The Arago kilogram was procured in 1821 by Gallatin while minister of the United States to France and was sent to this country, together with a platinum meter. The certificate of Arago, the celebrated physicist, which accompanied these standards, states that the kilogram differs from the original kilogram of the Archives by less than 1 mg. The weight is a platinum cylinder with flat bases, the edges being slightly rounded. The height and diameter are nearly equal, being approximately 39.5 mm each. There is no stamp or distinguishing mark of any kind, except near the center of one base there is a faint lathe or tool mark of circular form, thus: ⊙. The weight is contained in a square mahogany box, on the cover of which is a circular silver plate bearing the inscription "Kilogramme comparé pour son Poids à l'Etalon Prototype des Archives de France, et verifié par M. Arago. Fortin fecit." (Kilogram compared for its weight with the prototype standard of the Archives of France, and verified by Mr. Arago. Made by Fortin.) No particulars of Arago's comparison with the kilogram of the Archives were furnished, and consequently it is not known what means he used in making his comparison nor whether he reduced his weighings to vacuo. It was not until 1879 that the Arago kilogram was compared with other standards of recognized authority. It is true that it was compared between 1852 and 1873 with two kilograms in the possession of the Office of Weights and Measures, but as both of these weights were of brass and of unknown density, no great reliance could be attached to the results. In 1879, however, it was taken to England and there compared with the British platinum kilogram in the custody of the Standards Office. This comparison indicated that the Arago kilogram was 4.25 mg light, but this result could not be considered conclusive, on account of certain assumptions made in the reduction to vacuo and also in regard to the correction to the British kilogram.

In 1884 the weight was taken from the Standards Office in London, where it had been since 1879, to the International Bureau of Weights and Measures at Paris and there compared with two auxiliary kilograms whose values in terms of the kilogram of the Archives were known with the greatest accuracy. The result obtained from the comparison confirmed that previously obtained from the comparison with the British kilogram, the result giving

$$\text{Arago kilogram} = 1{,}000 \text{ g} - 4.63 \text{ mg}.$$

As the weights supplied to the States were to be made of brass, it was more convenient to compare them with a brass standard, and in order to do this two secondary brass standards were carefully compared between the years 1873–1876 with the Arago kilogram and afterwards used in all the work of adjustment and verification. One of the kilograms, known as the Silbermann kilogram, was presented to the United States by France in 1852, together with a number of other weights and measures. The other kilogram used was one made in the Office of Weights and Measures and was identical in form and material with the kilograms subsequently furnished to the States.

As the unit of capacity in the metric system is defined as the volume of the mass of 1 kilogram of pure water at the temperature of maximum density, the most convenient way to adjust such measures, and in fact all capacity measures, is by weighing the water they contain. The only two material standards that need to be considered, therefore, in connection with the metric weights and measures furnished to the States in accordance with the act of 1866 are the committee meter and the Arago kilogram described above.

By the end of 1880 practically all the States had been supplied with sets of metric weights and measures consisting of the following denominations:

Length measures	One brass line meter. One steel end meter.
Capacity measures	One liter made of brass. One dekaliter made of brass.
Weights	One 10-kilogram made of brass. One kilogram made of brass. One ½-kilogram made of brass. One gram made of brass. One set of small silver weights from 4 decigrams to 1 milligram.

6. International Standards of Weights and Measures

It is necessary at this point to go back a few years and give an account of the establishment of the International Bureau of Weights and Measures, since the present fundamental standards of length and mass for practically the whole civilized world result from the establishment of that institution.

In response to an invitation of the French Government, the following countries sent representatives to a conference held in Paris on August 8, 1870, to consider the advisability of constructing new metric standards: Austria, Colombia, Ecuador, France, Great Britain, Greece, Italy, Norway, Peru, Portugal, Russia, Spain, Switzerland, Turkey, and the United States of America, 15 countries in all. This conference was of short duration, on account of the war then raging between France and Germany.

A second conference was held two years later, at which 26 countries, including the United States, were represented. At this conference it was decided that new meters and new kilograms should be constructed to conform with the original standards of the Archives, and a permanent committee was appointed to carry out this decision. The preparation of the new standards had advanced so far by 1875 that the permanent committee appointed by the conference of 1872 requested the French Government to call a diplomatic conference at Paris to consider whether permanent means and appliances for the final verification of the new meters and kilograms should be provided, or whether the work should be regarded as a temporary operation.

In compliance with this request a conference was held in March 1875, at which 20 countries were represented, the United States as usual being included.

On May 20, 1875, 17 of the 20 countries represented signed a document known as the "Metric Convention" or the "Treaty of the Meter." This provided for the establishment and maintenance of a permanent International Bureau of Weights and Measures to be situated near Paris and to be under the control of an international committee elected by the General Conference on Weights and Measures.

In addition to the original primary work of verifying the new metric standards the International Bureau was charged with certain duties, the following being the most important:

(1) The custody and preservation, when completed, of the international prototypes and auxiliary instruments.

(2) The future periodic comparison of the several national standards with the international prototypes.

(3) The comparison of metric standards with standards of other countries.

The expenses of the bureau were to be defrayed by contributions of the contracting governments, the amount for each country depending upon the population and upon the extent to which the metric system was in use in the particular country.

After ratification by the U.S. Senate and the exchange of ratifications at Paris, the Metric Convention was "proclaimed" by Rutherford B. Hayes, President of the United States, on September 27, 1878.

The twenty countries represented at the diplomatic conference at which the treaty was prepared and signed were Argentina, Austria-Hungary, Belgium, Brazil, Denmark, France, Germany, Great Britain, Greece, Italy, the Netherlands, Peru, Portugal, Russia, Spain, Sweden-Norway, Switzerland, Turkey, the United States of America, and Venezuela. Three of these countries did not sign the convention at that time—Great Britain, Greece, and the Netherlands.

Under the terms of the Convention an International Conference of Weights and Measures was established, to meet once every six years and to comprise official delegates designated by each Power signatory to the Convention. The International Committee elected by this Conference meets every two years.

A Convention amending the 1875 Convention was signed at Sèvres, France, on October 6, 1921; after the customary preliminaries this was proclaimed by President Calvin Coolidge on October 27, 1923. Among other amendments made, the new Convention broadened the scope of the work of the International Bureau, enlarged the International Committee from 14 to 18 members, revised the method of calculating the contributions to be assessed against signatory countries for the support of the Bureau, and modified the procedure for access to the standards vault at the International Bureau.

The number of powers adhering to the Metric Convention—and thus supporting the International Bureau—has increased to 44. Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Cameroon, Canada, Chile, Czechoslovakia, Denmark, Dominican Republic, Egypt, Federal Republic of Germany, Finland, France, German Democratic Republic, Hungary, India, Indonesia, Iran, Ireland, Italy, Japan, Korea, Mexico, The Netherlands, Norway, Pakistan, Poland, Portugal, Rumania, Spain, South Africa, Sweden, Switzerland, Thailand, Turkey, USSR, United Kingdom, USA, Uruguay, Venezuela, Yugoslavia.

The International Committee has had as members, at one time or another, many of the world's leading metrologists. The United States has been represented on the Committee by J. E. Hilgard (1875–1887), B. A. Gould (1887–1896), A. A. Michelson (1897–1904), S. W. Stratton (1905–1931), A. E. Kennelly (1933–1939), E. C. Crittenden (1946–1954), A. V. Astin (1954–1969), L. M. Branscomb (1969–1972) and E. Ambler (1972–).

The International Bureau of Weights and Measures is situated in the town of Sèvres, France, near the Sèvres end of the Park of St. Cloud, which extends between the towns of St. Cloud and Sèvres. The plot of ground was ceded by France to become international territory. The main office building, used also for the library and for the home of the Director, was originally a royal dwelling known as the Pavillon de Breteuil. The present official address of

The International Bureau of Weights and Measures, Sèvres, France.

the bureau is Pavillon de Breteuil, Sèvres (Seine-et-Oise), France.

The construction of the meters and kilograms had been entrusted to a special committee which carried out its tasks meticulously and with great scientific thoughtfulness. These international and national standards were designated as "prototypes," a term that is confusing in the minds of many people. Notwithstanding the dictionary definition of "prototype" as the original, model, or pattern after which something is copied, the term in metrological usage signifies that which is first in status or chief in rank or importance, a usage that dates back at least to 1875. Thus the expression "International Prototype Kilogram" is used to mean the kilogram standard that ranks highest as an international standard, that provides the most authentic value in the world for the kilogram mass, and not necessarily as the pattern for the construction of other kilogram standards. The expression "United States National Prototype Kilograms No. 20 and 4" is used to mean the particular kilogram standards, identified as "No. 20" and "No. 4," respectively, which standards rank highest in this country.

The international and national prototype meter bars, constructed in accordance with the terms of the Convention of the Meter of 1875, are of like design; the cross section is designed to provide maximum rigidity in a bar of reasonably small dimensions and mass, and to reduce to a minimum the effects of any slight bending that may take place when a bar is in normal use. This cross section is a modified X known as the "Tresca section" in honor of the French scientist, Henri Tresca, who proposed it. The overall dimensions of the cross section of the prototype meter bars are 20 x 20 millimeters.

In a bar of Tresca cross section, the upper surface of the central rib lies in the plane of the neutral axis of the bar, the plane in which any variations in the length of the bar that may be caused by slight deformation of the bar are reduced to the practicable minimum.

The international and national prototypes are approximately 1020 millimeters in overall length. As originally constructed (some bars have been regraduated in recent years), near each end of a bar, on the upper surface of the central rib, is a small, elliptical, polished area, and on this area are engraved two groups of parallel lines, the first comprising three transverse lines and the second two longitudinal lines. The central lines of each of the two transverse groups are the essential defining lines of the bar, the auxiliary lines being positioned at one-half millimeter distances on either side. (These auxiliary lines were intended for such purposes as calibrating the micrometer microscopes of length comparators.) The lines of each transverse group are crossed by the lines of a longitudinal group, these latter lines being 0.2 millimeter apart and somewhat more than 1 millimeter in length; the longitudinal lines serve to identify that small portion of each defining line that is to be utilized when the bar is used. Also engraved on each bar is its identifying number.

As for the international and national kilograms, they are in the form of right circular cylinders of equal diameter and height—approximately 39 millimeters—with slightly rounded edges. Engraved on each is its identifying number.

Thirty-one meter bars and 40 kilograms were constructed under the supervision of the International Bureau. The work of construction and calibration was completed by 1889; and in September of that year the first General Conference on Weights and Measures was held in Paris, and this work was approved at this meeting.

The meter and kilogram that agreed most closely with the meter and kilogram of the Archives were declared to be the international meter and the international kilogram. These two standards, with certain other meters and kilograms, were deposited in a subterranean vault under one of the buildings of the International Bureau, where they are only accessible when three independent officials with different keys are present. The other standards were distributed by lot to the various governments contributing to the support of the International Bureau. Those falling to the United States were meters Nos. 21 and 27 and kilograms Nos. 4 and 20.

Meter No. 27 and kilogram No. 20 were brought under seal to this country by George Davidson, of the Coast and Geodetic Survey. On January 2, 1890, the packing cases containing these standards were opened at the White House and the standards were accepted by President Harrison, who certified that they were received in good condition and that he confidently believed that they were the standards referred to in the reports. These reports, relating to the standards in question, had been submitted by B. A. Gould, United States delegate to the International Conference on Weights and Measures, and by Davidson. The other two standards were received the following July and were deposited in the Office of Weights and Measures, where those accepted as national standards by the President had already been taken.[17]

7. The Mendenhall Order

Thomas Corwin Mendenhall, 1841–1924.

On April 5, 1893, T. C. Mendenhall, then Superintendent of Weights and Measures, with the approval of the Secretary of the Treasury, decided that the international meter and kilogram would in the future be regarded as the fundamental standards of length and mass in the United States, both for metric and customary weights and measures. This decision, which has come to be known as the "Mendenhall Order," was first published as Bulletin No. 26 of the Coast and Geodetic Survey, approved for publication April 5, 1893, under the title, "Fundamental Standards of Length and Mass"; it was republished in 1894 under the same title, as appendix No. 6—Report for 1893 of the Coast and Geodetic Survey, "to give it a more permanent form." In appendix No. 6 there was included as an addendum to the text of Bulletin No. 26 a section headed "Tables for Converting Customary and Metric Weights and Measures," comprising some text, five customary-to-metric conversion tables, and five metric-to-customary conversion tables.

As a matter of interest and record, the full text of appendix No. 6 of the Report for 1893 of the Coast and Geodetic Survey, with the exception of an editorial footnote and the ten conversion tables, is reproduced as appendix 3 of this publication.

The Mendenhall Order initiated a departure from the previous policy of attempting to maintain our standards of length and mass to be identical with those of Great Britain, and thereafter there was a small difference between the British and the United States yards, a difference which may have been negligible in 1893 but which became of real importance as the British Imperial Yard bar gradually changed in length and as the requirements for greater accuracy in measurements increased.

As has been seen, when the United States yard was first adopted upon Hassler's recommendation in 1832, it was defined as a particular interval on the Troughton bar, through which it was related to the British yard standard. The intention was to fix the United States yard as equal to the British yard.

When the "Imperial" system of weights and measures was established by the British in 1824, the Imperial Yard was defined in terms of a specific yard standard and a particular bar was legalized as the Imperial standard. In 1834, that bar was so damaged in the burning of the Houses of Parliament that replacement was necessary; a new bar was constructed, and in 1855 this bar was legalized as the new Imperial Standard Yard. In the course of the years this bar proved to be insufficiently stable in length and was found to be shortening by measurable amounts.

[17] Upon the establishment of the Bureau of Standards on July 1, 1901, all standards and other property in possession of the Office of Weights and Measures passed under the control of the Bureau.