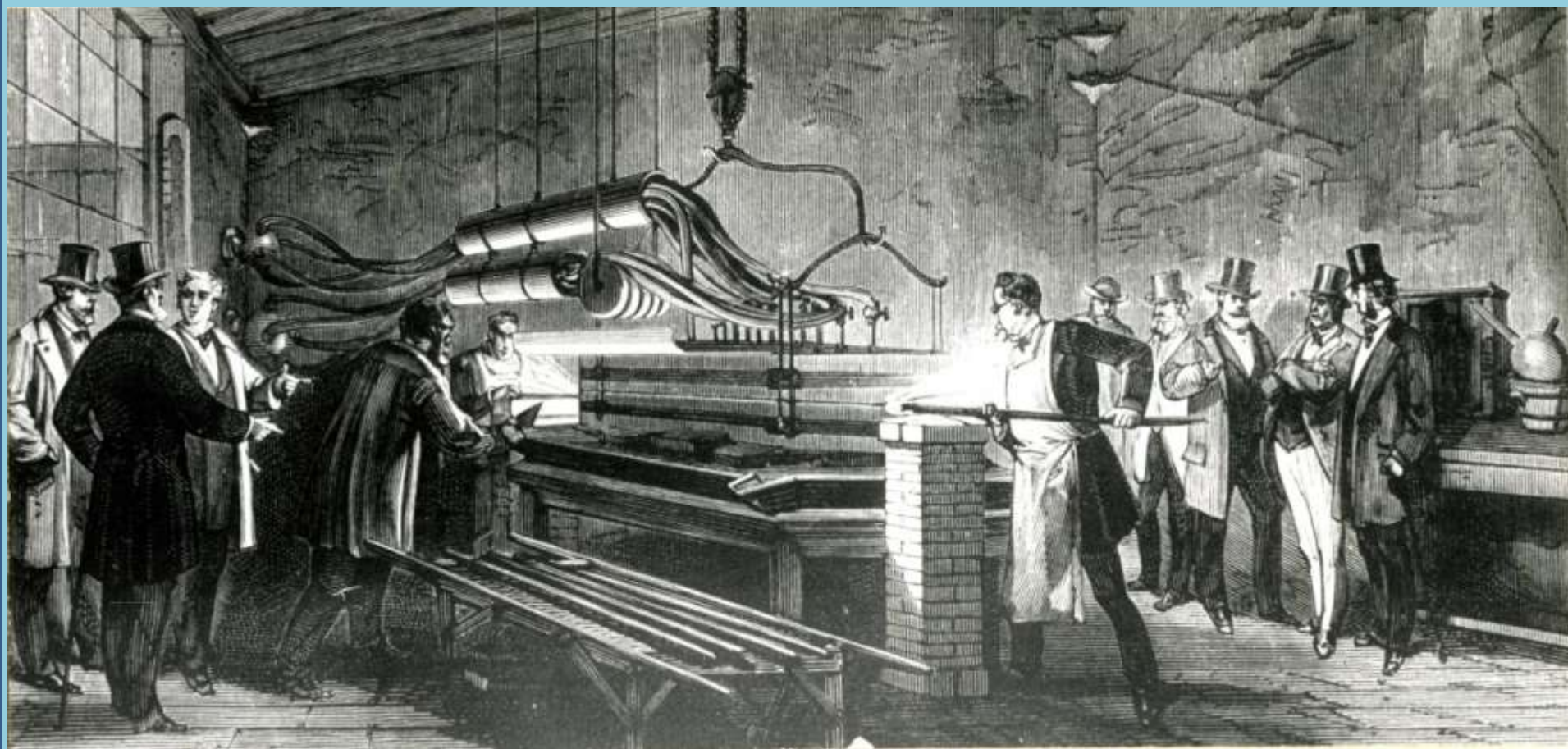
What was the definition of the kilogram?



One of a set of fifty Sèvres vases made
for members of the International Metre
Commission 1872

Eugene Peligot was a French member of
the Commission and was later much
involved in the preparation of the Pt-Ir
alloy for the metres and kilograms





Casting of one of the 1874 Conservatoire alloys in the presence of high dignitaries including the President of the Republic.



The International Prototype of the Kilogram K
No. III of a set of three made by Johnson-Matthey in London in 1879, chosen as
the one closest in mass to that of the Kilogram of the Archives

The Pavillon de Breteuil in 1875,
damaged during the Franco-
Prussian war of 1870







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Portrait du baron de Breteuil montrant de la main droite les plans des hôpitaux du nouvel Hôtel-Dieu (cliché château de Breteuil, d'après une copie, par Laurent Mosnier (1743-1808), du tableau du baron figurant au Louvre)

Plan de la Maison occupé ci devant par l'émigré Breteuil.

Situé dans le parc de front la montagne (du nord et du sud) et autres bâtiments dépendants et terrain environnant, divisés formant trois lots.

Explication.

- 1^{er} Lot.**
 A. principal corps de logis contenant 100. per. 14. joints de l'ancien rangé la partie de la petite cour ci. 100. per. 14. joints
 B. terrain vague s'étendant de la dite maison, et servant de pignon à l'ancien bâtiment de la terrasse formant la partie
 C. La terrasse en parties formant bache adroit de l'ancien bâtiment, et du terrain marqué en rouge contenant 100. per. 14. joints
 D. le jardin adroit de la terrasse contenant un arpent dix huit perches, jusqu'à la ligne rouge de séparation du 2nd lot. 1. ar. 18. per.
 E. jardin entre la maison propre d'après un arpent à la dite maison contenant 24. perches y compris parties de la cour
 F. autres bâtiments compris d'ancien, rénovés et autres annexes, bas du terrain vague au pignon
 Ensemble contenant ensemble 30. per. 14. joints

Lequel 1^{er} lot contient en totalité compris les dépendances d'ancien bâtiment

- 2nd Lot.**
 G. Champ labouré de l'ancien et les trois parties de l'ancien terrain rouge clair contenant ensemble 3. arp. 24. per. 14. joints
 H. petit jardin potager des dépendances formant partie contenant 0. ar. 22. per. 0.
 I. jardins sur les quels il y a plusieurs arbres de haute taille, contenant 0. ar. 24. per. 0.
 K. autres parties de l'ancien terrain rouge clair, contenant 1. ar. 16. per. 0.

- 3^{me} Lot.**
 L. Terrain et terrain adjoint, et autres parties annexes, plantées en parties en bois taillé compris l'ancien bâtiment, 3. arp. 24. per. 14. joints

- 4^{me} Lot.**
 M. bois taillé compris l'ancien bâtiment et y compris autres dépendances contenant ensemble 1. ar. 24. per. 0.
 N. jardin contenant 0. ar. 24. per. 0.

- 5^{me} Lot.**
 O. Maison terre en labour, et jardins contenant en totalité compris huit joints au delà de l'ancien 0. ar. 24. per. 0.
 P. terrain (celui de l'ancien) 0. ar. 24. per. 0.

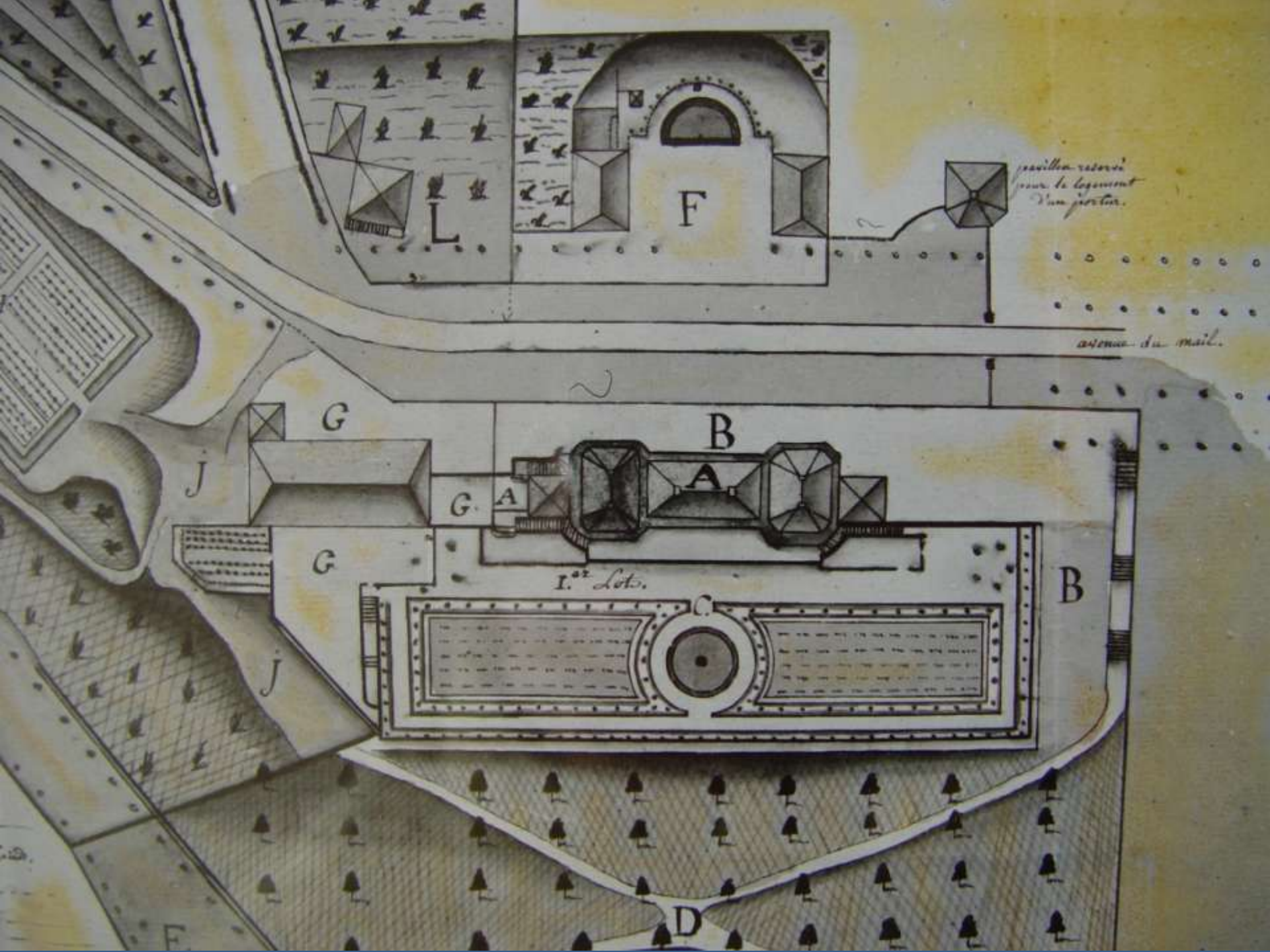
- 6^{me} Lot.**
 Q. parties de terrain labouré, et autres parties triangulaires plantées en bois contenant ensemble 1. ar. 24. per. 0.
 R. autres parties de terrain labouré, et autres parties triangulaires plantées en bois contenant ensemble 0. ar. 24. per. 0.

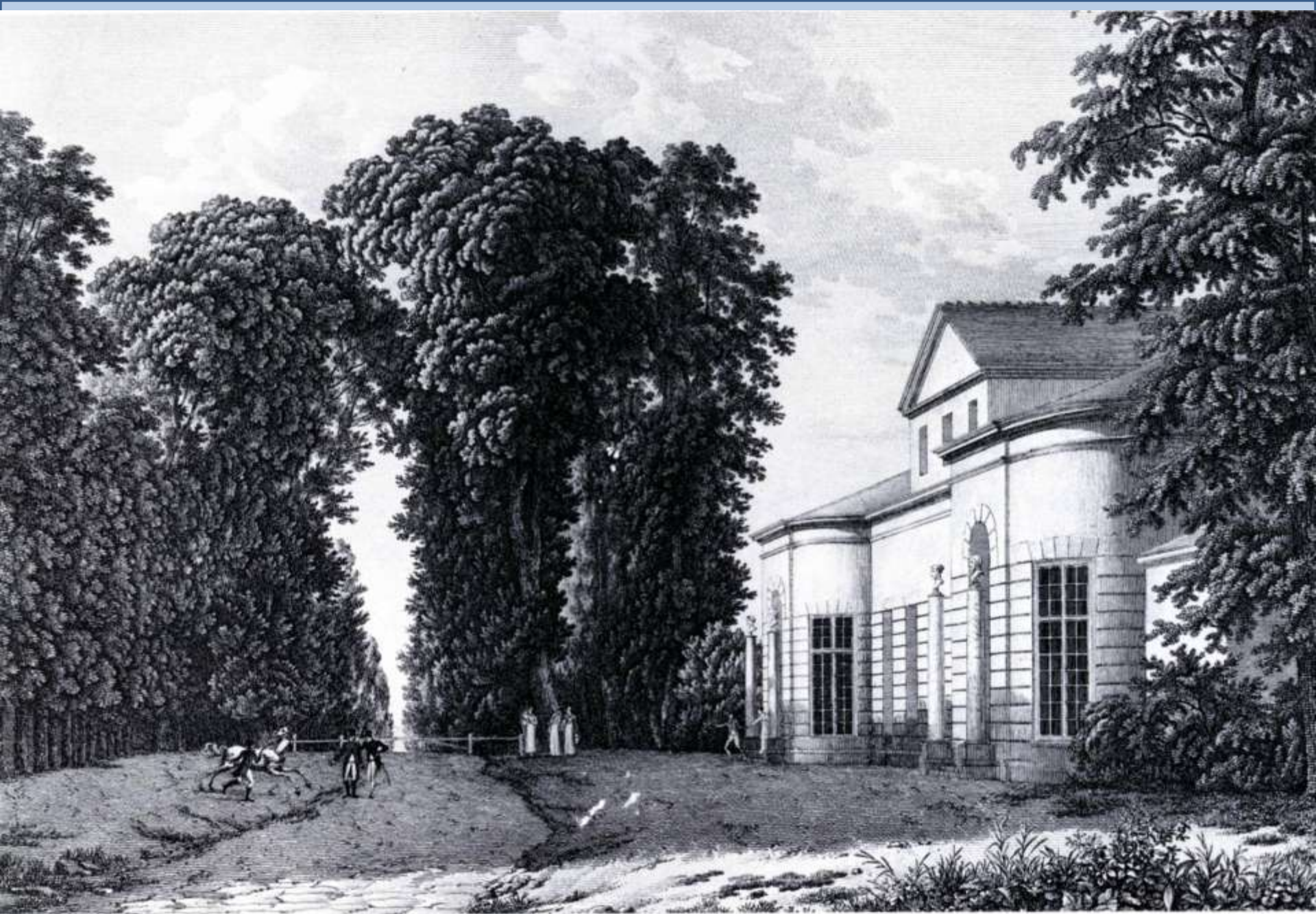
- 7^{me} et dernier Lot.**
 S. terrain labouré contenant 2. arp. 64. perches compris huit joints au delà de l'ancien 2. arp. 64. per. 0.
 T. terrain, celui de l'ancien 0. ar. 24. per. 0.

Recapitulation

1^{er} Lot -

2. arp. 64. perches







*Pavillon Boréouit
Parc de St. Cloud*





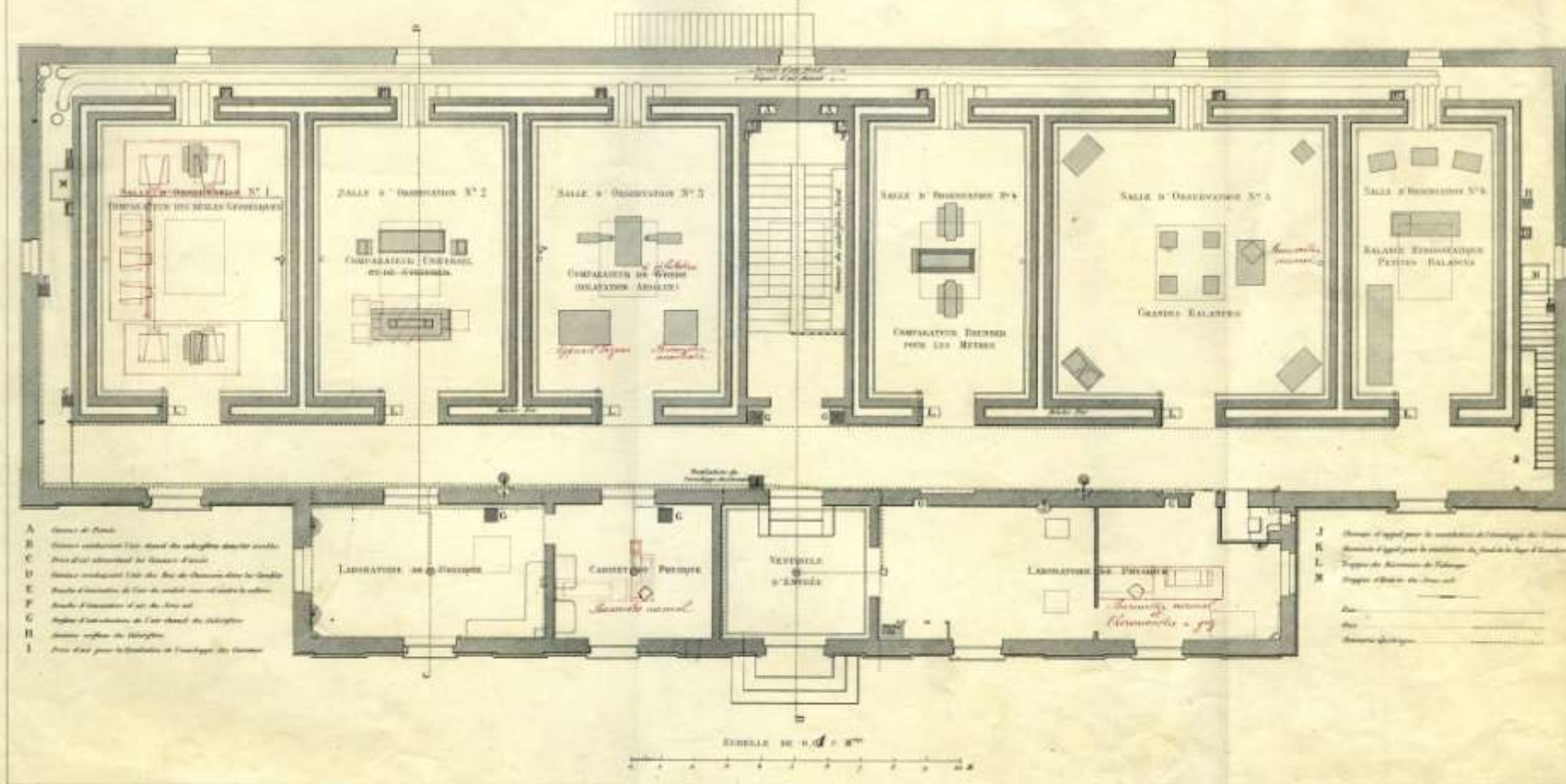
The BIPM in the 1930s



Image BIPM

The Observatory in 1929

Observatoire



The Observatoire, as it was when first occupied in 1878 with hand-written modifications c1890



The vault of the prototypes containing the International prototypes of the metre and the Kilogram plus their official copies. This was replaced by a modern safe in the 1990s

5.

Métre internationale



The storage and carrying case of prototype metres

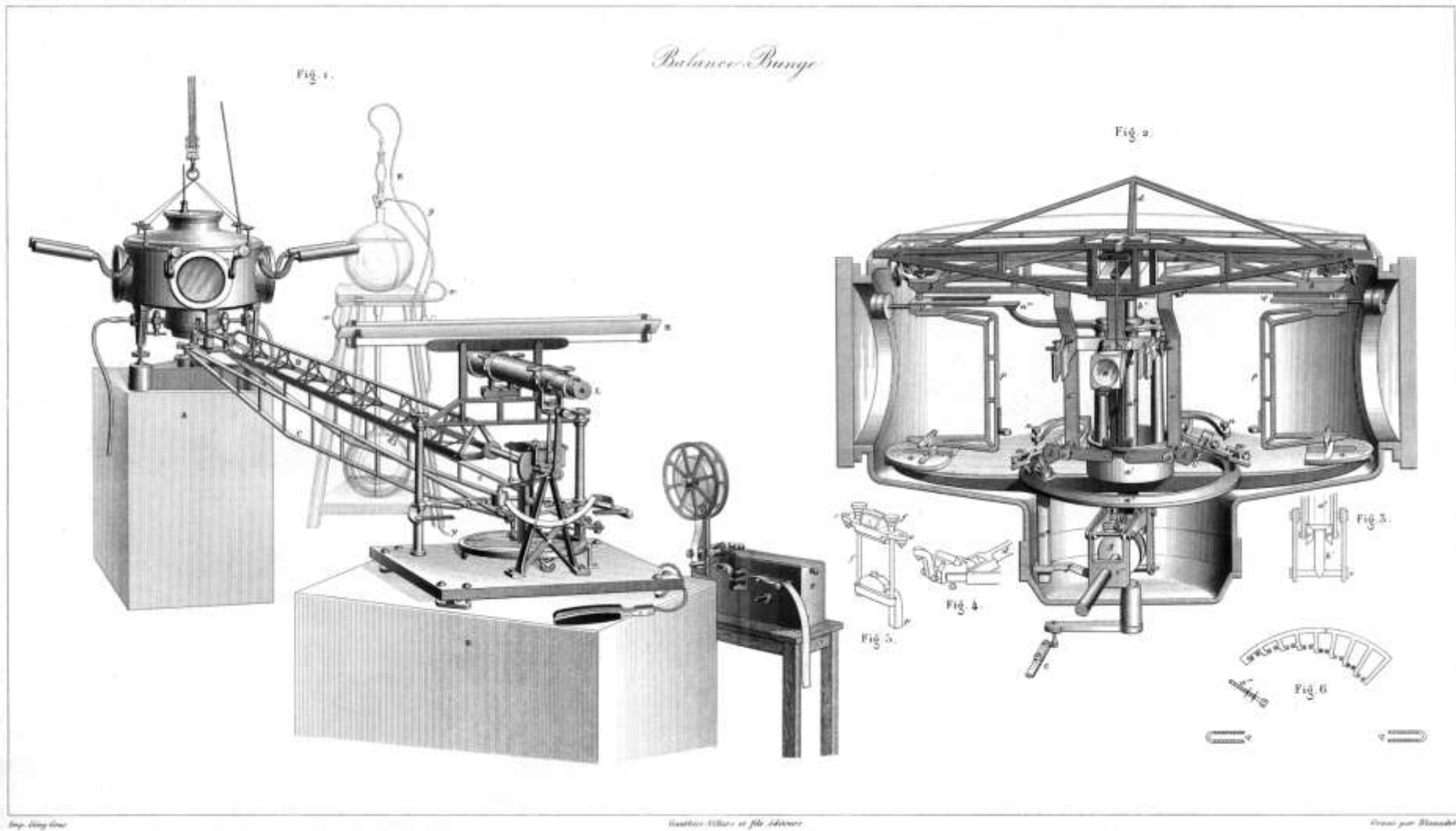
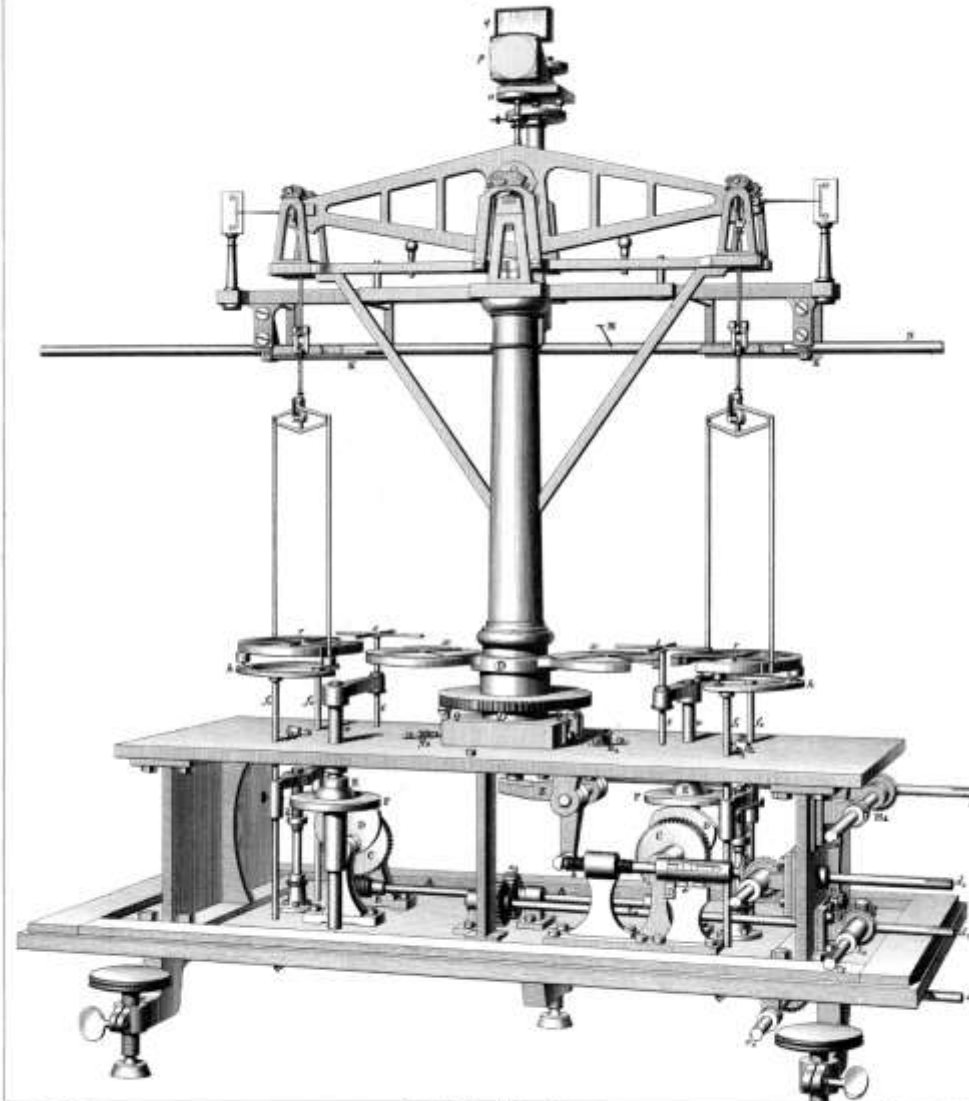


Plate 18: The Bunge balance, installed in 1879 was designed to compare 1 kg prototypes in vacuum, not easy to use and few vacuum studies were made, it still exists at the BIPM, *Travaux et Mémoires*, Vol IX, 1898. (Courtesy BIPM.)

PESÉES

Balance Ruprecht N°1

Imp. Buisson Paris

Gauthier-Villars, Éditeur à Paris

Gravé par Buisson

Plate 17: The Ruprecht No. 1 balance, installed in Room 5 with all the other balances, was the principal balance for the comparison of 1 kg prototypes from 1878 until 1973, it still exists at the BIPM, *Travaux et Mémoires*, Vol I, 1881. (Courtesy BIPM.)

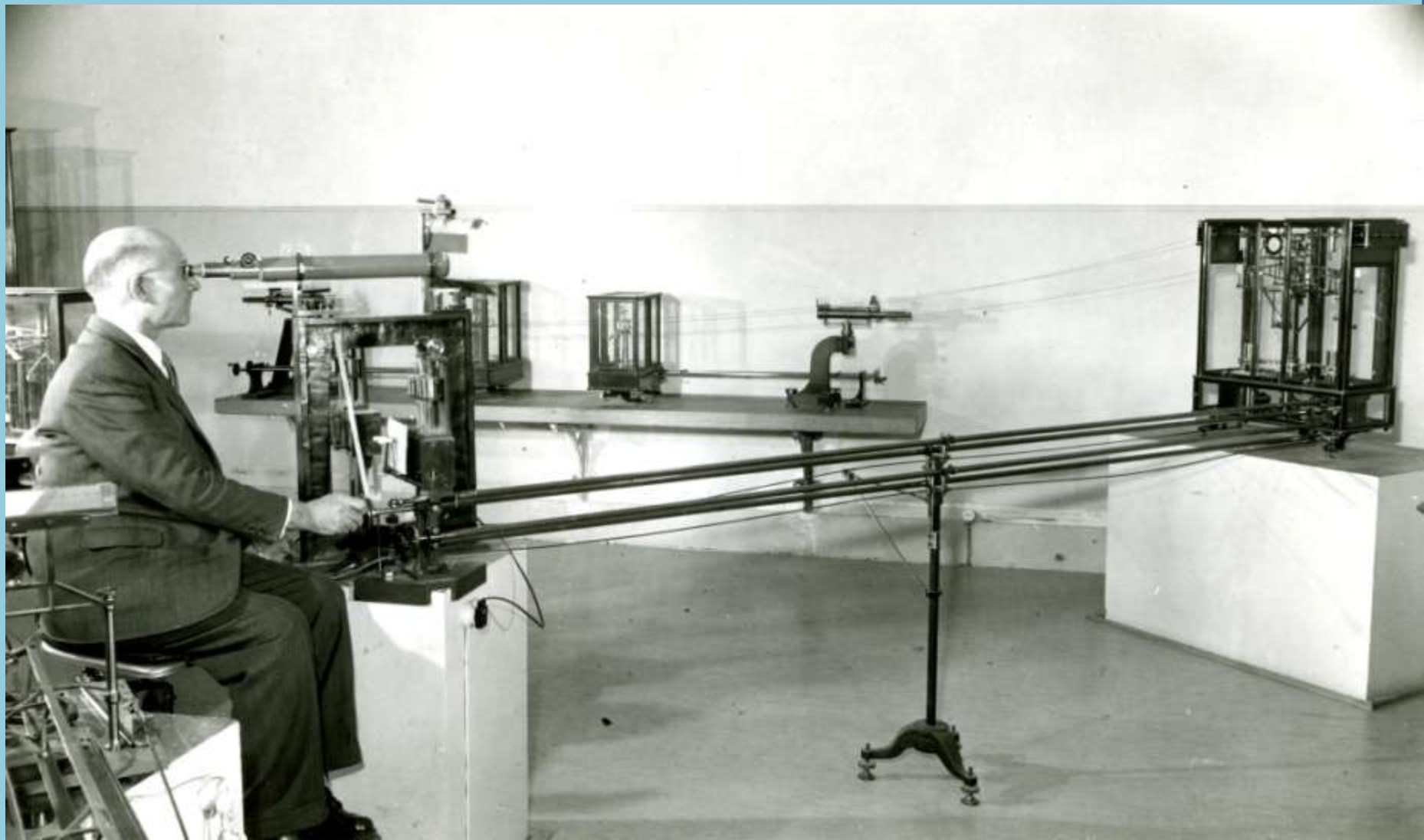


Image BIPM

Comparateur à dilatation

Fondations

Fig. 1.

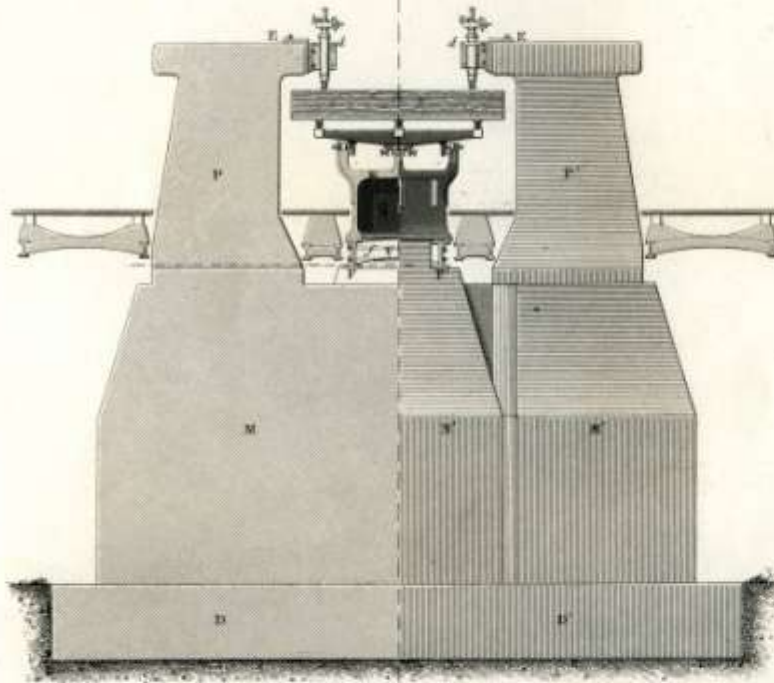
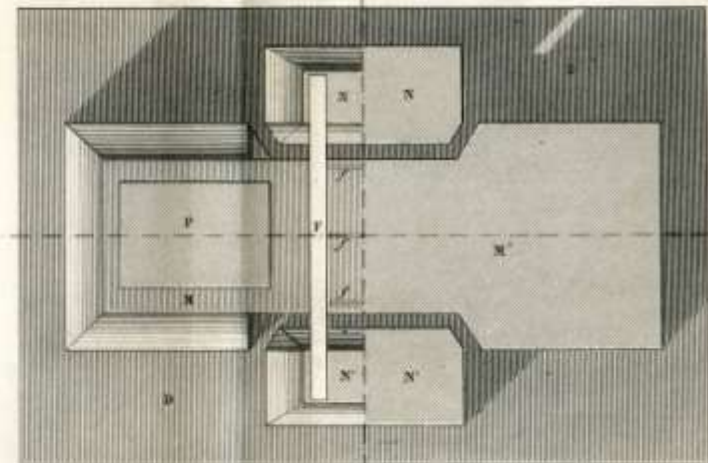


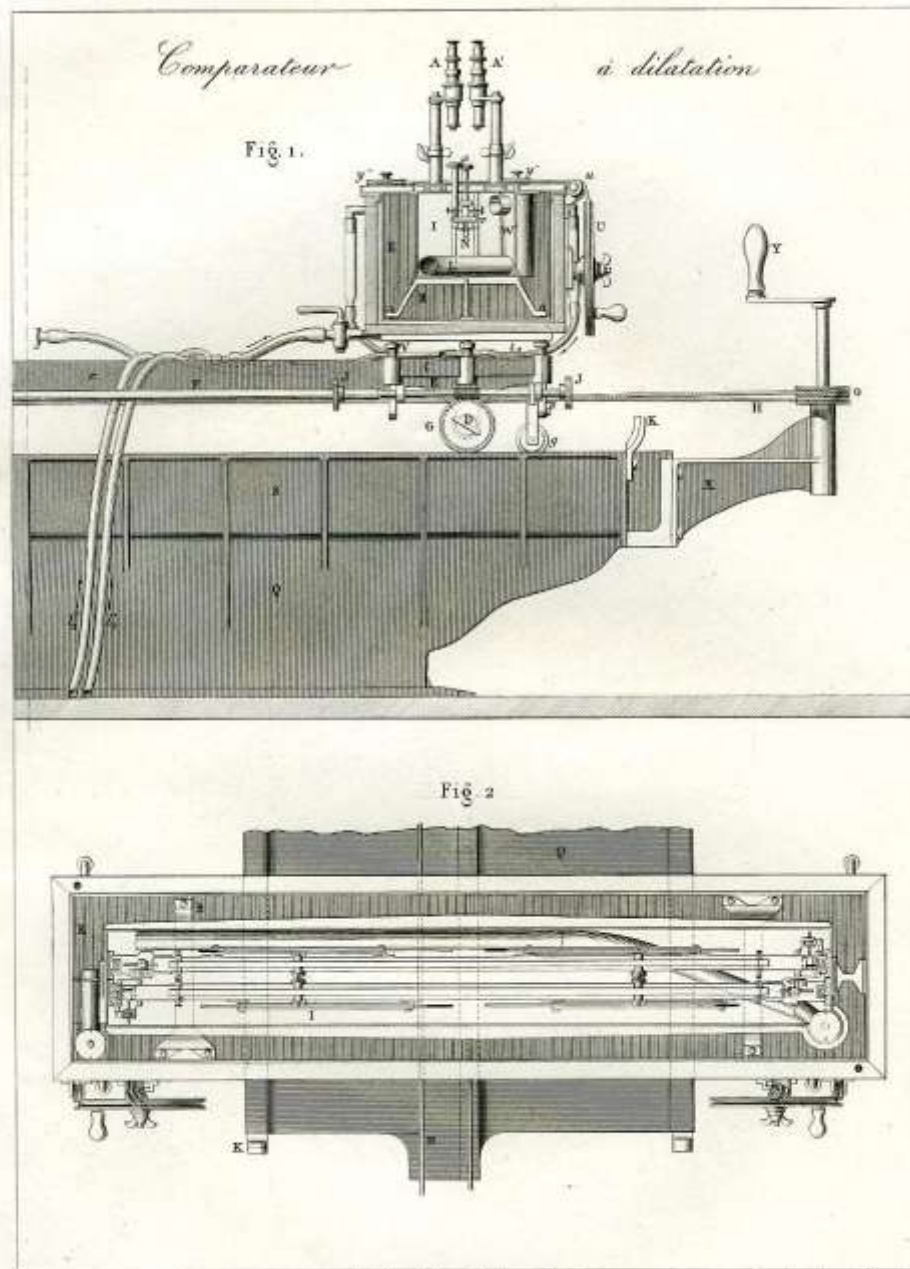
Fig. 2



Echelle 1/20

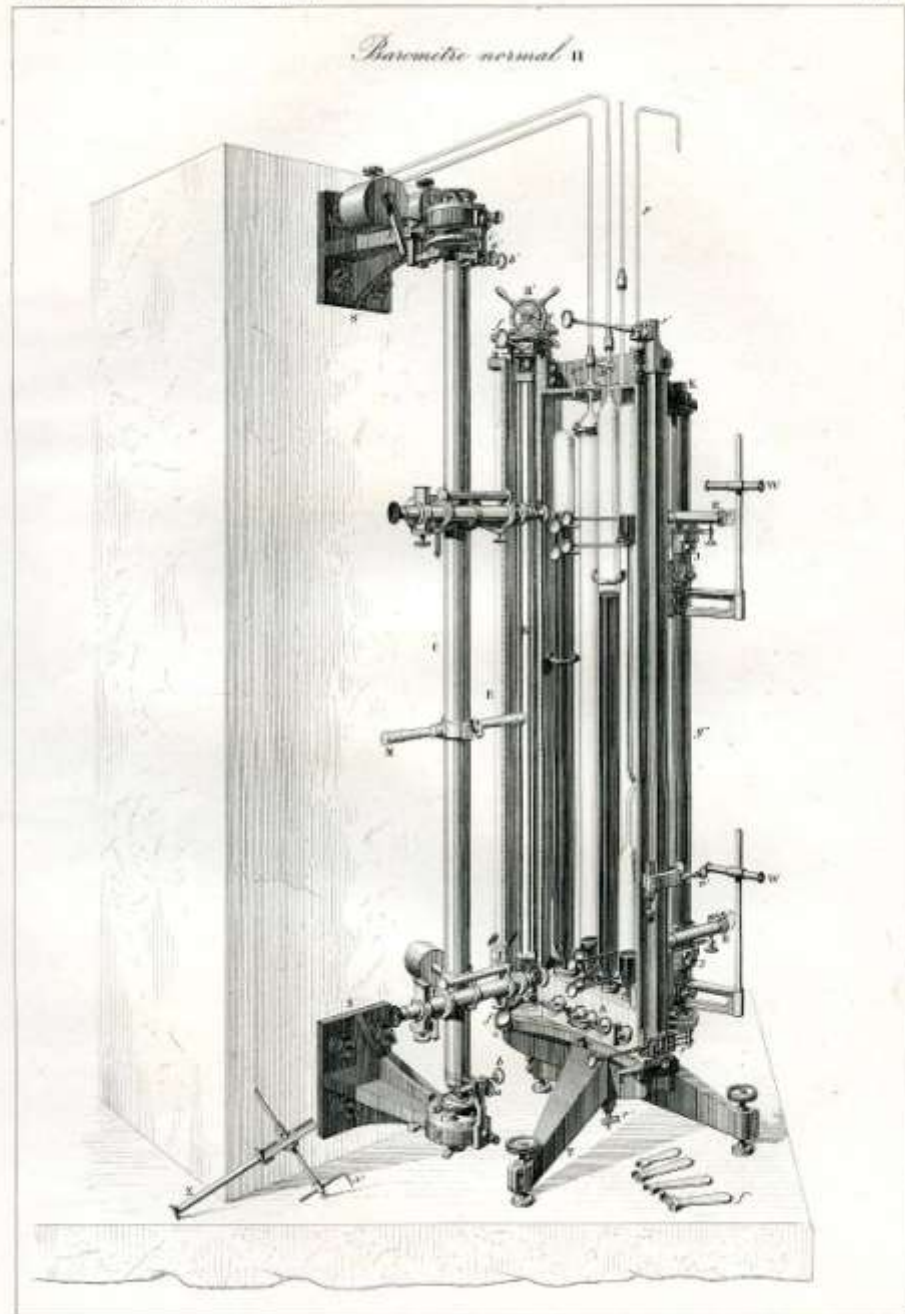


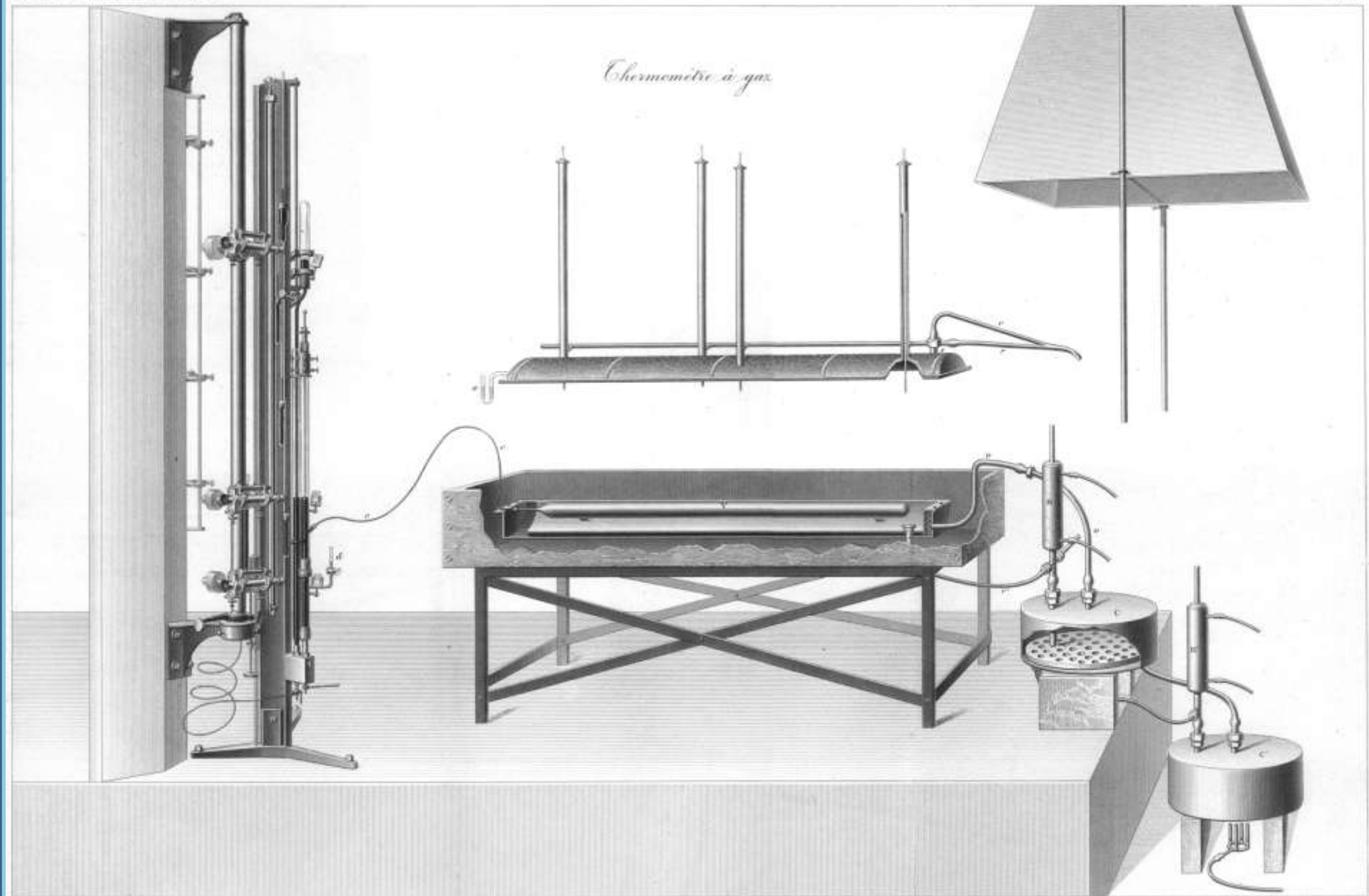
Thermal expansion comparator for metre bars installed in Room 3 of the Observatoire



The primary barometer installed in one of the front rooms of the Observatoire, used for the hydrogen gas thermometry in the 1880s. It served as the BIPM primary barometer until the 1960s

Image BIPM



Thermomètre à gaz

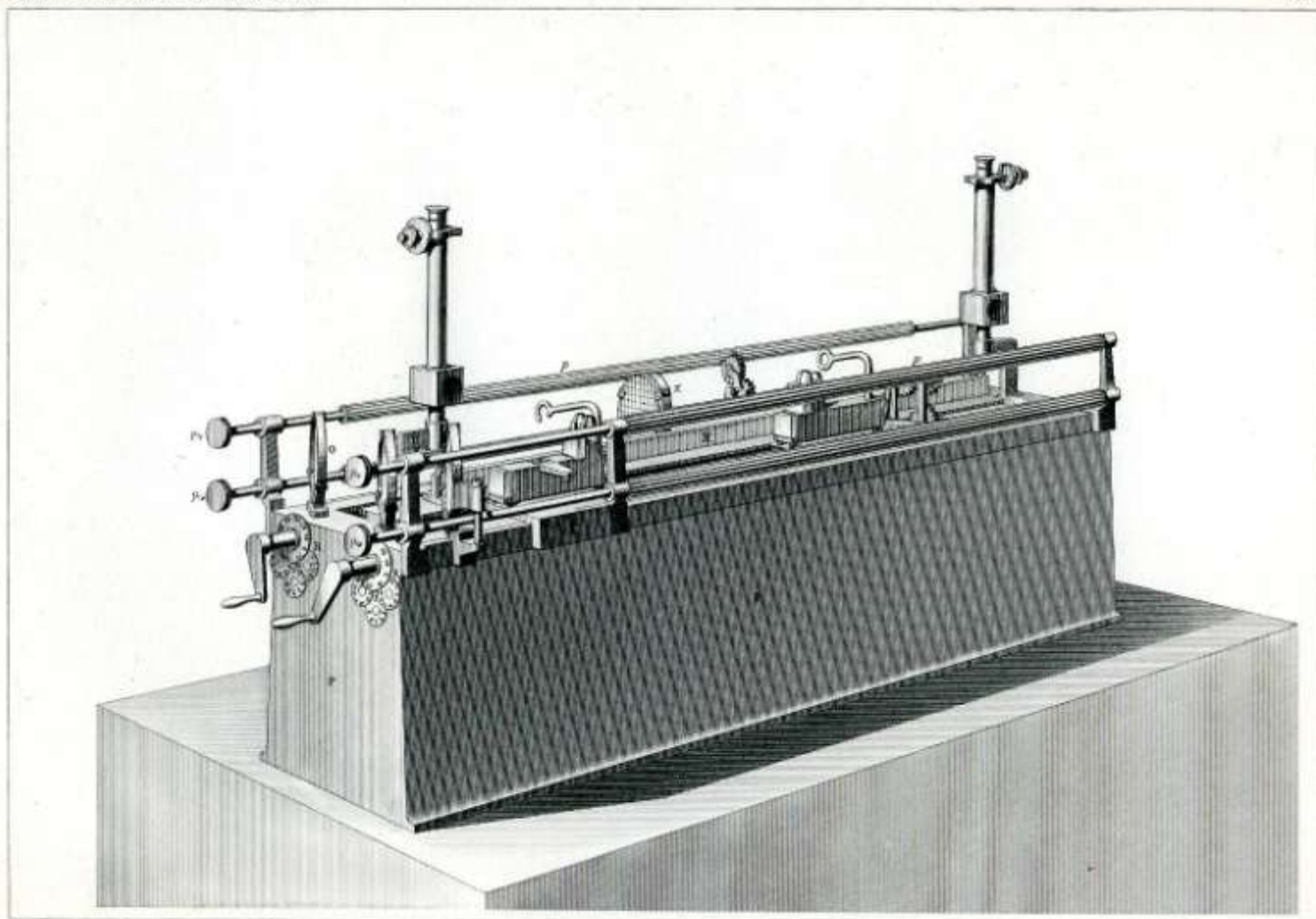
Gauthier-Villars et fils, Éditeurs, à Paris.

Dessiné par: Blumstedt

The hydrogen gas thermometer used to produce the 1887 normal hydrogen scale

“From the very beginning of the International Committee it has been generally recognized to be of fundamental importance to determine the relation between the metric units and some basic fundamental constants that one can deduce from natural phenomena”.

Extract from report of the 1891 meeting of the International Committee for Weights and Measures when it was decided to invite A.A. Michelson to come to the BIPM to measure the wavelength of the red light of cadmium in terms of the International prototype of the metre.



Ing. G. G. G. G. G.

Gauthier-Villars et Fils, Éditeurs, à Paris

Gravé par De Baux

Interferometer built and used at the BIPM in 1892 by A. A. Michelson for the measurement of the metre in terms of the wavelength of the red radiation of cadmium

$$1 \text{ metre} = 1\,553\,164.13 \lambda_R$$



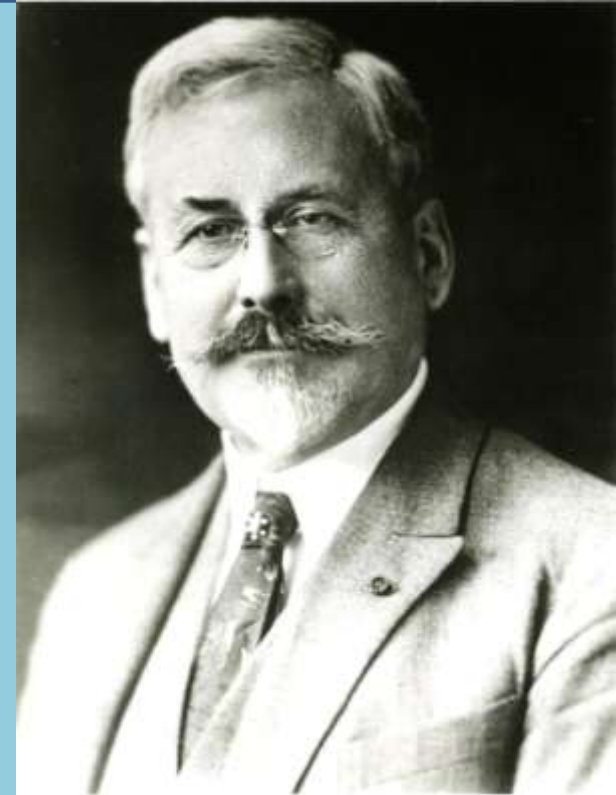
Ole-Jacob Broch (1818-1889)
Norwegian
Director 1879-1889

Broch carried out much of the work in calibrating the 40 new metre standards in the 1880s but died of pneumonia six months before the 1st General Conference on Weights and Measures



René Benoît (died 1922)
French
Director 1889-1915

Benoît worked with Michelson in 1892 to measure the wavelength of cadmium light in terms of the metre and later in 1906 made much more accurate measurements with Fabry and Perot



Charles Edouard Guillaume
(1861-1938)
Swiss
Director 1915-1936

Guillaume was one of the first scientific staff at the BIPM. He worked on thermometry and later on alloys of nickel. He was awarded the Nobel Prize for Physics in 1920 for his discovery of invar



The CIPM on the steps of the Grande Salle at
the BIPM September 1894



The CIPM on the steps of the same Grande Salle one hundred years later in 1994

Image BIPM





Image BIPM



The BIPM c 2002



Pavillon de Breteuil 2002











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FROM ARTEFACTS TO ATOMS

The BIPM and the Search for
Ultimate Measurement Standards

TERRY QUINN

