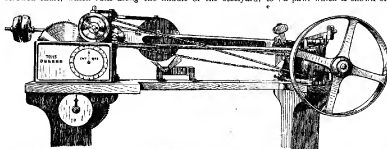


pressure shall exactly coincide with the line of the fulcrum knife-edge; the object of this is that the pressure may not influence the sway of the steelyard, which must depend entirely upon the poise. By means of a pair of mitre wheels the small spur wheel causes a screwed shaft, which runs along the middle of the steelyard, to



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FIG. 19.—Automatic Coal Weighing Machine.

revolve, and as it revolves it carries the large poise along the steelyard. Thus, if the poise be at the zero end of the steelyard at the left-hand side of the machine, when the load comes upon the platform the screwed shaft carries the poise along the steelyard till equilibrium is established, and the end of the steelyard drops. By the first part of this drop the movement of the poise is suddenly stopped, as will be explained below, and the travel of the poise along the steelyard, which measures the load on the platform, is recorded by the amount of rotation of the large spur wheel, and this is suitably shown on a dial in connexion with the wheel. By the second part of the drop the motion of the poise is reversed and the poise is run back to the zero

clutch with a shaft in the same line, on which are keyed a sprocket wheel and a ratchet wheel. The sprocket wheel is connected by a chain with a similar sprocket wheel which is keyed on the same shaft as that of the left-hand pulley. The ratchet wheel is acted upon by a pawl which is shown on the diagram. When the poise is at the zero end, and there is no load on the platform, the end of the steelyard is down, and has locked the ratchet wheel by means of the pawl; the shaft being thus locked, the sprocket wheel, and stopped, the drum-shaft runs free by the friction clutch, and the two pulleys which are connected by the crossed band are running idle. When the load to be weighed comes upon the platform, the end of the steelyard rises and unlocks the ratchet wheel through the pawl; the sprocket gearing is driven by the friction clutch, and drives the axle of the left-hand small pulley. The mitre wheels come into operation and the poise is carried along till the end of the steelyard drops, and locks the ratchet wheel. By means of a horizontal rod the same drop of the steelyard also locks together by clutch gearing the left-hand pulley and the adjacent sprocket wheel, and the pulley drives the sprocket wheel in the opposite direction to that which it had before. Consequently the motion of the mitre wheels is reversed and the poise is run back to zero. When the poise arrives at zero it frees the clutch which connects the pulley and the sprocket wheel, and the machine is then ready for the next load. The poise having arrived at the end of its run and unable to go further, the mitre wheels and the sprocket gearing are stopped, and the two pulleys and the cross belt run idle till the next load comes upon the platform.

Automatic Luggage Weighing Machine (fig. 20).—This machine is intended for the weighing of personal luggage at railway stations. It consists of a platform which is carried by levers arranged in the manner of an ordinary platform machine, which are connected with the registration mechanism by a vertical rod. This rod is continued upwards by a pair of thin nickel bands which are led right and left over two horizontal cylinders, round which they partly wrap, and to which they are firmly attached. The diameter of the middle part of the cylinders is greater than that of the ends, and the bands from the vertical rod are led over the middle part. To each cylinder a pair of similar nickel bands are led downwards from the top of a casting which is bolted to the frame. The lower ends of these bands pass round the under side of the end portions of the cylinders, wrapping close round them, and are firmly attached to them. To the bottom of each cylinder is rigidly attached a heavy solid cylinder of lead, and these are the regulators of the position of equilibrium of the cylinders when they rotate under the action of the lead. When the load comes upon the platform the pull of the vertical rod is transmitted by the nickel bands to the cylinders around which they are wrapped, and causes them to revolve. As they rotate they roll themselves up the pairs of bands which are attached to the top of the casting, and at the same time cause the leaden weights attached to the bottoms of the cylinders to take up a lateral position, where they exercise a leverage opposing the motion of the cylinders, and bringing them up in a definite position corresponding to the pull of the vertical rod. By the rolling of the cylinders up the vertical bands from the casting the cylinders are raised vertically through a space defined by the position of the leaden regulators. By means of a suitable and simple mechanism this vertical movement of the cylinders works plungers pistons in a pair of cylinders which contain glycerin, and these deaden the vibrations of the machinery while weighing is going on. The same vertical movement also actuates the index finger of a large dial, on which the weight of their luggage can be easily read by passengers standing near while their luggage is being weighed.

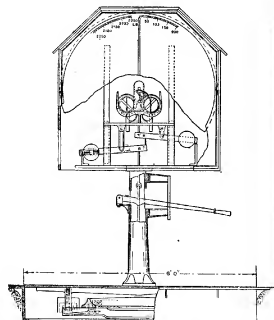
AUTHORITIES.—Julius Weisbach, *Mechanics of Machinery and Engineering* (London, 1848); Ernst Brauer, *Die Konstruktion der Waage* (Weimar, 1887); H. L. Cheney, *Car Weights and Measures* (London, 1887); Ayrton, *“Weighing Machinery,”* *Proc. Inst. C.E.*, vol. cviii.; W. H. Brothers on “Weighing Machinery,” *Trans. Soc. Engineers*, vol. for 1890. (W. Ay.)

WEIGHTS AND MEASURES. This subject may be most conveniently considered under three aspects—I. Scientific; II. Historical, and III. Commercial.

I. SCIENTIFIC

1. *Units.*—In the United Kingdom two systems of weights and measures are now recognized—the imperial and the metric. The fundamental units of these systems are—of length, the yard and metre; and of mass, the pound and kilogram.

The legal theory of the British system of weights and measures is—(a) the standard yard, with all lineal measures and their



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FIG. 20.—Automatic Luggage Weighing Machine.

end in readiness for the next load. All of this is effected automatically as follows.

The machine is driven continuously by a belt from a motor which wraps round the large drum at the right-hand side of the machine. On the same axle as the drum and behind it is a small pulley which is keyed upon the axle and is connected with the small pulley (which runs idle on its shaft) at the left-hand side of the machine by a crossed belt. Thus these two small pulleys are always running, but in opposite directions. The drum-shaft is connected by a friction

squares and cubes based upon that; (b) the standard pound of 7000 grains, with all weights based upon that, with the troy pound of 5760 grains for trade purposes; (c) the standard gallon (and multiples and fractions of it), declared to contain 10 lb of water at 62° F., being in volume 277.274 cub. in., which contain each 252.734 grains of water in a vacuum at 62°, or 252.438 grains of water weighed with brass weights in air of 62° with the barometer at 30 in. Of the metric units international definitions have been stated as follows:—

(a) The unit of volume for determinations of a high degree of accuracy is the volume occupied by the mass of 1 kilogram of pure water at its maximum density and under the normal atmospheric pressure; this volume is called litre.

(b) In determinations of volume which do not admit of a high degree of accuracy the cubic decimetre can be taken as equivalent to the litre; and in these determinations expressions of volumes based on the cube of the unit of linear measure can be substituted for expressions based on the litre as defined above.

(c) The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.

(d) The term "weight" denotes a magnitude of the same nature as a force; the weight of a body is the product of the mass of the body by the acceleration of gravity; in particular, the normal weight of a body is the product of the mass of the body by the normal acceleration of gravity. The number adopted for the value of the normal acceleration of gravity is 980.665 cm/sec².

2. *Standards.*—The metre (*mètre*-*à-trait*) is represented by the distance marked by two fine lines on an iridio-platinum bar ($t=0^{\circ}$ C.) deposited with the Standards Department. This metre (m.) is the only unit of metric extension by which all other metric measures of extension—whether linear, superficial or solid—are ascertained.

The kilogram (kg.) is represented by an iridio-platinum standard weight, of cylindrical form, by which all other metric weights, and all measures having reference to metric weight, are ascertained in the United Kingdom.

From the above four units are derived all other weights and measures (W. and M.) of the two systems.

The gallon is the standard measure of capacity in the imperial system as well for liquids as for dry goods.

In the United Kingdom the metric standard of capacity is the litre, represented (Order in Council, 19th May 1896) by the capacity of a hollow cylindrical brass measure whose internal diameter is equal to one-half its height, and which at 0° C., when filled to the brim, contains one kg. of distilled water of the temperature of 4° C., under an atmospheric pressure equal to 760 millimetres at 0° C. at sea-level and latitude 45°; the weighing being made in air, but reduced by calculation to a vacuum. In such definition an attempt has been made to avoid former confusion of expression as to capacity, cubic measure, and volume; the litre being recognized as a measure of capacity holding a given weight of water.

For the equivalent of the litre in terms of the gallon, see below III. *Commercial*.

In the measurement of the cubic inch it has been found that the specific mass of the cubic inch of distilled water freed from air, and weighed in air against brass weights ($\Delta=8.13$), at the temperature of 62° F., and under an atmospheric pressure equal to 30 in. (at 32° F.), is equal to 252.297 grains weight of water at its maximum density (4° C.). Hence a cubic foot of water would weigh 62.281 lb avoird., and not 62.321 lb as at present legally taken.

For the specific mass of the cubic decimetre of water at 4° C., under an atmospheric pressure equal to 760 mm., Guillaume and Chappuis of the Comité International des Poids et Mesures at Paris (C.I.P.M.) have obtained 0.9999707 kg., which has been accepted by the committee.

The two standards, the cubic inch and the cubic decimetre, may not be strictly comparable owing to a difference in the normal temperature (Centigrade and Fahrenheit scales) of the two units of extension, the metre and the yard.

¹ *Troisième Conférence Générale des Poids et Mesures* (Paris, 1901). *Metric Units Com. Rep. Soc.* (1896).

² *Phil. Trans.* (1892) and *Proc. Roy. Soc.* (1895), p. 143.

³ *Proc. Verb. Com. Intern. des Poids et Mesures* (1900), p. 84. *Congrès International de Physique réuni à Paris en 1900*.

For the weight of the cubic decimetre of water, as deduced from the experiments made in London in 1896 as to the weight of the cubic inch of water, D. Mendeleeff (*Proc. Roy. Soc.*, 1895) has obtained the following results, which have been adopted in legislative enactments in the United Kingdom:—

Temperature on the Hydrogen Thermometer Scale.		Weight of Water in vacuo.		
C.	F.	Of a Cubic Decimetre in Grammes.	Of a Cubic Inch in Grains.	Of a Cubic Inch in Russian Dols.
0°	32°·0	999.716	252.821	368.686
4	39.2	999.847	252.854	368.734
15	59.0	998.970	252.635	368.414
16½	62.0	998.715	252.568	368.316
20	68.0	998.082	252.407	368.083

In this no account is taken of the compressibility of water—that is to say, it is supposed that the water is under a pressure of one atmosphere. The weight of a cubic decimetre of water reaches 1000 grammes under a pressure of four atmospheres; but in *vacuo*, at all temperatures, the weight of water is less than a kilogram.

3. *National Standards.*—National standards of length are not legally now referred to natural standards or to physical con-

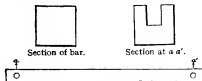


FIG. 1.—Present Imperial Standard Yard, 1844.

Total length of bronze bar, 38 in.; distance $a a'$, 36 in., or the imperial yard; $a a'$, wells sunk to the mid-depth of the bar, at the bottom of each of which is inserted a gold stud, having the defining line of the yard engraved on it.

stants,⁴ but it has been shown by A. A. Michelson that a standard of length might be restored, if necessary, by reference to the measurement of wave-lengths of light. Preliminary experiments have given results correct to ± 0.5 micron, and it appears probable that by further experiments, results correct to ± 0.01 may be obtained. That is to say, the metre might be redetermined or restored as to its length within one ten-millionth part, by reference to, *e.g.*, 1553103.5 wave-lengths of the red ray of the spectrum of cadmium, in air at 15° C. and 760 mm.

In all countries the national standards of weights and measures are in the custody of the state, or of some authority administering the government of the country. The standards of the British Empire, so far as they relate to the imperial and metric systems, are in the custody of the Board of Trade. Scientific research is not, of course, bound by official standards.

For the care of these national standards the Standards Department was developed, under the direction of a Royal Commission⁵ (of which the late Henry Williams Chisholm was a leading member), to conduct all comparisons and other operations with weight.

reference to weights and measures in aid of scientific research or otherwise, which it may be the duty of the state to undertake. Similar standardizing offices are established

⁴ *Valeur du Mètre*, A. A. Michelson (Paris, 1894); *Units*, Everett, Illustrations of C.G.S. System; *Units et Étalons*, Guillaume (Paris, 1890); Lupton's Numerical Tables, 1892; *Metric Equivalent Cards*, 1901; *Dictionary of Metric Measures*, L. Clark (1891); Glazebrook and Shaw's *Physics* (1901).

⁵ Report Standards Commission, 1870.

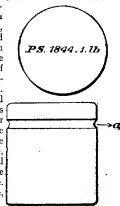


FIG. 2.—Imperial Standard Pound, 1844.

in other countries (see STANDARDS). Verified "Parliamentary Copies" of the imperial standard are placed at the Royal Mint, with the Royal Society, at the Royal Observatory, and in the Westminster Palace.

The forms of the four primary standards representing the four units of extension and mass are shown in figs. 1 to 4.

A secondary standard measure for dry goods is the bushel of 1824, containing 8 imperial gallons, represented by a hollow bronze cylinder having a plane base, its internal diameter being double its depth.

The imperial standard measure of capacity is a hollow cylinder (fig. 5) made of brass, with a plane base, of equal height and diameter; which when filled to the brim, as determined by a plane glass disk, contains 10 lb weight of water at $t=62^{\circ}$ F.B. = 30 in., weighed in air against brass weights.

4. *Atmospheric Pressure, and Materials.*—In the verification of a precise standard of length there may be taken into account the influence of the variation of atmospheric pressure. Taking the range of the barometer in Great Britain from 28 to 31 in., giving a difference of 3 in. (76 millimetres), which denotes a variation of 103 grammes per square centimetre in the pressure of the atmosphere, the change caused thereby in the length of a standard of linear measurement would appear to be as follows:—

For the yard measure of the form shown in fig. 1 a difference of length equal to 0.000002 in. is caused by the variation of atmospheric pressure from 28 to 31 in. For the metre of the form shown in fig. 3 the difference in length for a variation of 76 mm. in the barometer would be 0.000048 mm. on the metre.

With reference to the materials of which standards of length are made, it appears that the Matthiessen alloy iridio-platinum (90% platinum, 10% iridium) is probably of all substances the least affected by time or circumstance, and of this costly alloy, therefore, a new copy of the imperial yard has been made. There appears, however, to be some objection to the use of iridio-platinum for weights, as, owing to its great density ($\Delta=21.57$), the slightest abrasion will make an appreciable difference in a weight; sometimes, therefore, quartz or rock-crystal is used; but to this also there is some objection, as owing to its low density ($\Delta=2.65$) there is a large exposed surface of the mass. For small standard weights platinum ($\Delta=21.45$) and aluminium ($\Delta=2.67$) are used, and also an alloy of palladium (60%) and silver (40%) ($\Delta=11.00$).

For ordinary standards of length Guillaume's alloy (near) of nickel (35.7%) and steel (64.3%)

is used, as it is a metal that can be highly polished, and is capable of receiving fine graduations. Its coefficient of linear expansion is only 0.000008 for 1° C.¹

5. *Electrical Standards.*—Authoritative standards and instruments for the measurement of electricity, based on the fundamental units of the metric system, have been placed in the Electrical Laboratory of the Board of Trade.² These include

Current measuring instruments.	The standard ampere, and sub-standards from 1 to 2500 amperes.
Potential measuring instruments.	The standard volt, and sub-standards for the measurement of pressure from 25 to 3000 volts.
Resistance measuring instruments.	The standard ohm, sub-standards up to 100,000 ohms, and below 1 ohm to 1000 ohm.

6. *Temperature.*—In the measurement of temperature the Fahrenheit scale is still followed for imperial standards, and the Centigrade scale for metric standards. At the time of the construction of the imperial standards in 1844, Sheepshanks's Fahrenheit thermometers were used; but it is difficult to say now what the true temperature then, of 62° F., may have been as compared with 62° F., or 16.667° C., of the present normal hydrogen scale.

For metrological purposes the C.I.P.M. have adopted as a normal thermometric scale the Centigrade scale of the hydrogen thermometer, having for fixed points the temperature of pure melting ice (0°) and that of the vapour of boiling distilled water (100°), under a normal atmospheric pressure; hydrogen being taken under an initial manometric pressure of 1 metre, that is to say, at $1.01325 = 1.3158$ times the normal atmospheric pressure. This latter is represented by the weight of a column of mercury 760 mm. in height; the specific gravity of mercury being now taken as 13.5950, after Volkmann and Marek, and at the normal intensity followed under this pressure. The value of this intensity is equal to that of the force of gravity at the Bureau International, Paris (at the level of the Bureau), divided by 1.000332; a co-efficient which allows for theoretical reduction to the latitude 45° and to the level of the sea. The length of the metre is independent of the thermometer so far that it has its length at a definite physical point, the temperature of melting ice (0° C.), but there is the practical difficulty that for ordinary purposes measurements cannot be always carried out at 0° C.

The International Geodetic Committee have adopted the metre as their unit of measurement. In geodetic measurements the dimensions of the triangles vary with the temperature of the earth, but these variations in the same region of the earth are smaller than the variations of the temperature of the air, less than 10° C. Adopting as a co-efficient of dilatation of the earth's crust 0.00002, the variations of the distances are smaller than the errors of measurement (see GROVES).

7. *Standardizing Institutions.*—Besides the State departments dealing with weights and measures, there are other standardizing institutions of recent date.

In Germany, e.g. there is at Charlottenburg (Berlin) a technical institute (Physikalisches technisches Reichsanstalt) established under Dr W. Förster in 1887, which undertakes researches with reference to physics and mechanics, particularly as applied to technical industries.³ In England a National Physical Laboratory

(N.P.L.) has been established, based on the German institute, and has its principal laboratory at Bushy House, near Hampton, Middlesex. Here is carried out the work of standardizing measuring instruments of various sorts in use

¹ *Wissenschaftliche Abhandlungen der physikalischen Reichsanstalt*, Band II. (Berlin, 1900); *Denkschrift betreffend die Tätigkeit der K. Norm.-Arbeits-Komm.* (1869-1900).

by manufacturers, the determination of physical constants and the testing of materials. The work of the Kew Observatory, at the Old Deer Park, Richmond, has also been placed under the direction of the N.P.L. (see III. *Commercial*).¹ The C.I.P.M. at Paris, the first metrological institution, also undertakes verifications for purely scientific purposes. A descriptive list of the verifying instruments of the Standards Department, London, has been published.² In the measurement of woollen and other textile fabrics, as to quality, strength, number of threads, &c., there exists at Bradford a voluntary standardizing institution known as the Conditioning House (Bradford Corporation Act 1887), the work of which has been extended to a chemical analysis of fabrics.

8. *Ancient Standards of England and Scotland*.—A "troy pound" and a new standard yard, as well as secondary standards, were constructed by direction of parliament in 1758-1760, and were deposited with the Clerk of the House of Commons. When the Houses of Parliament were burned down in 1834, the pound was lost and the yard was injured. It may here be mentioned that the expression "imperial" first occurs in the Weights and Measures Act of 1824. The injured standard was then lost sight of, but it was in 1891 brought to light by the Clerk of the Journals, and has now been placed in the lobby of the residence of the Clerk of the House, together with a standard "stone" of 14 lb.³

In the measurement of liquids the old "wine gallon" (231 cub. in.) was in use in England until 1824, when the present imperial gallon (fig. 5) was legalized; and the wine gallon of 1707 is still referred to as a standard in the United States. Together with the more ancient standard of Henry VII. and of Queen Elizabeth, they are probably of the Norman period, and were kept in the Pyx Chapel at Westminster, now in the custody of the Commissioners of Works. A sketch of these measures is given in fig. 6.⁴

Besides these ancient standards of England (1405, 1588, 1601) there are at the council chambers of Edinburgh and



FIG. 6.—A, Winchester Bushel of Henry VII.; B, Standard Hundred-weight (112 lb) of Elizabeth; C, Ale Gallon of Henry VII.; D, the old Wine Gallon.

Linlithgow some of the interesting standards of Scotland, as the Stirling jug or Scots pint, 1618; the choppin or half-pint, 1555 (fig. 7); the Lanark troy and iron weights of the same periods (fig. 8).⁵

English Weights and Measures Abolished.—The yard and handul, or 40 in. ell, abolished in 1439. The yard and inch, or 37 in. ell (cloth measure), abolished after 1553; known later as the Scotch ell=37·06. Cloth ell of 45 in., used till 1600. The yard of Henry VII.=35·963 in. Saxon momeyers pound, or Tower pound, 5400 grains, abolished in 1527. Mark, 1 pound=3600 grains. Troy pound in use in 1415, established as monetary pound 1527. Troy weight was abolished, from the 1st of January 1879, by the Weights and Measures Act 1878, with the exception only of the Troy ounce, its decimal parts and multiples, legalized in 1853, 16 Vict. c. 29, to be used for the sale of gold and silver articles, platinum and precious stones. Merchant's pound, in 1270 established for all except gold, silver and medicines=6750 grains, generally superseded by avoirdupois in 1303. Mer-

chant's pound of 7200 grains, from France and Germany, also superseded. ("Avoirdupois" occurs in 1336, and has been thence continued.) The Elizabethan standard was probably 7000 grains.) Ale gallon of 1601=282 cub. in., and wine gallon of 1707=231 cub. in., both abolished in 1824. Winchester corn bushel of 8×268.8 cub. in. and gallon of 274½ are the oldest examples known (Henry



FIG. 7.—The Scots Choppin or Half-Pint, 1555.



FIG. 8.—Lanark Stone Troy Weight, 1618.

VII.), gradually modified until fixed in 1826 at 277·274, or 10 pounds of water.

French Weights and Measures Abolished.—Often needed in reading older works.

1 ligne,	12 = ponce,	22 = pied,	6 = aise,	2000 = livre de poids.
1/16 in.	1/2000 in.	1/12 in.	1/16 in.	1/16000 in.
1/16 in.	1/2000 in.	1/12 in.	1/16 in.	1/16000 in.
1/16 in.	1/2000 in.	1/12 in.	1/16 in.	1/16000 in.

Rhineland foot, much used in Germany, = 12·357 in. = the foot of the Scotch or English cloth ell of 37·06 in., or 3×12·353. (H. J. C.)

II. ANCIENT HISTORICAL

Though no line can be drawn between ancient and modern metrology, yet, owing to neglect, and partly to the scarcity of materials, there is a gap of more than a thousand years over which the connexion of units of measure is mostly guess-work.

Hence, except in a few cases, we shall not here consider any units of the middle ages. A constant difficulty in studying works on metrology is the need of distinguishing the absolute facts of the case from the web of theory into which each writer has woven them—often the names used, and sometimes the very existence of the units in question, being entirely an assumption of the writer. Again, each writer has his own leaning: A. Böckh, to the study of water-volumes and weights, even deriving linear measures therefrom; V. Queipo, to the connexion with Arabic and Spanish measures; J. Brandis, to the basis of Assyrian standards; Mommsen, to coin weights; and P. Bortolotti to Egyptian units; but F. Hultsch is more general, and appears to give a more equal representation of all sides than do other authors. In this article the tendency will be to trust far more to actual measures and weights than to the statements of ancient writers; and this position seems to be justified by the great increase in materials, and their more accurate means of study. The usual arrangement by countries has been mainly abandoned in favour of following out each unit as a whole, without recurring to it separately for every locality.

The materials for study are of three kinds. (i) *Literary*, both in direct statements in works on measures (e.g. Elias of Nisibis), medicine (Galen) and cosmetics (Cleopatra), in ready-reckoners (Didymus), clerk's (kātib's) guides, and like handbooks, and in indirect explanations of the equivalents of measures mentioned by authors (e.g. Josephus). But all such sources are liable to the most confounding errors, and some passages relied on have in any case to submit to conjectural emendation. These authors are of great value for connecting the monumental information,

¹ Treasury Committee on National Physical Laboratory, Parliamentary Paper, 1896.

² Descriptive List of Standards and Instruments, Parliamentary Paper, 1892.

³ Report on Standards deposited in House of Commons, 1st November 1891.

⁴ S. Fisher, *The Art Journal*, August 1900.

⁵ Buchanan, *Ancient Scotch Standards*.

⁶ In the absence of the actual standards of ancient times the units of measure and of weight have to be inferred from the other remains; hence unit in this division is used for any more or less closely defined amount of length or weight in terms of which matter was measured.

but must yield more and more to the increasing evidence of actual weights and measures. Besides this, all their evidence is but approximate, often only stating quantities to a half or quarter of the amount, and seldom nearer than 5 or 10%; hence they are entirely worthless for all the closer questions of the approximation or original identity of standards in different countries; and it is just in this line that the imagination of writers has led them into the greatest speculations, unchecked by accurate evidence of the original standards. (2) *Weights and measures actually remaining.* These are the prime sources, and as they increase and are more fully studied, so the subject will be cleared and obtain a fixed basis. A difficulty has been in the paucity of examples, more due to the neglect of collectors than the rarity of specimens. The number of published weights did not exceed 600 of all standards in 1880; but the collections from Naucratis (28),¹ Defenneh (29) and Memphis (44) have supplied over six times this quantity, and of an earlier age than most other examples, while existing collections have been more thoroughly examined. It is above all desirable to make allowances for the changes which weights have undergone; and, as this has only been done for the above Egyptian collections and that of the British Museum, conclusions as to the accurate values of different standards will here be drawn from these rather than continental sources. (3) *Objects which have been made by measure or weight,* and from which the unit of construction can be deduced. Buildings will generally yield up their builder's foot or cubit when examined (*Inductive Metrology*, p. 9). Vases may also be found bearing such relations to one another as to show their unit of volume. And coins have long been recognized as one of the great sources of metrology—valuable for their wide and detailed range of information, though most unsatisfactory on account of the constant temptation to diminish their weight, a weakness which seldom allows us to reckon them as of the full standard. Another defect in the evidence of coins is that, when one variety of the unit of weight was once fixed on for the coinage, there was (barring the depreciation) no departure from it, because of the need of a fixed value, and hence coins do not show the range and character of the real variations of units as do buildings, or vases, or the actual commercial weights.

PRINCIPLE OF STUDY.—1. *Limits of Variation in Different Copies, Places and Times.*—Unfortunately, so very little is known of the ages of weights and measures that this datum—most essential in considering their history—has been scarcely considered. In measure, Egyptians of Dynasty IV. at Gizeh on an average varied 1 in 350 between different buildings (27). Buildings at Persepolis, all of nearly the same age, vary in unit 1 in 450 (26). Including a greater range of time and place, the Roman foot in Italy varied during two or three centuries on an average $\frac{1}{175}$ from the mean. Covering a longer time, we find an average variation of $\frac{1}{175}$ in the Attic foot (25), $\frac{1}{175}$ in the English foot (25), $\frac{1}{175}$ in the English itinerary foot (26). So we may say that an average variation of $\frac{1}{175}$ by toleration, extending to double that by change of place and time, is usual in ancient measures. In weights of the same place and age there is a far wider range; at Defenneh (29), within a century probably, the average variation of different units is $\frac{1}{80}$, $\frac{1}{40}$, and $\frac{1}{20}$, the range being just the same as in all times and places taken together. Even in a set of weights all found together, the average variation is only reduced to $\frac{1}{40}$ in place of $\frac{1}{80}$ (29). Taking a wider range of place and time, the Roman libra has an average variation of $\frac{1}{40}$ in the examples of better period (43), and in those of Byzantine age $\frac{1}{20}$ (44). Altogether, we see that weights have descended from original varieties with so little intercomparison that no rectification of their values has been made, and hence there is as much variety in any one place and time as in all together. Average variation may be said to range from $\frac{1}{40}$ to $\frac{1}{20}$ in different units, doubtless greatly due to defective balances.

2. *Rate of Variation.*—Though large differences may exist, the rate of general variation is but slow—excluding, of course, all monetary standards. In Egypt the cubit lengthened $\frac{1}{175}$ in

some thousands of years (25, 44). The Italian mile has lengthened $\frac{1}{175}$ since Roman times (2); the English mile lengthened about $\frac{1}{175}$ in four centuries (31). The English foot has not appreciably varied in several centuries (25). Of weights there are scarce any dated, excepting coins, which nearly all decrease; the Attic tetradrachm, however, increased $\frac{1}{10}$ in three centuries (28), owing probably to its being below the average trade weight to begin with. Roughly dividing the Roman weights, there appears a decrease of $\frac{1}{175}$ from imperial to Byzantine times (43).

3. *Tendency of Variation.*—This is, in the above cases of lengths, to an increase in course of time. The Roman foot is also probably $\frac{1}{175}$ larger than the earlier form of it, and the later form in Britain and Africa perhaps another $\frac{1}{175}$ larger (25). Probably measures tend to increase and weights to decrease in transmission from time to time or place to place.

4. *Details of Variation.*—Having noticed variation in the gross, we must next observe its details. The only way of examining these is by drawing curves (28, 29), representing the frequency of occurrence of all the variations of a unit; for instance, in the Egyptian unit—the kat—counting in a large number how many occur between 140 and 141 grains, 141 and 142, and so on; such numbers represented by curves show at once where any particular varieties of the unit lie (see *Naucratis*, i. 83). This method is only applicable where there is a large number of examples; but there is no other way of studying the details. The results from such a study—of the Egyptian kat, for example—show that there are several distinct families or types of a unit, which originated in early times, have been perpetuated by copying, and reappear alike in each locality (see *Tanis*, ii. pl. 1.). Hence we see that if one unit is derived from another it may be possible, by the similarity or difference of the forms of the curves, to discern whether it was derived by general consent and recognition from a standard in the same condition of distribution as that in which we know it, or whether it was derived from it in earlier times before it became so varied, or by some one action forming it from an individual example of the other standard without any variation being transmitted. As our knowledge of the age and locality of weights increases these criteria in curves will prove of greater value; but even now no consideration of the connexion of different units should be made without a graphic representation to compare their relative extent and nature of variation.

5. *Transfer of Units.*—The transfer of units from one people to another takes place almost always by trade. Hence the value of such evidence in pointing out the ancient course of trade and commercial connexions (17). The great spread of the Phœnician weight on the Mediterranean, of the Persian in Asia Minor and of the Assyrian in Egypt are evident cases; and that the decimal weights of the laws of Manu (43) are decidedly not Assyrian or Persian, but on exactly the Phœnician standard, is a curious evidence of trade by water and not overland. If, as seems probable, units of length may be traced in prehistoric remains, they are of great value; at Stonehenge, for instance, the earlier paces are laid out by the Phœnician foot, and the later by the Pelasgo-Roman foot (26). The earlier foot is continually to be traced in other megalithic remains, whereas the later very seldom occurs (25). This bears strongly on the Phœnician origin of our prehistoric civilization. Again, the Belgic foot of the Tungri is the basis of the present English land measures, which we thus see are neither Roman nor British in origin, but Belgic. Generally a unit is transferred from a higher to a less civilized people; but the near resemblance of measures in different countries should always be corroborated by historical considerations of a probable connexion by commerce or origin (Head, *Hidoria Numorum*, xxvii.). It should be borne in mind that in early times the larger values, such as minae, would be transmitted by commerce, while after the introduction of coinage the lesser values of shekels and drachmae would be the units, and this needs notice, because usually a borrowed unit was multiplied or divided according to the ideas of the borrowers, and strange modifications thus arose.

¹ These figures refer to the authorities at the end of this section.

6. *Connections of Length, Volumes and Weights.*—This is the most difficult branch of metrology, owing to the variety of connexions which can be suggested, to the vague information we have, especially on volumes, and to the liability of writers to rationalize connexions which were never intended. To illustrate how easy it is to go astray in this line, observe the continual reference in modern handbooks to the cubic foot as 1000 oz. of water; also the cubic inch is very nearly 250 grains, while the gallon has actually been fixed at 10 lb of water; the first two are certainly mere coincidences, as may very probably be the last also, and yet they offer quite as tempting a base for theorizing as any connexions in ancient metrology. No such theories can be counted as more than coincidences which have been adopted, unless we find a very exact connexion, or some positive statement of origination. The idea of connecting volume and weight has received an immense impetus through the metric system, but it is not very prominent in ancient times. The Egyptians report the weight of a measure of various articles, amongst others water (6), but lay no special stress on it; and the fact that there is no measure of water equal to a direct decimal multiple of the weight-unit, except very high in the scale, does not seem as if the volume was directly based upon weight. Again, there are many theories of the equivalence of different cubic cubits of water with various multiples of talents (2, 3, 18, 24, 33); but connexion by lesser units would be far more probable, as the primary use of weights is not to weigh large cubical vessels of liquid, but rather small portions of precious metals. The Roman amphora being equal to the cubic foot, and containing 80 librae of water, is one of the strongest cases of such relations, being often mentioned by ancient writers. Yet it appears to be only an approximate relation, and therefore probably accidental, as the volume by the examples is too large to agree to the cube of the length or to the weight, differing $\frac{1}{10}$, or sometimes even $\frac{1}{10}$.¹

Another idea which has haunted the older metrologists, but is still less likely, is the connexion of various measures with degrees on the earth's surface. The lameness of the Greeks in angular measurement would alone show that they could not derive itinerary measures from long and accurately determined distances on the earth.

7. *Connections with Coinage.*—From the 7th century B.C. onward, the relations of units of weight have been complicated by the need of the interrelations of gold, silver and copper coinage; and various standards have been derived theoretically from others through the weight of one metal equal in value to a unit of another. That this mode of originating standards was greatly promoted, if not started, by the use of coinage we may see by the rarity of the Persian silver weight (derived

¹ Relative to the uncertain connexion of length, capacity and weight in the ancient metrological systems of the East, Sir Charles Warren, R.E., has obtained by deductive analysis a new equivalent of the original cubit (*Palestine Exploration Fund Quarterly*, April, July, October 1899). He shows that the length of the cubit arose through the weights, that is to say, the original cubit of Egypt was based on the cubic double-cubit of water and from this the several nations branched off with their measures and weights. For the length of the building cubit Sir C. Warren has deduced a length equivalent to 20.6169 English inches, which compares with a mean Pyramid cubit of 20.6015 in. as hitherto found. By taking all the ancient cubits, there appears to be a remarkable coincidence throughout with 20.6169 in.

Sir C. Warren has derived a primitive unit from a proportion of the human body, by ascertaining the probable mean height of the ancient people in Egypt, and so thereby has derived a standard from the stature of man. The human body has furnished the earliest measure for many races (H. O. Arnold Forster, *The Coming of the Kilogram*, 1898), as the foot, palm, hand, digit, nail, pace, ell (*ulna*), &c. It seems probable, therefore, that a royal cubit may have been derived from some kindly stature, and its length perpetuated in the ancient buildings of Egypt, as the Great Pyramid, &c.

So far this later research appears to confirm the opinion of Bockh (2) that fundamental units of measure were at one time derived from weights and capacities. It is curious, however, to find that an ancient nation of the East, so wise in geometrical proportions, should have followed what by modern experience may be regarded as an inverse method, that of obtaining a unit of length by deducing it through weights and cubic measure, rather than by deriving cubic measure through the unit of length.

from the Assyrian standard), soon after the introduction of coinage, as shown in the weights of Defenech (29). The relative value of gold and silver (17, 21) in Asia is agreed generally to have been $1\frac{1}{2}$ to 1 in the early ages of coinage; at Athens in 434 B.C. it was 14:1; in Macedonia, 350 B.C., 12:1; in Sicily, 400 B.C., 15:1; and 300 B.C., 12:1; in Italy in 1st century, it was 12:1; in the later empire 13:1; and under Justinian 14:1. Silver stood to copper in Egypt as 80:1 (Brugsch), or 120:1 (Revilleut); in early Italy and Sicily as 250:1 (Mommson), or 120:1 (Soutzo), under the empire 120:1, and under Justinian 100:1. The distinction of the use of standards for trade in general, or for silver or gold in particular, should be noted. The early observance of the relative values may be inferred from Num. vii. 23, 14, where silver offerings are 13 and 7 times the weight of the gold, or of equal value and one-half value.

8. *Legal Regulations of Measures.*—Most states have preserved official standards, usually in temples under priestly custody. The Hebrew "shekel of the sanctuary" is familiar; the standard volume of the apert was secured in the dromus of Anubis at Memphis (38); in Athens, besides the standard weight, twelve copies for public comparison were kept in the city; also standard volume measures in several places (2); at Pompeii the block with standard volumes cut in it was found in the portico of the forum (33); other such standards are known in Greek cities (Gythium, Panidion and Trojanopolis) (11, 33); at Rome the standards were kept in the Capitol, and weights also in the temple of Hercules (2); the standard cubit of the Nilometer was before Constantine in the Serapeum, but was removed by him to the church (2). In England the Saxon standards were kept at Winchester before A.D. 950 and copies were legally compared and stamped; the Normans removed them to Westminster to the custody of the king's chamberlains at the exchequer; and they were preserved in the crypt of Edward the Confessor, while remaining royal property (9). The oldest English standards remaining are those of Henry VII. Many weights have been found in the temenos of Demeter at Cnidus, the temple of Artemis at Ephesus, and in a temple of Aphrodite at Byblos (44); and the making or sale of weights may have been a business of the custodians of the temple standards.

9. *Names of Units.*—It is needful to observe that most names of measures are generic and not specific, and cover a great variety of units. Thus foot, digit, palm, cubit, stadium, mile, talent, mina, stater, drachm, obol, pound, ounce, grain, metretre, medimnus, modius, hin and many others mean nothing exact unless qualified by the name of their country or city. Also, it should be noted that some ethnic qualifications have been applied to different systems, and such names as Babylonian and Euboic are ambiguous; the normal value of a standard will therefore be used here rather than its name, in order to avoid confusion, unless specific names exist, such as *kuf* and *aten*.

All quantities stated in this article without distinguishing names are in British units of inch, cubic inch or grain.

Standards of Length.—Most ancient measures have been derived from one of two great systems, that of the cubit of 20.63 in., or the digit of .729 in.; and both these systems are found in the earliest remains.

20.63 in.—First known in Dynasty IV. in Egypt, most accurately 20.60 in. in the Great Pyramid, varying 20.51 to 20.71 in Dyn. IV. to VI. (27). Divided decimally in 100ths; but usually marked in Egypt into 7 palms of 28 digits, approximately; a mere juxtaposition (for convenience) of two incommensurate systems (25, 27). The average of several cubic rods remaining is 20.65, age in general about 1000 B.C. (33). At Philae, &c., in Roman times 20.76 on the Nilometers (44). This unit is also recorded by cubit lengths scratched on a tomb at Beni Hasan (44), and by dimensions of the tomb of Rameses IV. and of Edfu temple (5) in papyrus. From this cubit, *mahi*, was formed the *xylon* of 3 cubits, the usual length of a walking-staff; fathom, *ment*, of 4 cubits, and the *khet* of 40 cubits (18); also the *schoenus* of 12,000 cubits, actually found marked on the Memphis-Faiyum road (44).

Babylonian had this unit nearly as early as Egypt. The divided plotting scales lying on the drawing boards of the statues of Gudea (*Nature*, xxviii. 341) are of $\frac{1}{2}$ to .89, or a span of 10.44, which is divided in 16 digits of .653, a fraction of the cubit also found in Egypt.

Buildings in Assyria and Babylonia show 20.5 to 20.6. The Babylonian system was sexagesimal, thus (18)—

suban, 5=241, 6=242, 6=243, 6=244, 6=245, 6=246, 6=247, 6=248, 6=249, 6=250	
100 inch 3.44 20.6 1.24 7.430 225.000 445.000	

Asia Minor had this unit in early times—in the temples of Ephesus 20.55, Samos 20.62; Hultsch also claims Priene 20.90, and the stadia of Aphrodisias 20.67 and Laodicea 20.94. Ten buildings in all give 20.63 mean (18, 25); but in Armenia it arose to 20.76 in late Roman times, like the late rise in Egypt (25). It was specially divided into 1/10, the foot of 1/10 being as important as the cubit.

12.45 in. This was especially the Greek derivative of the 20.63 cubit. It originated in Babylonia as the foot of the 120.75 system (24), in accordance with the sexary system applied to the early decimal division of the cubit. In Greece it is the most usual unit, occurring in the Propylaea at Athens 12.44, temple at Aegina 12.40, Miletus 12.51, the Olympic course 12.62, &c. (18); thirteen buildings giving an average of 12.45, mean variation -.06 (25), = 1/2 of 20.75, m. var. .10. The digit = 1/10 palaeste, = foot of 12.44; then the system is—

foot, { 15=cubit, 4=orguia, 10=stadion, 100=stadium, 1000=stadium }	
12.4 in. { 12.45 12.45 12.45 12.45 12.45 12.45 12.45 12.45 12.45 12.45 }	12.45 12.45 12.45 12.45 12.45 12.45 12.45 12.45 12.45 12.45

In Etruria it probably appears in tombs as 12.45 (25); or perhaps in Roman Britain; and in medieval England as 12.47 (25).

This foot is scarcely known numerically. On the three 13.8 in. Egyptian cubits there is a prominent mark at the 19th 1/20.7 of digit, or 14 in., which shows the existence of such a measure (33). It became prominent when adopted by Philaetanus about 280 B.C. as the standard of Pergamum (42), and probably it had been shortly before adopted by the Ptolemies for Egypt. From that time it is one of the principal units in the literature (Didymus, &c.), and is said to occur in the temple of Augustus at Pergamum as 13.8 (18). Fixed by the Romans at 16 digits (13)—Roman foot, or its cubit at 1/10 Roman feet, it was legally = 13.94 at 123 B.C. (42); and 7 1/2 Philaetanean stadia were—Roman mile (18). The multiples of the 20.63 cubit are in late times generally reckoned in these feet of 12.45 in. The name "Babylonian foot" used by Borch (2) is only a theory of his, from which to derive volumes and weights; and no evidence for this name, or connexion with Babylon, is to be found. Much has been written (2, 3, 33) on supposed cubits of about 17.18 in. derived from 20.63—mainly in endeavouring to get a basis for the Greek and Roman feet; but these are really connected with the digit system, and the monumental or literary evidence for such a division of 20.63 will not bear examination.

17.30. There is, however, fair evidence for units of 17.30 and 17.30/20.76, same is found in Asia Minor as 17.25 or 17.30. On the Egyptian cubits a small cubit is marked as about 17 in., which may well be this unit, as 1/2 of 20.63 is 17.30; and these marks are placed before the 23rd digit, or 17.0, they cannot refer to 6 palms, or 17.7, which is the 24th digit, though they are usually attributed to that (33).

We now turn to the second great family based on the digit. This has been so usually confounded with the 20.63 family, owing to the juxtaposition of 28 digits with that cubit in Egypt, that it should be observed how the difficulty of their incommensurability has been felt. For instance, Lepsius (3) supposed two primitive cubits of 13.2 and 20.63, to account for 28 digits being only 20.4 when free from the cubit of 20.63—the first 24 digits being in some cases made shorter on the cubits to agree with the true digit standard, while the remaining 4 are lengthened to fill up to 20.6. In the Dynasties IV and V, in Egypt the digit is found in tomb

727 in. sculptures as 727 (27); while from a dozen examples in the later remains we find the mean 728 (25). A length of 10 digits is marked on all the inscribed Egyptian cubits as the "lesser span" (33). In Assyria the same digit appears as 730, particularly at Nimrud (25); and in Persia buildings show the 10-digit length of 7.34 (25). In Syria it was about 728, but variable; in eastern Asia Minor more like the Persian, being 732 (25). In these cases the digit itself, or decimal multiples, seem to have been used.

18.23. The pre-Greek examples of this cubit in Egypt, mentioned by Borch (2), give 18.23 as a mean, which is 25 x 729. 25 digits of 729, and has no relation to the 20.63 cubit. This cubit, or nearly so, was used in Judaea in the times of the kings, as the Siloam inscription names a distance of 1758 ft. as roundly 1200 cubits, showing a cubit of about 17.6 in. This is also evidently the Olympic cubit; and, in pursuance of the decimal multiple of the digit found in Egypt and Persia, the cubit of 25 digits was 1/2 of the orguia of 100 digits, the series being—

old digit, { 15=cubit, 4=orguia, 10=stadion, 100=stadium, 1000=stadium }	
730 inch 18.2 729 729 729 729 729 729 729 729 729	

Then, taking 1/2 of the cubit, or 1/2 of the orguia as a foot, the Greeks arrived at their foot of 12.14; this, though very well known in literature, is but rarely found, and then generally in the form of the cubit, in monumental measures. The Parthenon step, celebrated as 100 ft. wide, and apparently 225 ft. long, gives by Stuart 12.137, by Penrose 12.165, by Paccard 12.148, differences due to scale and not to slips in measuring. Probably 12.16 is the nearest

value. There are but few buildings wrought on this foot in Asia Minor, Greece or Roman remains. The Greek system, however, adopted this foot as a basis for decimal multiplication, forming

foot, 12.16 inches	25=orguia, 10=stadion, 100=stadium
12.16	12.16 12.16 12.16 12.16 12.16 12.16 12.16 12.16 12.16 12.16

which stand as 1/10 of the other decimal series based on the digit. This is the agrarian system, in contrast to the orguia system, which was the itinerary series (33).

Then a further modification took place, to avoid the inconvenience of dividing the foot in 16 1/2 digits, and a new digit was formed—longer than any value of the old digit—of 1/10 of the foot, or .760, so that the series ran

digit, { 15=cubit, 4=orguia, 10=stadion, 100=stadium, 1000=stadium }	
76 inch 12.16 12.16 12.16 12.16 12.16 12.16 12.16 12.16 12.16 12.16	

This formation of the Greek system (25) is only an inference from the facts yet known, for we have not sufficient information to prove it, though it seems much the simplest and most likely history.

11.62. Seeing the good reasons for this digit having been exported to the West from Egypt—from the presence of the 16 x 726—18.23 cubit in Egypt, and from the .729 digit being the decimal base of the Greek long measures—it is not surprising to find it in use in Italy as a digit, and multiplied by 16 as a foot. The more so as the half of this foot, or 8 digits, is marked off as a measure on the Egyptian cubit rods (33). Though Queipo has opposed this connexion (not noticing the Greek link of the digit), he agrees that it is supported by the Egyptian square measure of the plethron, being equal to the Roman acri (33). The foot of 11.6 appears probably first in the prehistoric and early Greek remains, and is certainly found in Etrurian tomb dimensions as 11.59 (25). Dörpfeld considers this as the Attic foot, and states the foot of the Greek metrological relief at Oxford as 11.65 (or 11.64, Hultsch). Hence we see that it probably passed from the East through Greece to Etruria, and thence became the standard foot of Rome; there, though divided by the Italian duodecimal system into 12 unciae, it always maintained its original 16 digits, which are found marked on some of the foot-measures. The well-known ratio of 25:24 between the 12.16 foot and this we see to have arisen through one being 1/2 of 100 and the other 16 digits—16 1/2 being as 25 : 24, the legal ratio. The mean of a dozen foot-measures (1) gives 11.616 = .008, and of long lengths and buildings 11.607 = .01. In Britain and Africa, however, the Romans used a rather longer form (25) of about 11.68, or a digit of .730. Their series of measures was—

digitus, 11.6 inch	4=palmus, 2=palmus, 5=palmus, 12=stadium, 8=milliare, 500=milliare
11.6	2.90 11.6 11.6 11.6 11.6 11.6 11.6 11.6 11.6 11.6

also uncia 968 = 1/16 pes, palmus 145 = 1/8 palmus, cubitus 17 1/2 = 1/4 palmus.

Either from its Pelagic or Etrurian use or from Romans, this foot appears to have come into prehistoric remains, as the circle of Stonehenge is 160 ft. in 11.68 across, and the same is found in one or two other cases. 11.60 also appears as the foot of some medieval English buildings (25).

We now pass to units between which we cannot state any connexion.

25.1.—The earliest sign of this cubit is in a chamber at Abydos (44) about 1400 B.C.; there, below the sculptures, the plain wall is marked out by red designing lines in spaces of 25.13 x .03 in., which have no relation to the size of the chamber or to the sculpture. They must therefore have been marked by a workman using a cubit of 25.13. Apart from medieval and other very uncertain data, such as the Sabbath day's journey being 2000 middling paces for 2000 cubits, it appears that Josephus, using the Greek or Roman cubit, gives half as many more to each dimension of the temple than does the Talmud; this shows the cubit used in the Talmud for temple measures to be certainly not under 25 in. Evidence of the early period is given, moreover, by the statement in 1 Kings (vii. 26) that the brazen sea held 2000 baths; the bath being about 2300 cub. in., this would show a cubit of 25 in. The corrupt text in Chronicles of 3000 baths would need a still longer cubit; and, if a lesser cubit of 21.6 or 18 in. be taken, the result for the size of the bath would be impossibly small. For other Jewish cubits see 18.2 and 21.6. Oppert (24) concludes from inscriptions that there was in Assyria a royal cubit of 1/2 the U cubit, or 25.20; and four monuments show (25) a cubit averaging 25.28. For Persia Queipo (33) relies on, and develops, an Arab statement, that the Arab *hukma* cubit was the royal Persian, thus fixing it at about 25 in.; and the Persian guezze at present is 25, the royal guezze being 1 1/2 times this, or 37 1/2 in. As a unit of 1.013, decimally multiplied, is most commonly to be deduced from the ancient Persian buildings, we may take 25.34 as the nearest approach to the ancient Persian unit.

21.6.—The circuit of the city wall of Khorsabad (24) is minutely stated on a tablet as 24,740 ft. (U), and from the actual size the U is therefore 10.86 in. Hence the recorded series of measures on the Senkereh tablet are valued (Oppert) as—

1/2 U, { 30=palmus, 1/2 U, 6=palmus, 2=30, 5=1/2 U, 12=1/2 U, 30=1/2 U }	
18 inch 3.6 10.8 10.8 10.8 10.8 10.8 10.8 10.8 10.8 10.8	

Other units are the sukulum or 1/2 U = 5.4, and cubit of 2 U = 21.9,

which are not named in this tablet. In Persia (24) the series on the same base was—

vitali,	6=arseni,	360=amparsa,	36=parathitha,	g=gr;
10.7 inches	21.4	7704	231,120	462,140

probably

yava,	6=angota,	10=aviti;	and gaea=	g=arseni;	also hira=	2 arava.
18 inch	1.07	10.7	12.5	42.8	21.0	

The values here given are from some Persian buildings (25), which indicate 21.4, or slightly less; Oppert's value, on less certain data, is 21.52. The Egyptian cubit, again, is an arm at 21.53, or about 10.9 marked on them, which seems like this same unit (33).

This cubit was also much used by the Jews (33), and is so often referred to that it has eclipsed the 25.1 cubit in most writers. The Gemara names 3 Jewish cubits (2) of 5, 6 and 7 palms; and, as Oppert (24) shows that 25.2 was reckoned 7 palms, 21.6 being 6 palms, we may reasonably apply this scale to the Gemara list, and read it as 18, 21.6 and 25.2 in. There is also a great amount of medieval and other data showing this cubit of 21.6 to have been familiar to the Jews after their captivity; but there is no evidence for its earlier date, as there is for the 25.1 in. cubit (from the brazen sea) and for the 18-in. cubit from the Silem inscription.

From Assyria also it passed into Asia Minor, being found on the city standard of Ushak in Phrygia (33), engraved as 21.8, divided into the Assyrian foot of 10.8, and half and quarter, 5.4 and 2.7. Apparently the same unit is found (18) at Heraclea in Lucania, 21.86; and, as the general foot of the South Italians, or Oscan foot (18), best defined by the 100 feet square being $\frac{1}{3}$ of the jugerum, and therefore = 10.80 or half of 21.60. A cubit of 21.5 seems certain to be indicated in prehistoric remains in Britain, and also in early Christian buildings in Ireland (28).

22.—Another unit not far different, but yet distinct, is found apparently in Punic remains at Carthage (25), Minor 11.16 (22.32), and probably also in Sardinia as 11.07 (22.14), where it would naturally be of Punic origin. In the Hauran 22.16 is shown by a basalt door (British Museum), and perhaps elsewhere in Syria (25). It is of some value to trace this measure, since it is indicated by some prehistoric English remains as 22.4.

20.0.—This unit may be that of the pre-Semitic Mesopotamians, as it is found at the early temple of Mukayyir (Ur), and with a few other cases (25), it averages 19.97. It is described by Oppert (24), from literary sources, as the great U of 222 susi or 39.96, double of 19.98, from which was formed a reed of 4 great U or 159.8. The measure decimally divided is also indicated by buildings in Asia Minor and Syria (25).

19.2.—In Persia some buildings at Persepolis and other places (25) are constructed on a foot of 9.6, or cubit of 19.2; while the modern Persian arish is 38.27 or 2×19.13 . The same is found very clearly in Asia Minor (25), averaging 19.3; and it is known in literature as the Pythic foot (18, 33) of 9.75, or $\frac{1}{2}$ of 19.5; if Censorinus is rightly understood. It may be shown by a mark (33) on the 26th digit of Sharpe's Egyptian cubit = 19.2 in.

13.3.—This measure does not seem to belong to very early times, and it may probably have originated in Asia Minor. It is found there as 13.35 in buildings. Hultsch gives it rather less at 13.1, as the "small Asiatic foot." Thence it passed to Greece, where it is found (25) as 13.36. In Romano-African remains it is often found, rather higher, or 13.45 average (25). It lasted in Asia apparently till the building of the palace at Mashita (A.D. 620), where it is 13.22, according to the rough measures we have (25). And it may well be the origin of the dirh' Stambuli of 26.6, twice 13.3. Found in Asia Minor and northern Greece, it does not appear unreasonable to connect it, as Hultsch does, with the Belgic foot of the Tungri, which was legalised (or perhaps introduced) by Drusus when conqueror, as 4 longer than the Roman foot, or 13.97; this statement was evidently an approximation by an increase of 2 digits, so that the small difference from 13.3 is not worth notice. Further, the pectus was 12 ft. of 18 digits, i.e. Drusian feet.

Turning now to England, we find (25) the commonest building foot up to the 15th century averaged 13.22. Here we see the Belgic foot passed over to England, and we can fill the gap to a considerable extent from the itinerary measures. It has been shown (31) that the old English mile, at least as far back as the 13th century, was of 10 and not 8 furlongs. It was therefore equal to 79,200 in., and divided decimally into 10 furlongs, 7920 chasms, or 1000 fathoms. For the existence of this fathom (half the Belgic pectus) we have the proof of its half, or yard, needed to be suppressed by statute (9) in 1439, as "the yard and full hand," or about 40 in.,—evidently the yard of the most usual old English foot of 13.22, which would be 39.66. We can restore then the old English system of long measure from the buildings, the statute prohibition, the surviving chain and furlong, and the old English mile shown by maps and itineraries, thus:—

foot,	3=yard,	5=athom,	10=chasm,	10=furlong,	10=mile.
13.22	39.66	79.20	7920	79200	792000

Such a regular and extensive system could not have been put into use throughout the whole country suddenly in 1250, especially as it must have had to resist the local foot now in use, which was enlarged (9) as early as 950. We cannot suppose that such a system would be invented and become general in face of the laws enforcing

the 12-in. foot. Therefore it must be dated some time before the 10th century, and this brings it as near as we can now hope to the Belgic foot, which lasted certainly to the 3rd or 4th century, and is exactly in the line of migration of the Belgic tribes into Britain. It is remarkable how near this early decimal system of Germany and Britain is the double of the modern decimal metric system. Had it not been unhappily driven out by the 12-in. foot, and repressed by statutes both against its yard and mile, we should need but a small change to place our measures in accord with the metre.

The Celtic leiga, or league, is a different unit, being 1.59 British miles by the very concordant itinerary of the Bordeaux pilgrim. This appears to be the great Celtic measure, as opposed to the old English, or Gennanic, mile. In the north-west of England and in Wales this mile lasted as 1.56 British miles till 1500; and the perch of those parts was correspondingly longer till this century (31). The "old London mile" was 5000 ft., and probably this was the mile which was modified to 5280 ft., or 8 furlongs, and so became the British statute mile.

STANDARDS OF AREA.—We cannot here describe these in detail. Usually they were formed in each country on the squares of the long measures. The Greek system was—

foot,	35=temposides				
4.027 sq. ft.	120=	36.66=	2220=	25=	4=
		102.58	2500	2500	10,258

The Roman system was—

pes,	100=decempeda,	36=dima,	4=actus,	2=jugerum.
74.54 ft.	94=	33.84	13.53	27.07
	jugerum,	4=heredium,	100=centessima,	4=
	4005 acin	1=	841.1	409.6

STANDARDS OF VOLUME.—There is great uncertainty as to the exact values of all ancient standards of volume—the only precise data being those resulting from the theories of volumes derived from the cubes of feet and cubits. Such theories, as we have noticed, are extremely likely to be only approximations in ancient times, even if recognized then; and our data are quite inadequate for clearing the subject. If certain equivalences between volumes in different countries are stated here, it must be plainly understood that they are only known to be approximate results, and not to give a certain basis for any theories of derivation. All the actual monumental data that we have are alluded to here, with their amounts. The impossibility of safe correlation of units necessitates a division by countries.

Egypt.—The hon was the usual small standard; by 8 vases which have contents stated in hons (8, 12, 20, 22, 33, 40) the mean is 29.2 cub. in. = .6; by 9 unmarked pottery measures (30) 29.1 = .16, and divided by 20; by 18 vases, supposed multiples of hon (1), 32 = .2. These last are probably only rough, and we may take 29.2 cub. in. = .5. This was reckoned $\frac{1}{2}$ of 5 hold 5 utensils of water (uten. 1470 grains), which were added to the weight; but this was probably an approximation, and not derivative, as there is (14) a weight called shet of 4.70 or 4.95 uten, and this was perhaps the actual weight of a hon. The variations of hon and uten, however, cover one another completely. From ratios stated before Greek times (35) the series of multiples was—

no,	8=hon,	4=banos,	10=sept (4=)	10=(Theban),	10=ma,
3.65 cub. in.	29.2	11.8	11.8	11.8	11.8

(Theban) is the "great Theban measure."

In Ptolemaic times the artaba (2336'), modified from the Persian, was general in Egypt, a working equivalent to the Attic metretres = value 2 apt or 3 tama; medimnos = tama or 2 artabas, and fractions down to $\frac{1}{16}$ artaba (35). In Roman times the artaba remained (Didymus), but $\frac{1}{4}$ was the usual unit (name unknown), and this was divided down to $\frac{1}{16}$ or $\frac{1}{32}$ artaba (35)—thus producing by $\frac{1}{2}$ artaba a working equivalent to the xestes and sextarius (35). Also a new Roman artaba (Didymus) of 1540 was brought in. Beside the equivalence of the hon to 5 utens weight of water, the mathematical papyrus (35) gives 5 beshas = 1 cub. cubit (Revillout's interpretation of this as 1 cubit? is impossible geometrically; see Rev. Eng., 1881, for this); this is very concordant, but it is very unlikely for 3 to be introduced in an Egyptian derivation, and probably therefore only a working equivalent. The other ratio of Revillout and Hultsch, 320 hons = cubit³, is certainly approximate.

Syria, Palestine and Babylonia.—Here there are no monumental data known; and the literary information does not distinguish the closely connected, perhaps identical, units of these lands. Moreover, none of the writers are before the Roman period, and many relied on pre-medieval rabbinic. A large number of their statements are rough (2, 18, 33), being based on the working equivalence of the bath or epha with the Attic metretres, from which are sometimes drawn fractional statements which seem more accurate than they are. This, however, shows the bath to be about 2500 cub. in. There are two better data (2) of Epiphanius and Theodoret—Attic medimnos = 1 bath, and saron (3 bath) = 1 modius; these give about 2240 and 2260 cub. in. The best datum is in Josephus (Ant. lib. 15. 3), where 10 baths = 41 Attic or 31 Sicilian medimni, for which it is agreed we must read modii (33); hence the bath = 2300 cub. in. Thus these three different reckonings agree closely, but all equally depend on the Greek and Roman standards, which are not well fixed. The Sicilian modius here is $\frac{1}{3}$, or slightly under $\frac{1}{4}$, of the bath, and so probably a

Punic variant of the $\frac{1}{2}$ bath or saron of Phoenicia. One close datum, if trustworthy, would be log of water = Assyrian mina, $\frac{1}{2}$ bath about 2200 cub. in. The rabbinical statement of cub. cubit of $\frac{1}{2}$ holding 320 logs puts the bath at about 2250 cub. in.; their log-measure, holding six hen's eggs, shows it to be over rather than under this amount; but their reckoning of bath = cubit cubed is but approximate; by 21.5 it is 1240, by 25.1 it is 1990 cubic in. The earliest Hebrew system was—

log.	4=kab	15=hin	6={ bath, or }	10={ homer-wed.
	125	250	105	2100
32 cub. in.	125	250	105	2100

'Issaron ("tenth-deal") is also called gomer. The log and kab are not found till the later writings; but the ratio of hin to 'Issaron is practically fixed in early times by the proportions in Num. xv. 4-9. Epiphanius stating great hin = 18 xestes, and holy hin = 9, must refer to Syrian xestes, equal to 24 and 12 Roman; this makes holy hin as above, and great hin a double hin, i.e. wash or saron. His other statements of saron = 65 or 50 sextaria remain unexplained, unless this be an error for bath = 50 or 50 Syr. sext. and $\therefore$ = 7290 or 2560 cub. in. The wholesale theory of Revillout (35) that all Hebrew and Syrian measures were doubled by the Ptolemaic revision, while retaining the same names, rests entirely on the resemblance of the names apet and epha, and of log to the Coptic and late measure lok. But there are other reasons against accepting this, besides the improbability of such a change.

The Phoenician and old Carthaginian system was (18)—

log.	4=kab	6=saron	30=corus
32 cub. in.	125	250	2100

valuing them by 31 Sicilian = 41 Attic modii (Josephus, above).

The old Syrian system was (18)

capit.	=Syr. xestes	=sabaio or saron	'11=collation	=bath-artaba
74 cub. in.	41	240	2110	2210

also

Syr. xestes	45=mois	15=metretres or artaba
41	195	3750

The later or Seleucidian system was (18)—

capit.	=Syr. xestes	90=Syr. metretres
74 cub. in.	41	4000

the Syrian being 14 Roman sextarii.

The Babylonian system was very similar (18)—

capit.	15=maris	10=homer	6=sachae
32 cub. in.	125	250	2100

The approximate value from capitula = 2 Attic choenices (Xenophon) warrants us in taking the achane as fixed in the following system, which places it closely in accord with the preceding.

capit.	45=artaba	40={ achane
744 cub. in.	125	250

the absolute values being fixed by artaba = 51 Attic choenices (Herod. i. 192). The maris of the Pontic system is $\frac{1}{2}$ of the above, and the Macedonian and Naxian maris $\frac{1}{3}$ of the Pontic (18). By the theory of maris = $\frac{1}{2}$ of 20.65 it is 17.55; by maris = Assyrian talent, 1850, in place of 1850 or 1980 stated above; hence the more likely theory of weight, rather than cubit, connexion is nearer to the facts.

Aeginetan System.—This is so called from according with the Aeginetan weight. The absolute data are all dependent on the Attic and Roman systems, as there are no monumental data. The series of names is the same in the Attic system (18). The values are $\frac{1}{11} \times$ the Attic (Athenaeus, Theophrastus, &c.), (2, 18), or more closely $\frac{1}{12} \times$ the Attic. Hence, the Attic cotyle being 17.5 cub. in., the Aeginetan is about 25.7. The Boootian system (18) included the achane; if this = Persian, then cotyle = 24.7. Or, separately through the Roman system, the minas of Cyprus (18) = 170 sextarii; then the cotyle = 24.8. By the theory of the metretres being 15 talents Aeginetan, the cotyle would be 23.3 to 24.7 cub. in. by the actual weights, which have tended to decrease. Probably then 25.0 is the best approximation. By the theory (18) of 2 metretres = cube of the 18-67 cubit from the 12.45 foot, the cotyle would be about 25.4 within .4; but then such a cubit is unknown among measures, and not likely to be formed, as 12.45 is $\frac{3}{4}$ of 20. The Aeginetan system then was—

cotyle	4=chenis	3=ebus	15={ medimnus
25 cub. in.	100	300	4500

This was the system of Sparta, of Boeotia (where the aporyma = 4 choenices, the cophnius = 6 choenices, and sates or saron or hecteus = 2 aporymae, while 30 medimni = achane, evidently Asiatic connexions throughout), and of Cyprus (where 2 choes = Cyprian medimnus, of which 5 = medimnus of Salamis, of which 2 = minas (18)).

Attic or Usual Greek System.—The absolute value of this system is far from certain. The best data are three stone slabs, each with several standard volumes cut in them (11, 18), and two named vases. The value of the cotyle from the Naxian slab is 15.4 (best, others 15.0-16.5); from a vase about 16.6; from the Panath. slab 17.1 (var. 16.2-18.2); from a Capuan vase 17.8; from the Ganus slab 17.8 (var. 17-18). From these we may take 17.5 as a fair approxi-

mation. It is supposed that the Panathenaic vases were intended as metretres; this would show a cotyle of 14.4-17.1. The theories of connexion give, for the value of the cotyle, metretres = Aeginetan talent, $\therefore$ 15.4-16.6; metretres $\frac{1}{2}$ of 12.16 cubed, $\therefore$ 16.6; metretres = $\frac{1}{2}$ of 12.16 cubed, $\therefore$ 16.8; medimnus = 2 Attic talents, hecteus = 20 minae, choenix = 2 talents, $\therefore$ 16.75; metretres = 3 cub. spirithu ($\frac{1}{2}$ cubit = 9.12), $\therefore$ 17.5; 6 metretres = 2 lit. of 12.45 cubed, $\therefore$ 17.8 cub. in. for cotyle. But probably as good theories could be found for any other amount, and certainly the facts should not be used, as almost every author has done, in favour of some one of half a dozen theories. The system of multiples was for liquids—

cyathus	11=aryphalos	4=cotyle	12=choius	12=metretres
29 cub. in.	44	17.5	210	2520

with the tetartem (8-8). 2 = cotyle, 2 = xestes (35-), introduced from the Roman system. For dry measure—

cyathus	6=cotyle	4=choenix	8=hecteus	6=medimnus
29 cub. in.	17.5	70	560	3560

with the xestes, and amphores (1680) = $\frac{1}{2}$ medimnus, from the Roman system. The various late provincial systems of division are beyond our present scope (18).

System of Gythium.—A system differing widely both in units and names from the preceding is found on the standard slab of Gythium in the southern Peloponnese (Rev. Arch., 1872). Writers have unified it with the Attic, but it is decidedly larger in its unit, giving 19.4 (var. 19.1-19.8) for the supposed cotyle. Its system is—

cotyle	4=hemibotrus	4=choius	3=lit.
58 cub. in.	232	922	2790

And with this agrees a pottery cylindrical vessel, with official stamp on it (AHMOZION, &c.), and having a fine black line traced round the inside, near the top, to show its limit; this seems to be probably very accurate, and contains 58.5 cub. in., closely agreeing with the cotyle of Gythium. It has been described (Rev. Arch., 1872) as an Attic choenix. Gythium being the southern port of Greece, it seems not too far to connect this 58 cub. in. with the double of the Egyptian hin = 58.4, as it is different from every other Greek system.

Roman System.—The celebrated Farnesian standard conus of bronze of Vespasian, "mensura exactae in Capitolio P. X." contains 206.7 cub. in. (2), and hence the amphora 1654. By the sextarius of Dresden (2) the amphora is 1695; by the congius of Ste Geneviève (2) 1700 cub. in.; and by the ponderarium measures at Pompeii (33) 1540 to 1840, or about 1620 for a mean. So the Farnesian congius, or about 1650, may best be adopted. The system for liquid was—

quartarius	4=sextarius	6=congius	4=urna	2=amphora
8.6 cub. in.	34.4	206	825	1650

for dry measure 16 sextarii = modius, 550 cub. in.; and to both systems were added from the Attic the cyathus (2-87), acetabulum (4-3) and hemina (17-2 cub. in.). The Roman theory of the amphora being the cubic foot makes it 1569 cub. in., or decidedly less than the actual measures; the other theory of its containing 80 librae of water would make it 1575 by the commercial or 1600 by the monetary libra—again too low for the measures. Both of these theories therefore are rather working equivalents than original derivations; or at least the interrelation was allowed to become far from exact.

Indian and Chinese Systems.—On the ancient Indian system see *Nismatisa Orientalia*, new ed. i. 24; on the ancient Chinese, *Nature*, xxi. 565, and xxv. 318.

STANDARDS OF WEIGHT.—For these we have far more complete data than for volumes or even lengths, and can ascertain in many cases the nature of the variations, and their type in each place. The main series on which we shall rely here are those: (1) from Assyria (38) about 800 b.c.; (2) from the eastern Delta of Egypt (29) (Defenheck); (3) from western Delta (28) (Naucaetia); (4) from Memphis (44)—all these about the 6th century B.C.; and therefore before much interference from the decreasing coin standards; (5) from Cnidus; (6) from Athens; (7) from Corfu; and (8) from Italy (British Museum) (44). As other collections are but a fraction of the whole of these, and are much less completely examined, little if any good would be done by including them in the combined results, though for special types or inscriptions they will be mentioned.

16-6 grains. The Syrian unit was the kat, which varied between 128 and 145 grains (28, 29). There were several families or varieties within this range, at least in the Delta, probably five or six in all (29). The original places and dates of these cannot yet be fixed, except for the lowest type of 138-140 grains; this belonged to Heliopolis (7), as two weights (35) inscribed of "the treasury of An" show 139.9 and 140.4, while a plain one from there gives 138.8; the variety 147-149 may belong to Hermopolis (35), according to an inscribed weight. The names of the kat and tema are fixed by being found on weights, the uten by interrelation with the series was—

(67)	10=kat	10=uten	10=tema
14.9 grs.	146	1460	14,600

The tema is the same name as the large wheat measure (35), which was worth 30,000 to 10,000 grains of copper, according to Ptolemaic receipts and accounts (Rev. Eg., 1881, 150), and therefore very likely worth to tens of copper in earlier times when metals were scarcer. The kat was regularly divided into 10; but another division, for the sake of interrelation with another system, was in $\frac{1}{2}$ and 1

scarcely found except in the eastern Delta, where it is common (29). and it is known from a papyrus (38) to be a Syrian weight. The uten is found $\pm 6=2.25$, in Upper Egypt (rare) (44). Another division (in a papyrus) (38) is a silver weight of $\frac{1}{2}$ kat $\approx$ about 88—perhaps the Babylonian signs of 86. The uten also may be binařly divided into 128 peks of gold in Ethiopia; this may refer to another standard (see 129) (33). The Ptolemaic copper coinage is on two bases—the uten, binařly divided, and the Ptolemaic five shekels (1050), also binařly divided. (This result is from a larger number than other students have used, and study by diagrams.) The theory (3) of the derivation of the uten from $\frac{1}{128}$ cubic cubit of water would fix it at 1472, which is accorđant; but there seems no authority either in volumes or weights for taking 1500 utens. Another theory (3) derives the uten from $\frac{1}{1073}$ of the cubic cubit of 24 digits, or better $\frac{1}{2}$ of 20.63; that, however, will only fit the very lowest variety of the uten, while there is no evidence of the existence of such a cubit. The kat is not unusual in Syria (44), and among the haematite weights of Troy (44) are nine examples, average 144, but not of extreme varieties.

129 grs.: 258 grs. The great standard of Babylonia became the parent of several other systems; and itself and its derivatives became more widely spread than any other standard. It was known in two forms—one system (24) of—

um,	60-shekel,	100-shekel,	60-maneh,	60-talent;
36 grs.	21.3	1.07	1.07	405,000

and the other system double of this in each stage except the talent. These two systems were distinctly named on the weights, and are known now as the light and heavy Assyrian systems (19, 24). (It is better to avoid the name Babylonian, as it has other meanings also.) There are no weights dated before the Assyrian bronze lion weights (9, 17, 19, 38) of the 11th to 8th centuries B.C. Thirteen of this class average 127.2 for the shekel; 9 haematite barrel-shaped weights (38) give 128.2; 16 stone duck-weights (38), 126.5. A heavier value is shown by the precious metals—the gold plates from Khorsabad (18) giving 129, and the gold daric coinage (21, 35) of Persia 129.2. Nine weights from Syria (44) average 128.8. This is the standard of the Babylonian system, and is also the standard of the Hebrew, by Pollux = 70 minae Attic, by Adrian = 72 minae Attic, and, therefore, about 470,000 grains. In Egypt this is found largely at Naucratis (28, 29), and less commonly at Deffneh (29). In both places the distribution, a high type of 129 and a lower of 127, is like the monetary and trade varieties above noticed; while a smaller number of examples are found, fewer and fewer, down to 118 grains. At Memphis (44) the shekel is scarcely known, and a $\frac{1}{2}$ mina weight was there converted into another standard (of 200). A few barrel weights are found at Karnak, and several egg-shaped shekel weights at Gizeh (44), also a few of large glass scarabs for funerary purposes. In Egypt a class of large glass scarabs for funerary purposes seem to be adjusted to the shekel (30). Whether this system or the Phoenician of 224 grains was that of the Hebrews is uncertain. There is no doubt but that in the Maccabean times and onward 218 was the shekel; but the use of the word darkemón by Ezra and Nehemiah, and the probabilities of their case, point to the daragmaneh, $\frac{1}{2}$ maneh or shekel of Assyria; and the mention of $\frac{1}{2}$ shekel by Nehemiah as poll tax nearly proves that the 129 and not 218 grains is intended, as 218 is not divisible by 3. But the Maccabean use of 218 may have been a reversion to the older shekel; and this is strongly shown by the fraction $\frac{1}{3}$ shekel (Ezra, ix, 6), the frequent mention of large decimal numbers of shekels in the earlier books, and the certain fact of 100 shekels being = mina. This would all be against the 129 or 258 shekel, and for the 218 or 224. There is, however, one good datum if it can be trusted: 300 talents of silver (2 Kings xviii. 14) are 800 talents on Sennacherib's cylinder (34), while the 30 talents of gold is the same in both accounts. Eight hundred talents on the Assyrian silver standard would be 267—or roundly 300—talents on the heavy trade or gold system, which is therefore probably the Hebrew. Probably the 129 and 224 systems coexisted in the country; but on the whole it seems more likely that 129 or rather 218 grains was the Hebrew shekel before the Ptolemaic times—especially as the 100 shekels to the mina is paralleled by the following Persian system (Hultsch)—

shekel,	$\frac{1}{100}$ = mina,	60-talent of gold
129 grs.	61.20	367,000

the Hebrew system being

shekel,	$\frac{1}{100}$ = mina,	60-talent of gold
129 grs.	61.20	367,000

and, considering that the two Hebrew cubits are the Babylonian and Persian units, and the volumes are also Babylonian, it is the more

likely that the weights should have come with these. From the east this unit passed to Asia Minor; and six multiples of 2 to 20 shekels (av. 127) are found among the haematite weights of Troy (44), including the oldest of them. On the Aegean coast it often occurs in early coinage (17)—at Lampacusa 131–129, Phocaea 256–254, Cyzicus 252–247, Methymna 174.6, &c. In later times it was a main unit of North Syria, and also on the Euphrate, leoden weights of Antioch (4), Callatis and Tomis being known (38). The mean of these eastern weights is 7700 for the mina, or 128. But the leaden weights of the west (44) from Corfu, &c., average 7580, or 126.3; this standard was kept up at Cyzicus in trade long after it was lost in coinage. At Corinth the unit was evidently the Assyrian and not the Attic, being 129.6 at the earliest (17) (though modified to double Attic, or 133, later) and being +3, and not into 2 drachms. And this agrees with the mina being repeatedly found at Corcyra, and with the same standard passing to the Italian coinage (17) similar in weight, and in division into $\frac{1}{2}$ —the heavier coinages (17) down to 400 a.c. (Ierina, Vela, Sybaris, Posidonia, Metapontum, Tarentum, &c.) being none over 126, while later on many were adjusted to the Attic, and rose to 134. Six disk weights from Carthage (44) show 126. It is usually the case that a unit lasts later in trade than in coinage; and the prominence of this standard in Italy may show how it is that this mina (18 unciae = 7400) was known as the "Italic" in the days of Galen and Dioscorides (2).

126 grs. A variation on the main system was made by forming a $\frac{1}{2}$ mina of 50 shekels. This is one of the Persian series (gold), 6300, and is one of the Hebrew series noted above. But it is most striking where it is found on the coins, as in the distinction of it. Eleven weights from Syria and Cnidus (44) (of the curious type with two breasts on a rectangular block) show a mina of 6250 (125.0); and it is singular that this class is exactly like weights of the 224 system found with it, but yet quite distinct in standard. The same passed into Italy and Corfu (44), averaging 6000—divided in Italy into unciae ($\frac{1}{2}$), and scrupula ($\frac{1}{16}$), and called lira (in Corfu). It is known in the coinage of Hatria (18) as 6320. And a strange division of the shekel in 10 (probably therefore connected with this decimal mina) is shown by a series of bronze weights (44) with four curved sides and marked with circles (British Museum, place unknown), which may be Romano-Gallic, averaging 125.5 to 126. This whole class seems to cling to sites of Phoenician trade, and to keep clear of Greece and the north—perhaps a Phoenician form of the 129 system, avoiding the sexagesimal multiples.

If this unit have any connexion with the kar, it is that a kar of gold is worth 15 shekels or $\frac{1}{2}$ mina of silver; this agrees well with the range of both units, only it must be remembered that 129 was used as gold unit, and another silver unit deduced from it. More likely then the 143 and 129 units originated independently in Egypt and Babylonia.

86 grs. From 129 grains of gold was adopted an equal value of silver = 1720, on the proportion of 1:133, and this 8600; was divided in 10 = 172—which was used either in 516,000, this form, or its half, 86, best known as the siglus (17). Such a proportion is indicated in Num. vii, where the gold spoon of 10 shekels is equal in value to the bowl of 130 shekels, or double that of 70, i.e. the silver vessels were 200 and 100 sigli. The silver plates at Khorsabad (18) we find to be 80 sigli of 84.6. The Persian silver coinage shows about 86.0; the daric was $\frac{1}{2}$ of this or 25.7. Xenophon and others state it at about 84. As the monetary weight it seems to have been raised, perhaps entirely, in consequence of the Persian dominion; it varies from 174 downwards, usually 167, in Aradus, Cilicia and on to the Aegean coast, in Lydia and in Macedonia (17). The silver bars found at Troy averaging 2744, or $\frac{1}{2}$ mina of 8232, have been attributed to this unit (17); but no division of the mina in $\frac{1}{2}$ is to be expected, and the average is rather low. Two haematite weights from Troy (44) show 86 and 87.2. The mean from leaden weights of Chios, Tenos (44), &c., is 8430. A duck-weight of Canopus, probably early, gives 8490; the same passed on to Greece and Italy (17), averaging 86.0; but in Italy it was divided, like all other units, into 128 or 256 parts (44). It is also seen in the Etruscan coinage as 175 = 72 (17). By the Romans it was used on the Danube (18), two weights of the first legion there showing 8610; and this is the mina of 20 unciae (8400) named by Roman writers. The system was—

shekel,	$\frac{1}{100}$ = mina,	60-talent of gold
129 grs.	61.20	367,000

A derivation from this was the $\frac{1}{2}$ of 172, or 57.3, the so-called Phoenician drachma, equal in silver to the $\frac{1}{2}$ of the gold unit of 258 grains. It was used at Phocaea as 58.5, and passed to the colonies of Posidonia and Vela as 59 or 118. The colony of Massilia brought it into Gaul as 58.2–54.9.

224 grs. That this unit (commonly called Phoenician) is derived from the 129 system can hardly be doubted, both being $\frac{1}{2}$ of 448, so intimately associated in Syria and Asia Minor. The relation is 258:229 :: 9:8; but the exact form in which the descent took place is not settled: $\frac{1}{2}$ of 129 of gold is worth 57 of silver or a drachm, $\frac{1}{2}$ of 230 for by trade weights 127 and 265; otherwise, deriving it from the silver weight of 86.0, the silver, the drachm in 172 is the drachm in 172, or double of the Persian daric of 28.7, and the sacred unit of Diömya in Ionia was this half-drachm, 27; or thirdly, what is indicated by the Lydian coinage (17), 86 of

gold was equal to 1150 of silver, 5 shekels or $\frac{1}{5}$ mina. Other proposed derivations from the kat or pek are not satisfactory. In actual use this unit varied greatly: at Naucratis (29) there are groups of it at 231, 225 and others down to 208; this is the earliest form in which we can study it, and the corresponding values to these are 130 and 126, or the gold and trade varieties of the Babylonian, which the lower kat down to 208 corresponds to the shekel down to 118, which is just what is found. Hence the 224 unit seems to have been formed from the 129, after the main families or types of that had arisen. It is scarcer at Defenneh (29) and rare at Memphis (44). Under the Ptolemies, however, it became the great unit of Egypt, and is very prominent in the later literature in consequence (18, 35). The average of coins (21) of Ptolemy I. gives 219.6, and thence they gradually diminish to 210, the average (33) of the whole series of Ptolemies being 218. The "argenteus" (as Revault transcribes a sign in the papyrus) (35) was of 5 shekels, or 1900; it arose about 160 B.C., became earlier 160 B.C. a weight unit for copper. In Syria, as early as the 15th century B.C., the tribute of the Rutennu, of Naharina, Megiddo, Anakkasa, &c. (34), is on a basis of 154-484 kats, or 300 shekels ($\frac{1}{2}$ talent) of 226 grains. The commonest weight at Troy (44) is the shekel, averaging 224. In coinage it is one of the commonest units in early times; from Phoenicia, round the coast to Macedonia, it is predominant (17); at a maximum of 230 (Ialysus), it is in Macedonia 224, but seldom exceeds 220 elsewhere, the earliest Lydian of the 7th century being 219, and the general average of coins 218. The system was—

(1), 7 grs.	8-drachm, 56	4-shekel, 224	25-mina, 3000	120-talent, 602,000
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From the Phoenician coinage it was adopted for the Macedonian. It is needless to give the continual evidences of this being the later Jewish shekel, both from coins (223) and writers (18, 33); the question of the early shekel we have noticed already under 129. In Phoenicia and Asia Minor the mina was specially made in the form with two breasts (44), 19 such weights averaging 5600 (=224), and thence it passed into Greece, more in a double value of 11,200 (=224). From Phoenicia this naturally became the main Punic unit; a bronze weight from Iol (18), marked 100, gives a drachma of 56 or 57 (224-228); and a Punic inscription (18) names 28 drachmae 25 Attic, and 57 to 59 grains (228-236); while a probably later series of 8 marks from Carthage (44) show 208, but vary from 197 to 234. In Spain it was 226 to 246 in different series (17), and it is a question whether the Massiliote drachmae of 58.55 are not Phoenician rather than Phocaic. In Italy this mina became naturalized, and formed the "Italic mina" of Hero, Priscian, &c.; also its double, the mina of 26 unciae or 10,800, = 50 shekels of 216; the average of 42 weights gives 5390 (=215.6), and it was divided both into 100 drachmae, and also in the Italic mode of 12 unciae and 288 scripulae (44). The talent was of 120 mina of 5400, or 3000 shekels, shown in the talent from Hieraculum, 1700, and by the weight inscribed POSTO CXXV. (i.e., 12 librae) TALENTUM SICLOVM V. III., i.e., talent of 3000 shekels (2) (the M being omitted; just as Epiphanius describes this talent as 125 librae, or θ (=9) nomimata, for 9000). This gives the same approximate ratio 96:100 to the libra as the usual drachma reckoning. The Alexandrian talent of Ptolemy, 12,000 denarii, is the same talent again. It is believed that this mina & 12 unciae by the Romans is the origin of the Arabic rati of 12 ahiyas, or 5600 grains (33), which is said to have been sent to Harun al-Rashid by Charlemagne, and was designated the French muid and amount of 3666 grains. But, as this is probably the same as the English monetary pound, or tower pound of 5400, which was in use earlier (see Saxon coins), it seems more likely that this pound (which is common in Roman weights) was directly inherited from the Roman civilization.

80 grs. Another unit, which has scarcely been recognized in 4000; metrology hitherto, is prominent in the weights from 4000. Egypt—some 50 weights from Naucratis and 15 from Defenneh plainly agreeing on this and on no other basis. Its value varies between 75.5 and 81.8—mean 79.43 grains (29), or 81 at Defenneh (29). It has been connected theoretically with a binary division of the 10 shekels or "stone" of the Assyrian systems (28), 1296:16 being 80:6; this is suggested by the most usual multiples being 10 and 40 = 25 and 50 shekels of 129; it is thus akin to the mina of 50 shekels previously noticed. The tribute of the Asi, Rutennu, Khita, Assaru, &c., to Thothmes III. (34), though in uneven numbers of kats, comes out in round thousands of units when reduced to this standard. That this unit is quite distinct from the Phoenician 86 grains is clear. Next, in Syria, there is inscribed a wide gap between the two systems. Next, in Syria, there is inscribed weights of Antioch and Berytus (18) show a mina of about 16,400, or 209 $\times$ 82. Then at Abydos, or more probably from Babylonia, there is the large bronze lion-weight, stated to have been originally 400,500 grains; this has been continually +60 by different writers, regardless of the fact (*Rev. arch.*, 1862, 36) that it bears the numeral 100; this therefore is certainly a talent of 100 minae of 4005; and as the mina is generally 50 shekels in Greek systems it points to a weight of 80.1. Further west the same unit occurs in several Greek (44) which weigh 800 to 820 grains—mean 809.5—i.e., 80.5. Turning to Egypt, we find this often, but usually overlooked as a degraded form of the Persian 86 grains signa. But the earliest

coinage in Cilicia, before the general Persian coinage (17) about 380 B.C., is Tarsus, 164 grains; Soli, 169, 163, 158; Nagidus, 158, 161-153 later; Issus, 166; Mallus, 163-154—all of which can only by straining be classed as Persian; but they agree to this standard, which, as we have seen, was used in Syria in earlier times by the Khita, &c. The Milesian or "naïve" system of Asia Minor (18) is fixed by Hultsch at 163 and 81.6 grains—the coins of Miletus (17) showing 160, 80 and 39. Coming down to literary evidence, this is abundant. Boeckh decides that the "Alexandrian drachma" was $\frac{1}{2}$ of the Solonic 67, or = 80.5, and shows that it was not Ptolemaic, or Rhodian, or Aeginetan, being distinguished from these in inscriptions (2). Then the "Alexandrian mina" of Dioscorides and Galen (2) is 20 unciae = 8250; in the "Analecta" (2) it is 150 or 158 drachmae = 8100. Then Attic: Euboeic or Aeginetan = 18.25 in the metrologists (2); and the Euboeic talent = 158 Attic drachmae = 15800 grains. The "Alexandrian" wood talent: Attic talent: = 6:5 (Hero, Didymus), and 4,800,000, which is 60 minae of 8000. Pliny states the Egyptian talent at 80 librae = 396,000; evidently = the Abydos lion talent, which is $\approx$ 100, and the mina is $\approx$ 3960, or 50 $\times$ 79.2. The largest weight is the "wood" talent of Syria (18) = 6 Roman talents, or 1,860,000, evidently 120 Antioch minae of 15,500 or 2 $\times$ 7750. This evidence is too distinct to be set aside, and, exactly confirming as it does the Egyptian weights and coin weights, and agreeing with the early Asiatic tribute, it cannot be overlooked in future. The system was

drachm, 86 grs.	2-stater, 170	50-mina, 8000	50-talent, 400,000	60=Greek talent, 480,000
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This system, the Aeginetan, one of the most important to the Greek world, has been thought to be a degradation of the Phoenician (17, 21), supposing 220 grains to have been reduced in primitive Greek usage to 194. But we are now able to prove that it was an independent system—(1) by its not ranging usually over 200 grains in Egypt before it passed to Greece; (2) by its earliest example, perhaps before the 224 unit existed, not being over 208; and (3) by there being no intermediate standard between the Phoenician and the large number of Egyptian weights, nor in the Ptolemaic coinage, in which both standards are used. The first example (30) is one with the name of Amenhotep I. (17th century B.C.) marked as "gold $\frac{1}{2}$ ", which is 5 $\times$ 207.6. Two other marked weights are from Memphis (44), showing 201.8 and 196.4, and another Egyptian 191.4. The range of the (34) Naucratis weights is 180 to 199, divided in two groups averaging 190 and 195, equal to the Greek monetary and trade varieties. Ptolemy I. and II. also struck a series of coins (32) averaging 199. In Syria haematite weights are found (30) averaging 198.5, divided into 292, 494, and 2470, and the division is shown by gold rings from Egypt (38) of 24.9. In the medical papyrus (38) a weight of $\frac{1}{2}$ kat is used, which is thought to be Syrian; now $\frac{1}{2}$ kat = 92 to 101 grains, or just this weight which we have found in Syria; and the weights of $\frac{1}{3}$ and $\frac{1}{4}$ kat are very rare in Egypt except at Defenneh (29), on the Syrian road, where they abound. So we have thus a weight of 207-191 in Egypt on marked weights, joining therefore completely with the Aeginetan unit in Egypt 190 to 186, and coinage of 199, and strongly connected with Syria, where a double mina of Sidon (18) is 10,460 or 50 $\times$ 209.2. Probably before any Greek coinage we find this among the haematite weights of Troy (44), ranging from 208 to 193.2 (or 104-96.6), i.e., just covering the range from the earliest Egyptian down to the early Aeginetan coinage. Turning now to the earliest groups, we see the fuller weight kept up (17) at Samos (202), Miletus (201), Calymna (100, 50), Methymna and Scyros (99, 49), Ionia (107); while the coinage of Aegina, (17, 12), which by its wide diffusion made this unit best known, though a few of its earliest staters go even to 207, yet is characteristic of the 190 group, and the two groups which are recognized in Egypt, and thus started what has been considered the standard value of 194, or usually 190, decreasing afterwards to 184. In later times, in Asia, however, the fuller weight, or higher Egyptian group, which we have just noticed in the coinage, was kept up (17) into the series of cistophori (196-191), as in the Ptolemaic series of 195. At Athens the old mina was fixed by Solon at 150 of his drachmae (18) or 9800 grains, according to the earliest drachmae, showing a stater of 196; and this continued to be the trade mina in Athens, at least until about B.C., but in a reduced form, which is equal only to 138 Attic drachmae, or 9200. The Greek mina weights show (44), on an average of 37,9650 (=stater of 193), varying from 186 to 199. In the Hellenic coinage it varies (18) from a maximum of 200 at Phaeae to 192, usual full weight; this unit occupied (17) all central Greece, Peloponnesus and most of the islands. The system was—

obol, 16 grs.	6-drachm, 96	2-stater, 192	50-mina, 8000	60-talent, 972,000
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* That this unit was used for gold in Egypt, one thousand years before becoming a silver coin weight in Asia Minor, need not be dwelt on, when we find it in the Lydian (17) gold pieces and silver on the same standard, which was expressly formed for silver alone, i.e., 84 grains. The Attic and Assyrian standards were used indifferently for either gold or silver.

18 inches: yard of 36 inches, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$ yard, nail, inch, and duodecimal, decimal and binary parts of the inch.

Imperial Measures of Capacity.—Liquid measures from 52 gallons to 1 gallon, quart, pint, $\frac{1}{2}$ pint, gill, $\frac{1}{2}$ gill, $\frac{1}{4}$ gill. Dry measures of bushel, $\frac{1}{2}$ bushel, peck, gallon, quart, pint $\frac{1}{2}$ pint.

Apothecaries' Measures.—40 fluid ounces to $\frac{1}{2}$ fl. oz., 16 fluid drachms to $\frac{1}{2}$ fl. dr., 60 minims to 1 minim.

Avoirdupois Weights.—Cental (100 lb), 56 lb ($\frac{1}{2}$ cwt.), 28 lb, 14 lb (stone), 7, 4, 2, 1 lb; 8, 4, 2, 1, $\frac{1}{2}$ ounce (8 drams); 4, 2, 1, $\frac{1}{2}$ drams.

Troy Weights.—The ounce (480 gr.) and multiples and decimal parts of the ounce troy from 500 ounces to 0.001 oz.

Apothecaries' Weights.—to oz. to 1 oz. (480 gr.); 4 drachms to $\frac{1}{2}$ oz.; 2, 1 drachms; 2 scruples to $\frac{1}{2}$ scruple; and 6 grains to $\frac{1}{2}$ grain.

Pennyweights.—20 dwt. (480 grains), 10, 5, 3, 2, 1 dwts.
Grain Weights.—4000, 2000, 1000 gr. (making 7000 gr. or 1 lb), 500 to 0.01 gr.

2. The international trade metric weights and measures (1897) handed in shops, &c., of which there are also Board of Trade standards, are set out as follows:—

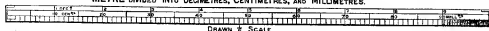
IMPERIAL TO METRIC

1 yard	=	0.914399 m.
1 square yard	=	0.836126 m ² .
1 cubic inch	=	16.387 c.c.
1 gallon ¹	=	4.5459631 l.
1 pound (7000 grains)	=	0.45359243 kg.
1 ounce troy (480 gr.)	=	31.1035 grammes.
1 fluid drachm	=	3.552 millilitres (ml.).
1 fluid ounce	=	2.84123 centilitres (cl.).

METRIC TO IMPERIAL

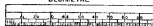
1 metre (m.) at 0° C.	=	39.370113 inches at 62° F.
1 square metre (m ²).	=	10.7639 square feet.
1 cubic decimetre (c.d.)	=	61.024 cubic inches.
or		
1000 cubic centimetres (c.c.)	=	1.7598 pints.
1 litre (l.)	=	2.2046223 lb avoird.
1 kilogram (kg.)	=	15.4323564 grains
	=	or
1 gramme (g.)	=	0.7716 scruple.

METRE DIVIDED INTO DECIMETRES, CENTIMETRES, AND MILLIMETRES.



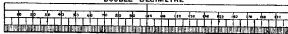
DRAWN 1 SCALE

DECIMETRE



DRAWN 2 SCALE

DOUBLE DECIMETRE



DRAWN 3 SCALE

A



B



C



D

FIG. 9.—International Metric Trade Weights and Measures, 1897. A, linear; B, capacity; C, and D, weights.

Length.—Decimetre or 10 metres; double metre; metre or 1000 millimetres; decimetre or 0.1 metre; centimetre or 0.01 metre; millimetre.

Capacity.—20 litres; 10 litres or decalitre; 5, 2, 1, 0.5, 0.2, 0.1 (decilitre); 0.05, 0.02, 0.01 (centilitre); 0.005, 0.002, 0.001 (millilitre) litres.

Cubic Measures.—1000 (litre), 500, 200, 100, 50, 20, 10, 5, 2 cubic centimetres, 1 c.c. or 1000 cubic millimetres.

Weights.—20, 10, 5, 2, 1 kilograms; 500 to 1 gramme; 5 to 1 decigram; 5 to 1 centigram; 5 to 1 milligram. (Series 5, 2, 2, 1, i.e. with a duplicate weight of "2".)

3. *Equivalents.*—The metric equivalents of the units of the metric system in terms of the imperial system, as recalculated in 1897, are as follows:—¹

¹ The equivalent of the litre in gallons may also be derived as follows:—

Let $P(1 - \rho/d) = P^1(1 - \rho^1/d^1)$, where P is the weight of the water contained in the gallon when weighed in London—g. London = g. Paris (45°) $\times 1.000577$.

The correction for temperature, 62° F., is -0.0906 in.; hence 29.9094 inches. One inch = 25.4 mm.; also $29.9094 \times 25.4 = 759.69876$; and $759.69876 \times 1.000577 = 760.137$ mm. P^1 is the weight of the brass weights (10 lb) $\Delta = 8.143$.

ρ , the density (0.00121838) of dry air, containing 4 vols. of carbonic acid in 10,000 vols.; $t = 16.667$ ° C.; $B = 750.137$ mm. of mercury at 0°, lat. 45°, and at sea-level. Coefficient of expansion of air = 0.00367; Δ mercury at 0° C. = 13.595. d is the density of water at 62° F. (16.667° C.) = 0.9988611. ρ^1 , the density of the brass as above. 10 lb = 4.5359243 kg.

From the above it follows that $P = 4.5407857$ kg. Therefore—1 gallon = $P/0.9988611 = 4.5459631$ litres.

¹ *Metric Equivalents*, King's Printers (1898).

The equivalents of the Russian weights and measures, in terms also of the imperial and metric weights and measures, were recalculated in 1897.¹ The following are the leading equivalents:

1 Russian pound =	$\begin{cases} 0.025 \text{ pood.} \\ 96 \text{ zolotniks.} \\ 9216 \text{ dolbs.} \\ = 0.4957240 \text{ kg.} \\ = 0.90282018 \text{ lb avoird.} \end{cases}$
1 archinne =	$\begin{cases} 0.00066 \text{ verst.} \\ = 0.33 \text{ sague.} \\ = 16 \text{ vercnoks.} \\ = 280 \text{ liuks.} \\ = 0.711300 \text{ metre.} \\ = 0.777778 \text{ yard.} \end{cases}$
1 vedro =	$\begin{cases} 10 \text{ schoffos} \\ = 100 \text{ tcharkas} \\ = 12.299 \text{ litres} \\ = 2.7056 \text{ gallons.} \end{cases}$
1 tchetvertse =	$\begin{cases} 8 \text{ tchetveriks} \\ = 2.0991 \text{ hectolitres} \\ = 5.7719 \text{ bushels.} \end{cases}$

4. *Local Control.*—The necessary local inspection and verification of weights and measures in use for trade (as distinct from the verbal and written use of weights and measures) is in the United Kingdom undertaken by inspectors of weights and measures, who are appointed by the local authorities, as the county and borough councils. An inspector is required to hold a certificate of qualification, and for his guidance general regulations are made by his local authority as to modes of testing weights, measures and weighing instruments.² In Europe the local inspection is generally carried out through the State, and a uniform system of local verification is thereby maintained.

5. *Errors.*—In the verification of weights and measures a margin of error is permitted to manufacturers and scale-makers, as it is found to be impossible to make two weights, or two measures, so identical that between them some difference may not be found either by the balance or the microscope. For common weights and measures this margin (tolerance, remedy or allowance, as it is also called) has been set out by the Board of Trade for all the various kinds of weights and measures in use for commercial purposes in the United Kingdom, and similar margins of error are recognized in other countries. For instance, on 1 lb avoird. weight made of brass, 2 grains in excess are allowed; on 1 oz. troy or apothecaries' weight, $\frac{1}{10}$ of a grain is allowed; on 1 pint pot, 4 fluid drachms is permitted; on 1 brass yard, 0.05 inch in excess or 0.02 inch in deficiency in length is allowed for ordinary trade purposes.

6. *Foreign Weights and Measures.*—Throughout the British Empire the imperial system of weights and measures is legal.

In Russia, as in the United Kingdom and the United States, the national weights and measures are followed (§ 3 above), although the use of metric weights and measures is permissive.

In India the native weights, &c., ancient and arbitrary, are still followed. In 1880 the British yard was adopted for the whole of India (Measures of Length Act) at a normal temperature of 85° F. as standardized to the imperial yard at 63° F. The metric system was also introduced, mainly for railway purposes, in 1870 and 1871 (Indian Acts). Certified measures of the yard, foot and inch are kept by the Commissioners of Police at Calcutta, Madras and Bombay.

In standardizing a weight for use in India, correction has to be made for the weight of air displaced by the material standard, and for such purpose the normal temperature of 85°, atmospheric pressure 29.8 inches, latitude 22° 35' 6" S. (Calcutta), $g = \frac{145}{148} = 0.9982515$ are taken. The "tola" (180 grains) is properly the Government unit of weight for currency; and 80 tolas make the "Government seer."

7. *Customary Weights and Measures.*—In some districts of the United Kingdom, as well as in provincial districts of other countries, old local and customary denominations of weights and measures are still found to be in use, although their use may have been prohibited by law. So powerful is custom with the people.³

8. *Legislation.*—In everyday transactions with reference to weights and measures, the British legislature also exercises

control in industrial pursuits. For instance, in weighing live cattle, owners of markets are now required to provide adequate accommodation.⁴ Useful statutes have also been passed to protect the working class, as in checking the weighing instruments used in mines in Great Britain, over which instruments wages are paid, and in the inspection of similar instruments used in factories and workshops. The Merchandise Marks Act 1887 makes it an offence also to apply in trade a false description, as to the number, quantity, measure, gauge or weight of goods sold; and this Act appears to reach offences that the Weights and Measures Acts may perhaps not reach.

9. *Pharmaceutical Weights and Measures.*—By the Medical Act of 1858, and the Act of 1862, the General Council of Medical Education and Registration of the United Kingdom are authorized to issue a "Pharmacopoeia" with reference to the weights and measures used in the preparation and dispensing of drugs, &c. The British Pharmacopoeia issued by the Council in 1898 makes no alteration in the imperial weights and measures required to be used by the Pharmacopoeia of 1864. For all pharmaceutical purposes, however, the use of the metric system alone is employed in all paragraphs relating to analysis, whether gravimetric or volumetric. For measures of capacity the Pharmacopoeia continues to use imperial measuring vessels graduated at the legal temperature of 62° F. The official names of the metric capacity units are defined at 4° C., as generally on the Continent. The new Pharmacopoeia also follows foreign practice, and employs metric measures of capacity and volumetric vessels graduated at 15.5° C., or 60° F. Specific gravity bottles are also adjusted at 60° F., the figures indicating specific gravities being quotients obtained by dividing in each instance the weight of the solid or liquid by the weight of an equal bulk of water, both taken at 60° F.

10. *Gauges.*—Gauges, as understood at one time, included only those used in the measurement of barrels, casks, &c.; and hence the term "gauger." For engineering and manufacturing purposes the more important linear gauges are, however, now used, adjusted to some fundamental unit of measure as the inch; although in certain trades, as for wires and flat metals, gauges continue to be used of arbitrary scales and of merely numerical sizes, having no reference to a legal unit of measure; and such are rarely accurate. A standard gauge, however, exists (Order in Council, August 1883), based on the inch, but having numbered sizes from 7.0 (5 inch) to No. 50 (0.001 inch) to meet the convenience of certain trades.

11. *Screws.*—The screw is an important productive measuring instrument, whether used as a micrometer-screw of less than an inch in length, or as a master-screw of 20 feet in length. The probable errors and eccentricities of small micrometer-screws have been carefully investigated to ± 0.0001 inch; but the accuracy of leading screws used in workshops has not been sufficiently verified. For some engineering purposes it would appear to be desirable to produce master-screws to an accuracy of ± 0.001 of an inch to the foot of screw, so as to serve indirectly for the verification of "guiding screws" for general use in workshops.⁵ Attempts in this direction were originally made by Whitworth, Clement, Denkin, Rogers, Bond and others, but we still need a higher accuracy in screw-threads.

12. *Educational.*—Ordinary arithmetic books often contain references to local and customary weights and measures and to obsolete terms of no practical use to children. It appears to be desirable, as the Committee of Council on Education have done, to recognize only the legal systems of weights and measures—the imperial and metric. The Education Code of Regulations for 1900 prescribes that the tables of weights and measures to be learned include those only which are in ordinary use, viz. in all classes or forms above the third tables of

- { Weight—ton, cwt, stone, lb, oz, and dr.,
- { Length—mile, furlong, rod or pole, chain, yd., ft. and inch,
- { Capacity—quart, bushel, qt., gill, qt. and pt.

In Code standards above the fifth, in addition to the foregoing, the tables of

- { Area—sq. mile, acre, rood, pole, yd., ft. and inch,
- { Volume—cubic yard, foot and inch,

Instruction in the principles of the metric system, and in the advantages to be gained from uniformity in the method of forming multiples and sub-multiples of the unit, are, under this Code, to be

¹ Markets and Fairs (Cattle) Acts 1887, 1891; Coal Mines Regulation Act 1887; Factory and Workshop Act 1878.

² Pharmacopoeia (1901); Calendar Pharmaceutical Society, 1902.

³ Order in Council, 26th August 1881.

⁴ *Système métrique des usages agricoles*, Thury (Geneva, 1878). Bulletin Soc. d'Encouragement pour l'Industrie Nationale, Paris, 1894. Report of British Association on Screw-threads, 1900.

¹ C.I.P.M. *Procès-verbaux* (1897), p. 155.

² Regulations, Birmingham, Glasgow, London, Manchester, &c.

³ Report Select Committee (1892); *Merchant's Handbook*, W. A. Browne (1892); Reports H.M. Representatives Abroad, Foreign Office, 1900-1901.

given to the scholars in Standards IV., V., VI. and VII. As a preparation for this it is stated in the Code that it will be useful to give in Standard III. (arithmetic) elementary lessons on the notation of decimal fractions. (See ARITHMETIC.)

Table of the Principal Foreign Weights and Measures now in use, and of their Equivalents in Imperial or in Metric Weights and Measures.

Almude	Portugal	16.8 litres.
Anoman (Ammomam, Anomam)	Ceylon	0.699 quarter (dry measure), 5.60 bushels.
Ara	Italy	1 metric are, 119.6 sq. yds.
Archin, or Archin	Turkey	1 new archin (Law 1881) = 1 metre (39.37 inches) = 10 parmaks (decimetres) = 100 khars (centimetres). 1 mill = 1000 archins (kilometres). Pharaoh = 10 mills. Another pharaoh = 2 hours' journey.
Archin	Bulgaria	0.758 metre (masous).
Archine, or Archine	Russia	0.680 metre (tailors).
Ardeb	Egypt	28 inches, or 0.7112 metre.
Are	Egypt	5.447 bushels (Customs). 5 bushels (old measure).
Area	Spain	= 100 sq. metres = 119.6 sq. yds.
Arpent	France	1 metric are.
Arroba	Canada	Legal arpent was equal to 100 sq. perches = 51.07 metric area in Quebec = 180 French feet.
Arroba	Portugal	14.68 to 15 kilogrammes.
Artaba	Spain	Mayor = 3.55 gallons, or 1 cantara.
Aune	Persia	1.809 bushel.
Baril	Belgium	Menor = 2.76 gallons (liquids).
Bat, or Tical	France	1 metre. Formerly 1.312 yard.
Batman	Jersey	1.884 metre (1812).
Behar	Rome	4 feet.
Berri	Siam	12.834 gallons.
Boisseau	Turkey	234 grains.
Boutyika	Arabia	6½ lb av.; varies locally.
Brassa	Turkey	= 10 ocks.
Braccio	Arabia	439.45 lb av., nearly.
Brasse	Turkey	1.084 mile (old measure).
Braza	Belgium	15 litres.
Bu, or tsubo	Russia	1.353 pint (wine bottle).
Bushel	Portugal	2.2 metres.
	Spain	0.670 metre (commercial).
	Rome	Braccio d'ara = 29.328 inches.
	France	5.328 feet.
	Argentina	5.682 feet.
	Japan	3.0306 square metres.
	U. States	215.02 cubic inches, about
	Canada	0.96944 imperial bushel. 1 bushel = 8 gallons = 32 quarts = 64 pints.
Bunder	Netherlands	2.471 acres (old hectare).
Cabot	Jersey	10 pots, or 4 gallons, 1 quart 3 gills imperial measure.
Candy	Bombay	590 lb av.
Cantar	Madras	493.7 lb av.
Cantara piccolo	Turkey	124.7 lb av. (old weight).
Capicha	Italy	74.771 lb av.
Catty	Persia	0.58 gallon.
	China	1½ lb av. See <i>Tael</i> .
	N. Borneo	1½ lb av.
	Siam	2.075 lb av., or ½ hap.
Cawnie	Madras	1.322 are.
Cental	U. States	100 lb av. (As in Great Britain).
	Canada	
Centigramme		= 1/100 grain = 0.154 grain.
Centilitre		= 1/100 litre = 0.07 gill.
Centimetre		= 0.394 inch = 1/10 m.
Centimetre, cubic (c.c.)		= 0.061 cubic inch, or 1 c.c.
Centimetre, square		= 0.155 square inch.
Centner	Austria	50 kilogrammes = 110.231 lb. av.
	Denmark	50 kilogrammes = 110.231 lb. av.
	Switzerland	50 kilogrammes = 110.231 lb. av.
Chain	Canada	66 feet.
	Cyprus	0.33 pic.
Chang	China	10 ch'ih = 11 ft. 9 inches (Treaty).
Chapah	Siam	2.675 lb.
Chec. See <i>Tahil</i>	N. Borneo	1½ lb av.
Chek	Hong Kong	14½ inches.
Chemira	Persia	0.289 gallon.
Ch'ien	China	581 grains (silver weight).
Ch'ih	China	Varies throughout China from 11 to 15.8 inches. For Customs purposes the Treaty ch'ih = 14.1 inches, and 5 ch'ih = 1 pu.

Ch'ih	Peking	= 12.5 } public works. = 12.5 } = 12.4 } statistics. = 12.6 } architects. = 12.7 } common. = 13.1 } tribunal of mathematics. = 13.7 } Board of Revenue.
	Shanghai	= 14.1 Customs. = 1 kilogramme.
Chilogramme	Italy	1 kilogramme.
Chin or Catty	China	1½ lb av. (Treaty).
Ching	China	121 sq. feet (Treaty).
Ch'ing	China	72,600 sq. feet (Treaty).
Chittack	Bengal	5 tolas, or 900 grains.
Ch'ok	Corea	7½ in. (linear); 12½ in. (building).
Chdo	China	1815 sq. feet (Treaty).
Chupah	Singapore	1.66 av. lb. of water at 62° F., as a measure of capacity.
Chupak	Malacca	144 oz. av. of water.
	Straits Settlements	1 quart.
Colothun	Persia	1.809 gallon.
Coss	Bengal	1.176 metre.
Covado	Portugal	0.66 metre.
Covid, or Cubit	Madras	18 to 21 inches.
	Bombay	18 inches.
	Siam	18 inches.
Covido	Arabia	18 inches approximately.
Covido (Great)		27 inches.
Cuartillo	Spain	1.16 litre (dry); 0.504 litre liquid.
Daktylon (Royal)	Greece	1 centimetre.
Daribah	Egypt	43.58 bushels (Customs).
Dogagramme		= 10 grms. = 5.64 drams av.
Decalitre		= 10 litres = 2.2 gallons.
Decametre		= 10.936 yards.
Décalina	Russia	= 2400 square sàgènes = 2.7 acres.
Decigramme		= 1/10 grm. = 1.54 grain.
Decilitre		= 1/10 litre = 0.176 pint.
Decimetre		= 3.937 inches = 0.1 metre.
Decimetre, cubic		= 1000 c.c. = 6.1024 cub. in.
Decimetre, square		= 100 sq. centim. = 15.5 sq. in.
Denaro	Rome	18.17 grains (old weight).
Denunam	Turkey	1 metric are.
Diraa, or Drâa, or Pic	Egypt	27 inches usually.
	Turkey	21.3 inches Nile measure.
Dirhem	Egypt	27 inches (old measure of pike).
		1.761 dram av. (Customs).
		3.0884 grammes (Cairo).
Djerib	Turkey	1 hectare.
Dolia, or Dola	Russia	0.686 grain.
Drachma	Netherlands	96 doli = 1 solotnick.
	Turkey	3.906 grammes.
Drachmé (Royal)	Crece	154.324 grains.
	Constantinople	1 grammé (gold weight).
		= 57.871 grains. See <i>Ock</i> .
Dram. See <i>Oke</i>		
Ducat	Vienna	53.873 grains.
Duim	Netherlands	1 centimetre.
Eimer	Austria	12.448 gallons.
El	Netherlands	1 metre. (Old ell = 27.08 inches).
Ell	Jersey	4 feet.
Ella	N. Borneo	1 yard.
Elle	Switzerland	0.6561 yard.
Endaseh, or Hindzai	Egypt	Usually 25 inches.
Faltche	Moldavia	1 hectare, 43 ares, 22 centiares.
Fanca	Argentina	3.773 bushels.
	Portugal	55.364 litres.
	Spain	526 bushel.
	Peru	1½ bushel.
Fass		1.615 acre, but varies locally.
Feddah	Germany	1 hectolitre.
	Egypt	1.038 acre (Masri). Also 1.127 acre locally.
Fen	China	1.266 are (old).
Fierdingkar	Denmark	5.83 grains (silver weight).
Fod	Denmark	0.9564 bushel.
	Norway	1.0297 foot.
Foglietto	Rome	0.3137 metre.
Foot	U. States	0.8 pint.
	Canada	12 inches.
	Amsterdam	French foot = 12.8 inches.
	South Africa	{ 11.147 in. } old measure.
	Old Rhenish	{ 12.356 in. }

Mou	China	Commonly 806-65 sq. yds. Varies locally. Shanghai = 6600 sq. ft. (Municipal Council). By Customs Treaty = 920-417 sq. yds., based on ch'ih of 14-1 inches.	Pouce	France	1-066 inch (old measure).
Mud	Netherlands	1 hectolitre.	Russia	Russia	1 inch.
Myriagramme	Netherlands	= 10 kilogrammes = 22-046 lb av.	Poud, or Poed	U. States	0-01622 ton = 36 lb.
Ngoma	East Africa	7½ keilas.	Pound	U. States	Standard troy lb = 5760 grains. Avoird. lb = 7000 grains.
Nin	Siam	1½ inch.	Russia	Russia	0-0028 lb av. (0-4005 kilogramme).
Obolos	Greece	1 decigramme.	Jersey	Jersey	7361 grains = 16 oz. Jersey = 1 livre.
Ock	Turkey	Legal ock (1881) = 100 drachmas. New batman = 10 ocks, and kantar = 10 batmans ock = 1 kilogramme.	Pu	China	70-5 inches = 5 ch'ih.
Octavillo	Spain	0-29 litre.	Puddee	Madras	2-89 pints. 100 cubic inches = Government puddee.
Oitavo	Portugal	1-730 litre.	Pulgada	Spain	0-027 inch.
Oke	Bulgaria	1-28 litre (for liquids).	Pund	Denmark	1-1023 lb av., or 500 grammes.
		1-282 kilogramme (old).		Norway	0-4981 kilogramme.
	Cyprus	2½ lb. av. = 400 drams (Cyprus).		Sweden	5360 grains. Varies locally, 5300-5 grains (apoth.).
	Egypt	2-751 lb av. (Customs). 2-805 lb (Alexandria).	Quart	U. States	See <i>Brake</i> .
	Greece	2-80 lb = 1-282 kilogramme.	Quarto	Rome	2-024 bushels.
	Turkey	1-1518 pint. 2-834 lb av. (old weight).		Portugal	3-26 litres.
Onça	Portugal	28-668 grammes.	Quintal	Spain	100 libras (Castilian) = 101-4 lb.
Ones	France	30-59 grammes (old).		Portugal	58-752 kilograms, or 129½ lb av.
Oncta	Rome	336-164 grains.		Argentina	100 libras, or 101-27 lb av.
Onze	Netherlands	1 hectogramme, 10 onzen = pond.	Quintal (metre)	France	= 100 kilogrammes = 1-968 cwt.
Ounce	U. States	Av. ounce = 437-5 grains.	Quintale	Italy	1 metric quintal.
Packen	Russia	1083-382 lb av.	Ratel	Persia	1-014 lb av.
Palaui (Royal)	Greece	1 decimetre.	Rattel, or Rottle	Arabia	1-02 lb av., nearly (dry measure).
Palm	Holland	1 decimetre.			17-219 lb av. weight.
Palmo	Portugal	0-22 metre.	Ri	Japan	2-440 miles (itinerary). 2-118 miles (natural).
	Spain	8-346 inches.	Rode	Denmark	3-762 metres.
Para	N. Borneo	90 lb av.	Roede	Netherlands	1 dekanetre.
Parah	Ceylon	5-59 pints.	Rotl, or Rottolo	Egypt	0-9005 lb av. (Customs). 0-9805 lb av. (Govt.).
Parasang, See <i>Persakh</i> .				Cairo	2-206 lb great rottolo.
Parmak. See <i>Archin</i> .				Alexandria	0-715 lb less rottolo.
Paserece	Bengal	5 seers.			2-124 lb great rottolo. Rottolo mina = ½ oka.
Pé	Portugal	½ metre (old).	Rottol	Turkey	2-513 pints (old measure).
Peches (Royal)	Greece	1 metre = 1-543 old pecheuse.	Rubbio	Spain	1-012 quarter (dry measure).
Pecul	China	133½ lb av.	Sagène	Russia	7 feet.
Perche	France	22 square pieds de roi. In Quebec 14-6 French feet.	Scheffel	Germany	50 litres, formerly 14-56 metzen (Prussia).
Persakh, or Parasang	Persia	Probably 3-88 miles = 6000 guz.	Schepel	Netherlands	1 decalitre.
Pfund	Germany	= 16 unzen = 32 loth (old weight). 1-01 to 1-23 lb av. Zoll. pfund (1872) = 500 grammes. Old zoll lb = 1-1023 lb av. 500 grammes = 16 unze. Apoth. pf. = 375 grammes. Pfund = 560-06 grammes. Zoll. pfund (1871) = 500 grammes.	Schoppen	Germany	1 litre, formerly 0-11 gallon.
	Prussia			Switzerland	0-375 litre.
	Switzerland		Se	Japan	11-015 square yards (= 9918 are).
	Vienna		Seer	India	Government seer = 2½ lb av.
Pharoagh. See <i>Archin</i> .					Bengal, 60 tolas weight of rice (heaped measure), about 60 cubic inches (struck measure).
Pic	Cyprus	2 feet.			Southern India = weight of 24 current rupees.
Picul	Japan				Madras, 25 lb nearly.
	Straits Settlements, Hong Kong	133½ lb av.			Juggurat, weight of 40 local rupees.
	North Borneo	A measure of 180 lb weight of water.			Bombay, old seer, about 28 lb.
Picki	Greece	0-648 metre.	Seidel	Austria	0-6224 pint.
Pie	China	25 gallons (dry measure).	Sen	Siam	44-4 miles, nearly.
Pie de Burgos	Rome	11-73 inches.	Ser	India	1 litre (Indian Law, 1871).
Pied	Spain	11-13 inches.	Shaku	Japan	0-30 metre, also 9-18273 square decimetres; also 18-039 cubic centimetres.
Pied de Roi	Belgium	11-81 inches = 10 pounces.			
Pike	Canada	12-79 inches.	Sheng	China	1-813 pint.
Pint	Paris	0-3248 metre.	Shih	China	160 lb.
Pinte	Turkey	See <i>Dir'aa</i> .	Shoo	Japan	1-804 litre.
Pipa	U. States	0-8325 imperial pint.	Skaal-pund	Sweden	435-076 grammes, or 0-959 lb av.
	France	0-931 litre.		Norway	0-4981 kilogramme, or officially ½ kilogramme.
	Portugal	534 litres (Oporto).	Skeppe	Denmark	17-39 litres.
		420 litres (Lisbon).	Skeppe	Norway	17-37 litres.
		590 litres (officially).	Skaal	Germany	1 metre, or 3-1 old fuss, but varied.
Pipe	Gibraltar	105 to 126 gallons.	stadron (Royal)	Greece	1 kilometre.
Pishil. See <i>Keila</i> .			Sere (metric)		1 cubic metre.
Poide de Marc	France	0-2448 kilo = 8 ounces.	Stero	Italy	1 metric stero.
Polegada	Portugal	27-77 millimetres.	Stroepe	Holland	1 millimetre.
Pond	Netherlands	1 kilogramme. Apothecaries pond = 375 grammes.	Stremma	Greece	1 metric are. 238-1 square peches (Constantinople).
Pot	Denmark	1-7 pint = 4 peckle.	Strich	Germany	1 millimetre.
	Switzerland	2-64 pints or 1-5 litre.	Striche	Switzerland	31 strich = 1 millimetre.
	Belgium	1½ litre (dry). ½ litre (liquid).	Stunde	Germany	Old itinerary measure, 2-3 to 3-4 miles.
	Norway	0-965 litre.			

Scunde	Switzerland	4.8 kilometres. Stunder = 5 stunden, or 24 kilometres.
Sultchek	Turkey	Cubic measure (1881) whose sides equal a parmak (decimetre).
Sung	Corea	4 lb av., nearly.
Tael	Siam	93½ grains.
	Hong Kong	1½ oz. av.
	China	Silver weight, 1½ oz. av.
	Japan	10 momme.
	(No current coin of the tael.)	
Tahil	Straits Settlements	1½ oz. av. = 10 chee = 100 hoon.
Tam	Hong Kong	133½ lb av.
Tan	China	= 25 gallons. Also 133½ lb weight.
Tang	Burma	2 miles, nearly.
Tang-sun	China	About 3½ miles = 10 li.
Tank	Bombay	17½ grains, or 72 tanks = 30 pice.
Tcharka	Russia	0.866 gill = 0.218 pint.
Tchetverte	Russia	5.772 bushels = 8 tchetvertiks, or 2.099 hectolitres.
Teng	Burma	Burmese measures of capacity depend on the teng or basket. Officially a basket is 2218.2 cubic inches, but the teng varies locally — Akyab = 23 lb of rice. Bassett = 5½ lb of rice. Moulmein = 48 lb of rice. Rangoon = 48 to 50 lb of rice.
Thanan	Siam	1.5 pint.
Thangsatt	Siam	4.688 gallons.
To	Japan	18.0391 litres = 3.9703 galls. = 1.98 pecks.
Toise	France	2.1315 yards.
Tola	India	180 grains. Legal weight of rupee.
Tomand	Arabia	187.17 lb av. of rice.
Ton	U. States	2240 lb av., also a net ton of 2000 lb.
Tönde	Denmark	131.392 litres (liquid measure). 139.121 litres (dry measure).
Tonne, or Millier	France	1000 kilogrammes.
	Germany	1000 kilogrammes = 0.9842 ton.
Tonne (metric).	Portugal	793.15 kilogrammes.
Tonnellada	Greece	29.526 cwt.
Tonos	China	18 pints approximately.
Tou	Bulgaria	128.2 kilogrammes.
Tovar	China	1.41 inch (Treaty measure).
T sun	China	100.142 miles = 25 li, based on the ch'ih of 14.1 inches.
Tu	China	
Vara	Peru	33 inches.
	Spain	2.784 feet.
	Argentina	2.841 feet.
	Portugal	1.11 metre.
Vat	Holland	1 hectolitre.
Vedro	Russia	2.7056 gallons = 10 schtöffs, or 12.3 litres.
	Bulgaria	12.8 litres.
	Russia	1.75 inch.
Verchok.	Russia	0.66288 mile.
Verata, or Verst.	Holland	1 metric aere.
Vierkanterode.	Denmark	1.7 gallon.
Viertel	Switzerland	15 litres.
Viss	Rangoon	3½ lb av.
Wa	Siam	80 inches.
Wigrie	Netherlands	1 gramme.
Wisse	Netherlands	1 metric aere.
Yari	U. States	36 inches.
	Mexico	838 centimetres.
Zac	Netherlands	1 hectolitre.
Zer (Persia). See Gae.		
Zoll	Switzerland	3½ Zoll = 1½ decimetre. Old Zoll nearly one inch. (See also Pfund.)
Zolotnik	Russia	65.8306 grains, or 96 doli.

(H. J. C.)

WEIGHT-THROWING, the athletic sport of hurling heavy weights either for distance or height. Lifting and throwing weights of different kinds have always been popular in Great Britain, especially Scotland and Ireland, and on the continent of Europe, particularly in Germany, Switzerland and Austria-Hungary. No form of throwing weights is included in the

British athletic championship programme, although "putting the shot" (q.v.) and "hammer-throwing" (q.v.) are recognized championship events. In America throwing the 56-lb weight for distance belongs to the championship programme. It was once a common event in Great Britain at all important athletic meetings, the ordinary slightly conical half-hundredweight being used and thrown by the ring attached to the top; the ring, however, was awkward to grip, and a triangular handle was afterwards substituted. In America the 56 lb weight is a ball of iron or lead with a triangular or pear-shaped handle. The weight used to be thrown standing, but since 1888 it has been thrown from a 7-ft. circle with a raised edge, like that used for the hammer and shot in America.

In throwing the athlete stands slightly stooping, with his feet about 18 in. apart and grasping the handle with both hands opposite his thighs. The weight is swung round and back past the right leg as far as possible, then up, over and round the head, as in the hammer-throw. One complete swing round the head is usually enough, as too much momentum is apt to throw the athlete off his balance. The weight is then swung round together with the whole body as rapidly as possible, as in hammer-throwing. The athlete works himself to the front of the circle just before the moment of delivery and begins the final heave with his back towards the direction in which he wishes to throw the weight. This heave is accomplished by completing the final spin of the body, giving the legs, back and arms a vigorous upward movement at the same time, and following the weight through with the uplifted arms as it leaves the hands, but taking care not to overstep the circle. With one hand a smoother swing can be made but much less power applied. In throwing for height the athlete stands beside the high-jump uprights and casts the weight over the cross-pole, making the swing and spin in a more vertical direction with a heave upward at the moment of delivery. Throwing for height and with one hand were formerly events in the American championship programme, but have been discontinued. The record for throwing the 56-lb weight for height is 15 ft. 6½ in., made by the American-Irishman J. S. Mitchell. The record for distance, 38 ft. 8 in., was made in 1907 by the American-Irishman John Flanagan. In throwing weights large and heavy men have an advantage over small, brute strength being the chief requisite, while a heavy body makes a better fulcrum while revolving than a light one.

WEI-HAI-WEI, a British naval and coaling station, on the N.E. coast of the Shan-tung peninsula, China, about 40 m. E. of the treaty port of Chi-fu and 115 m. from Port Arthur. It was formerly a Chinese naval station strongly fortified, but was captured by the Japanese in February 1895, and occupied by their troops until May 1898, pending the payment of the indemnity. Port Arthur having in the spring of that year been acquired by the Russian government under a lease from China, a similar lease was granted of Wei-hai-wei to the British government, and on the withdrawal of the Japanese troops the British fleet took possession, the flag being hoisted on the 24th of May 1898. No period was fixed for the termination of the lease, but it was stipulated that it should continue so long as Russia continued to hold Port Arthur. The lease of Port Arthur having been ceded to Japan in September 1905, the British lease of Wei-hai-wei was made to run for as long as Japan held Port Arthur.

The harbour is formed by an island named Liu-kung-tao running east and west across the mouth of a small bay, leaving an entrance at each end. Towards the mainland the water shoals, and the best anchorage is under the lee of the island. The native city is walled, and has a population of about 2000. The chief port is named Port Edward; it has good anchorage with a depth of 45 ft. of water. The leased area comprises, besides the harbour and island, a belt of the mainland, 10 English miles wide, skirting the whole length of the bay. The coast line of the bay is some 10 m., and the area thus leased extends to 285 sq. m. Within this area Great Britain has exclusive jurisdiction, and is represented by a commissioner under the colonial office; and has, besides, the right to erect fortifications, station troops and take any other measures necessary for defensive purposes at any points on or near the coast in that part of the peninsula east of 121° 45' E. Within that zone, which covers 1505 sq. m., Chinese administration is not interfered with, but no troops other than Chinese and British are allowed there. The territory consists of rugged hills rising to 1600 ft. and well-cultivated valleys. The hills also, as far as possible,