INTERNATIONAL METRIC COMMISSION

THE following methodical statement of the resolutions come to by the International Commission on Weights and Measures at its recent meeting at Paris was presented to the French Academy of Sciences by M. Tresca, one of the secretaries of the Commission.

I. *In reference to the Metre*

1. As a starting-point for carrying into effect an international measure, the Commission takes the metre of the Archives, in its present condition.

2. The Commission declares that, considering the actual condition of the platina measure of the Archives, it thinks the marked or line metre (*mètre à traits*) may be deduced from it with certainty. Nevertheless, this opinion of the Commission requires to be confirmed by the different processes of comparison which can be employed in this investigation.

3. The proportion (*équation*) of the International Metre will be deduced from the present length of the metre in the Archives, determined according to all the comparisons which have been made by means of the processes which the International Metric Commission will be in a condition to employ.

4. While deciding that the new International Metre ought to be a line-metre (*mètre à traits*), of which every country will receive an identical copy made at the same time as the universal prototype, the Commission will feel bound afterwards to construct a certain number of standards marked by projections (*étalons à bouts*) for those countries which desire them; and the proportions of such metres to the new prototype *à traits*, will also be determined under the care of the International Commission.

5. The International Metre will have the length of the metre at zero (centigrade).

6. There will be employed for the manufacture of the metres an alloy composed of 90 parts of platina and 10 of iridium, with a margin (*une tolerance*) of 2 to the 100, more or less.

7. In manufacturing the measures, the ingot must be formed by a single casting by means of the processes used in the working of the known metals. The number and form of these measures will be determined by the International Commission.

8. These measures will be annealed for many days, at the highest temperature—notwithstanding that they are never likely to be subjected to anything but the most feeble strains—before taking them to be compared with the standard instruments.

9. The bars of platina alloy upon which the line-metres are to be traced, will have a length of 102 centimetres, and their transverse section will be represented by the model described in a note of M. Tresca.

10. The bars intended for the construction of the projection metre measures (*à bouts*), will have a similar transverse section, but symmetrical in the vertical direction, conformably to the special figure which represents it; the nobs or projections (*bouts*) will then be wrought with a spherical surface of one metre radius.

11. During all the operations which the standard metres must undergo, they will be supported on the two rollers (*rouleaux*) indicated by General Baron de Wrede; but, for their preservation, they will be placed in a suitable case.

12. Each of the International Metres ought to be accompanied by two mercurial thermometers, isolated, and carefully compared with an air-thermometer; it is deemed necessary that these thermometers should be verified from time to time by means of the air-thermometer.

13. The method of M. Fizeau will be employed to determine the dilatation of the platina alloy used in the construction of the metres.

14. The prototypes will be submitted to the processes by means of which the coefficients of the absolute dilatation of the complete metres can be best determined. These measures will be separately made, at five different temperatures at least, between zero and 40° centigrade.

15. The comparison of the prototypes with each other ought to be made at, at least, three temperatures comprised between these same limits.

16. The Commission decides that two apparatus be constructed, the one with a longitudinal movement for tracing these metres, the other with a transverse movement for their comparison.

17. The comparisons will be made by immersing new standards in a liquid and in air; but the standard of the Archives must not be immersed in any liquid before the end of the operations.

18. The tracing of the line or traced metres (*à traits*), and their first comparison with the metre of the Archives, will be for the first effected by means of M. Fizeau's process.

19. For the determination of the proportions of the various standards, there will be employed moreover all the means of comparison already known and approved, according to circumstances, either by actually bringing the different forms into contact, or by the method of Messrs. Airy and Struve, or by that of MM. Stamkart and Steinheil.

20. The relations between the Archive metre and the new International traced metre, as well as the relations between the other traced standards and the International Metre, will be determined by comparing the results of all these observations.

21. Operations will be performed, on the other hand, by setting out from the International Metre for the construction of the standards with projections (*étalons à bouts*), which may be asked for by various states.

II. *In reference to the Kilogramme*

22. Considering that the simple relation established by the authors of the metric system between unity of weight and unity of volume is represented by the actual kilogramme in a manner sufficiently exact for the ordinary uses of industry, and even of science; considering also that the exact sciences have no real need of a simple numerical relation, but only of a determination as exact as possible of that relation; and considering the difficulties which would result from a change of the existing unity of metric weight, it is decided that the international kilogramme will be derived from the kilogramme of the Archives in its present condition.

23. The International Kilogramme ought to be decided by weighing in a vacuum.

24. The material of the International Kilogramme will be the same as that of the International Metre, viz.: an alloy of platinum and iridium, as stated in No. 6.

25. The material of the kilogramme will be founded and cast in a single cylinder, which will afterwards be subjected to furnace heat and mechanical operations, such as will give to its whole mass the necessary homogeneity.

26. The form of the International Kilogramme will be the same as that of the kilogramme of the Archives, viz., a cylinder whose depth is equal to its diameter, and whose corners may be easily rounded.

27. The determination of the weight of the cubic decimetre or water ought to be made under the direction of the International Commission.

28. The balances which will be used for weighing ought to be, not only those which may be placed for the present at the disposal of the Executive Committee by institutions and men of science who possess them, but also a new balance constructed according to conditions of the greatest exactness.

29. The volumes of all kilogrammes will be determined by the hydrostatic method; but the kilogramme of the Archives will neither be placed in water nor in a vacuum before the end of the operations.

30. To determine the weight of the new kilogramme, in comparison with that of the Archives, in a vacuum, two auxiliary kilogrammes will be made use of, as nearly as possible of the same weight and the same volume as that of the Archives, according to the method indicated by M. Stas. Each of the new kilogrammes ought also to be compared in air with the kilogramme of the Archives.

31. When the International Kilogramme is constructed, all others will be compared with it, in air and in vacuum, for the determination of their proportions.

32. For this purpose is employed the method of alteration and that of substitution, with a counterpoise of the same material.

33. The corrections for losses of weight in air will be effected by means of the most precise and least disputed data of science.

III. *In reference to the carrying out of the Commission's Decision*

34. The making of the new prototypes of the metre and the kilogramme, the tracing of the metres, the comparison of the new prototypes with those of the Archives, as well as the construction of the auxiliary apparatus necessary to these operations, are entrusted to the care of the French section, with the concurrence of the Permanent Committee, provided in the following article.

35. The Commission has chosen from its members a Permanent Committee, which will do duty till the next meeting of the Commission, with the following organisation and powers:—(*a.*) The Permanent Committee will be composed of twelve members, belonging to different countries. Five of these members

constitute a quorum: it will choose a president and secretary, and will meet as often as it deems necessary, but at least once a year. (*b*.) The Committee will direct and superintend the execution of the decisions of the International Commission, in reference to the comparison of the new metric prototypes with each other, as well as the construction of balances and other auxiliary apparatus necessary for these comparisons. (*c*.) The Permanent Committee will perform the work indicated in (*b*) with all appropriate means which may be at its disposal; it will meet for the performance of its task at the International Bureau of Weights and Measures, the establishment of which will be recommended to the nations interested. (*d*.) When the new prototypes will be constructed and compared, the Permanent Committee will give a report of its work to the International Commission, which will sanction the prototypes before distributing them to the different countries.

36. The Commission suggests to Governments interested how great would be the utility of founding at Paris an International Institution of Weights and Measures, upon the following bases:—1st. The establishment would be international and declared neutral. 2nd. Its seat will be at Paris. 3rd. It would be founded and supported at the common cost of all the countries which adhere to the treaty that might be made between the interested states for the creation of the establishment. 4th. The establishment will depend upon the International Metric Commission, and will be placed under the superintendence of the Permanent Committee, who will choose the director. 5th. The International Bureau would serve the following purposes:—(*a*.) It will be at the disposal of the Permanent Committee for the comparisons which will serve as a basis for the verification of the new prototypes with which the Committee is charged. (*b*.) The preservation of the international prototypes, in accordance with the directions laid down by the International Commission. (*c*.) The periodical comparison of the international prototypes with the national standards and with the tests, as well as that of the standard thermometers, according to the rules laid down by the Commission. (*d*.) The construction and verification of the standards which other countries may require in future. (*e*.) The comparison of the new metric prototypes with the other fundamental standards employed in the different countries and in science. (*f*.) The comparison of standards and scales which may be sent for its verification, either by Governments or by scientific societies, or even by mechanicians and servants. (*g*.) The Bureau would execute all the works which the Commission or its Permanent Committee would require of it in the interest of metrology and the propagation of the metric system.

37. The Bureau of the Commission is required to apply to the French Government, and request it to be good enough to communicate diplomatically the views of the Commission concerning the foundation of an International Bureau of Weights and Measures to the Governments of all the countries represented in the Commission, and to invite these Governments to conclude a treaty to create harmoniously, and as soon as possible, such an International Bureau upon the bases proposed by the Commission.

IV. Concerning the means of Preserving the Standards and the Guarantee of their Invariability

38. The Commission is of opinion that the International Standard ought to be accompanied by four identical measures, maintained at a temperature as invariable as possible; another identical measure ought to be preserved, for the sake of experiment, at an invariable temperature in vacuo; it would take means to establish tests in quartz and beryl, to be compared at any time with the complete measure, in whole or by portions. (The other means are reserved.)

39. The Commission thinks that in the interest of geodesy the French Government should cause to be re-measured, at a convenient time, one of the new French bases.

All these resolutions were made by the Commission most harmoniously, and in a spirit of complete confraternity; all the votes were nearly unanimous.

BIRTH OF CHEMISTRY

III.

Practical Chemistry of the Ancients.—Metallurgy; gold, silver, electrum, copper, bronze, tin.

IN the preceding articles we have discussed such theories of the ancients as involve the conception of change of matter (notably the assumed transmutation of the elements), and which hence concern the early history of chemistry. Having done with theory, we have now to inquire to what extent the ancients were acquainted with practical chemistry, what metals or other elements were known to them, and what processes dependent upon chemical action. We do not, of course, use the term "practical chemistry" strictly in its present sense, because chemistry as a science was altogether unknown to the ancients. Some have indeed endeavoured to prove that the Egyptians must have been acquainted with the science, from the skill with which they used various metallic oxides for colouring glass; but we have no proof of this. Neither Herodotus, nor Pliny, nor Vitruvius, indicates any knowledge of chemistry as a science among either Egyptians, Greeks, or Romans. Pliny, in his celebrated "Natural History," has laboriously amassed all the practical science and pseudo-science which the ancients possessed, and we find no mention of either chemistry or alchemy. At the same time it is impossible that the Egyptians and Sidonians can have attained their marvellous skill in the manufacture and colouring of glass, and in the extraction and working of metals, without the acquirement of a considerable amount of knowledge of the properties of matter, and of certain chemical changes. But this knowledge could never be worked up into a comprehensive system; it resulted from the labour of artizans, and the gulf between the philosopher and the manipulator was both wide and deep. There could be no union of practice and theory. Between Herakleitos with his theory that fire is the primal element, the actuating force of the Universe, and the man who wrought metals never so deftly, who applied fire to the use and service of mankind, there was no sympathy, no reciprocal transference of ideas. To reason concerning the properties of matter with one's eyes shut was all very well, but to experiment with matter, to endeavour to determine the cause of such and such a change by experiment, was utterly unworthy of a philosopher. Anaxagoras is said to have made an experiment to prove that there is no vacuum. Aristotle found that a bladder of air weighed in air weighed more than the empty bladder (which, if the experiment be properly made, is by no means the case), and hence concluded that the air has weight. But these are solitary exceptions; the way to study Nature, if she is to be studied at all, is, they maintained, to apply the pure, unaided intellect to the study, and to keep mind and matter as distinct as possible. From all this it resulted that your workers in metals and in curious arts, your makers of glass and pigments, kept their knowledge of matter to themselves, as secrets to be handed down from father to son.

Seven metals were known to the ancients, viz., gold, silver, copper, tin, iron, lead, and mercury. The first six are mentioned by Homer, and appear to have been known from remote antiquity, while mercury was not known till a later date; it was, however, common in the first century B.C. The Greek word μεταλλον, whence *metallum* and *metal*, signifies *a mine*, hence it was applied to anything found in mines, notably metals; μέταλλον is connected with μεταλλάω, "to search for diligently."

Gold has been valued from the earliest ages, on account of the peculiarity of its colour, its lustre, and its unalterability in air. The metal is invariably found in the native state, that is, uncombined with other substances, hence no metallurgical operation is necessary for its extraction. It is very often met with in surface deposits, and in early times was undoubtedly far more common in alluvium and the beds of rivers than now. It would thus be easily extracted by washing, and the grains could readily be fused together into a mass. Gold mines formerly existed in Ethiopia, in which the gold was found in a matrix of quartz, like much of the Australian gold of the present day. These mines were worked by the Egyptians, who employed large gangs of slaves for the purpose. The quartz was crushed, and the gold obtained from it by washing. We find representations of gold washings, and the subsequent fusion of the metal, on Egyptian tombs, at least as early as 2500 B.C., that is to say, about the time of Joseph in Hebrew history. The woodcut (Fig. 1) on the following page is given by Sir Gardner Wilkinson, and is taken from a tomb at Beni Hassan: it represents gold washing, and the fusion and weighing of the metal.

It is obvious that the process is only indicated, and not accurately or minutely portrayed. Another form of furnace is depicted below (Fig. 2), and a blowpipe somewhat different from that shown in Fig. 1. The raised portion of the furnace is doubtless for the purpose of concentrating the heat upon the crucible, on the principle of the reverberatory furnace.

Gold once obtained was soon made into ornaments; very fine gold wire was used by the Egyptians for embroidery 3,300 years ago. Many of the Egyptian and Etruscan gold ornaments are