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WEIGHTS, MEASURES AND BALANCES

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The study of Weights and Measures is not one which has drawn the attention of many. Metrology is not one of the exact sciences, although a great deal has been written upon the subject from time to time.

Of the antiquity of Weights and Measures there is no question; when the fingers of the hand played the part of knives and forks, and the skins of wild animals took the place of couches, Weights and Measures were forming their functions in the daily life of man.

Of the utility of such functions it is, perhaps, not necessary to speak, but everywhere measures, weights and balances must necessarily accompany commerce and science.

The question whether the weight or the measure came first has not been settled—probably the measure took priority in matter of time, as it seems more reasonable and more natural that the simplest should be first. As between the measure of extension and the measure of capacity, the chances are probably even.

In the earliest history the need of some means whereby greater certainty of quantity could be assured than by barter at sight would become obvious; and quality in those days would have to look after itself; no great harm would result from this, as the fine art of adulteration is a much later product of man's ingenuity. The staple commodities of life would be amongst the first articles of exchange, such as corn and wine. Corn would most likely be sold in heaps of certain dimensions, or by the basket-full, oil and wine by the pitcher or the pot.

Human nature being such as it is, the interests of justice would quickly disclose the necessity of definite and uniform measures, and there must have been, at a very early date, attempt at some form of standardisation, and in connection with this one of the most interesting speculations arises, which is: to what source did the ancients go for their standards?

Measures of parts of the human body were at an early date requisitioned for this purpose, as is shown from numerous biblical references. The finger or digit, the palm, the span and the cubit, which is supposed to be the length of the fore arm—that is, the distance from the elbow to the tip of the middle-finger—would be amongst the first lengths which would suggest themselves to those looking for a method of measuring. The proportions of the parts referred to have a fixed relationship, notwithstanding the variations of the human form, that is to say:—

4 Fingers or digits	=	1 palm
3 Palms	=	1 span
2 Spans	=	1 cubit or fore-arm
4 Cubits	=	Height of a man

It will be found, upon experiment, that the ratios referred to here are sufficiently accurate for rough and ready purposes.

In fixing the specific value of these measures originally, probably the dimensions as exemplified in the king or averaged size man would be taken as a basis.

The effort to find in nature a constant and invariable standard of length has not yet been successful, and, with the varying factors which must in nature necessarily affect such a standard, it is not difficult to understand why this is so.

If measures were first to be introduced, and preceded weights, the balance, and consequently weights, were not far behind.

In the Book of Genesis we read that Abraham bought the field of Ephron with its cave, and weighed out the silver, which he had named, "400 Shekels of Silver." How the earliest weights originated cannot be explained. It may be noted, however, that grain has practically always been used as weight, and not only as weight, but as a measure, as, for instance, we know from our tables that three barley-corns make one inch.

Josephus—the historian—says that Cain was the first wealthy man; that he taught his band luxury and rapine, and broke the public tranquility by introducing weights and measures. Apparently the result of this introduction still continues, for most assuredly the public tranquility in this respect has not yet been restored, and the want of uniformity in weights and measures seems to be as persistent and as difficult of overcoming as any other problem.

"Custom is stronger than law," and it would be difficult to find a more striking example of this maxim than the tenacity with which weights and measures cling to their existence, although perhaps it is not hard to understand. They are based upon the capabilities and the practical needs of man. We might almost say that our weights and our measures have made us, and not that we have made them.

The introduction of the Metric system in France, the first great break from tradition, in a metrological sense, though opportune, was attended with enormous difficulties, and the change even there is not absolute yet.

It is not intended to discuss the relative merits of the Imperial and Metric systems of weights and measures, and perhaps it is sufficient to say that, to part with the inch, the pint, and the yard would be to part with old friends that have served and are serving us well. Still, it must be admitted that, if the Imperial system is to hold its own, it will have to prove its right to exist against the more convenient system of calculation, which is the property of the Metric system of weights and measures.

The Mina.

Our system of weights has been traced by some to the Babylonian "MINA" by means of ancient weights now in existence, and which date back to 2000 B.C. One of the most interesting of these MANEH or MINA weights is now deposited at the British Museum; it is a green-stone weight, of conical form, found in Egypt, and it weighed 15,097.6 grains. It bears an interesting cuneiform inscription, which has been translated as follows:—"One maneh standard weight, the property of Merodach-sar-ilami, a duplicate of the weight which Nebuchadnezzar, King of Babylon, the son of Nabopolazzar, King of Babylon, made in exact accordance with the deified weight of Dungi, a former king."

The system of Ancient Assyrian and Babylonian weights, from which the Greek system of weights has been considered to be derived (as mina or maneh), has been described by Layard ('Discoveries in the Ruins of Nineveh and Babylon," 1853), and the derived weight of one mina appears sometimes to have approximated to the weight of an avoirdupois pound.

The scene represented here is from an Egyptian papyrus entitled "The Book of the Dead." The soul of the departed is being weighed in the balance against a feather, "Anubus" conducts the shade before the god to receive judgment. The date of the papyrus is 1350 B.C., and is the most ancient illustration of the balance known.

This picture was discovered upon an Egyptian tombstone by Lepsius. It is supposed to pourtray the weighing of bars of silver or gold, and it may be noted that the weights are in the form of a bull's head. The exact date is unknown, but certainly it can be placed long before the commencement of the Christian era. It will be noticed also that this specimen, and the preceding one, are even-armed balances, and it may be asserted with some confi-

dence that this is the earliest type of weighing instrument. It is remarkable that, at the present time, after a lapse of thousands of years, the even-armed balance is still pre-eminent, being the simplest in construction, and consequently the best in results. Few instruments have a better record for persistence of form, the difference between the ancient and modern balance being found in detail and material, and not in principle of construction.

The readiness with which an even-armed balance can be made will be seen from the specimen on the sheet. The beam comes from India, and is simply a rounded wooden pole pierced in the middle and near each end with holes. It will be noticed that the holes near the extremities do not pass right through the beam, but are curved to issue in the upright end face and sides. This arrangement is ingenious, as it tends to bring the end bearings into line with the centre bearing, which is one of the conditions of the sensitiveness of the balance.

Such a balance could not be recommended for testing standard weights, but it would answer very well where one is not particular to half a brick.

This fine fellow was being used by a farmer in the West Riding of Yorkshire in 1890, and although it was unjust into the bargain, remonstrance would not satisfy the farmer that it would not meet the requirements of the British Weights and Measures Act, 1889. It was good enough for his father, his grandfather, and his great grandfather, therefore it was good enough for him. To overcome his conservatism the power of the law had to be invoked. Acts of Parliament having no regard for the poetry of life, the luckless farmer was fined, and the magistrates ordered the forfeiture of the scale to the local Department of Weights and Measures.

The balance is put to some curious uses. In Morocco, for instance, water for drinking purposes is always sold by weight. The water-carrier parades the street with his goat-

skin of water slung across his back, clanging a bell, and when selling he allows the water to flow into one of the scale-cups until the beam stands level. The cup is then handed to the purchaser, who drinks direct, always leaving a small quantity in the cup, which is used to rinse it out so that it may be cleaned for the next user. The usual price of a cup of water is one "floos," about the 1-20th part of our penny.

In the summer, rich Moors often pay for a whole skin full, and then give the man orders to go round the town crying, "Free water for all."

A modern Assay Balance, which, when loaded with 1 gramme, will turn to the 1/200 of a milligramme, which is, approximately, 1/14,000 of a grain. This gives an idea of the marvellous degree of sensitiveness which has been reached in the construction of balances of precision. The movements of the indicator are read through the magnifying glasses, which can be seen in the illustration.

As already stated, it is almost certain that the even-armed balance was the first type of weighing instrument to be brought into use. The introduction of the uneven-armed balance, or steelyard, is generally credited to the Romans, hence the term "Roman Balance," by which this form of instrument is also widely known. That rich repository of antiquities, Pompeii, has given to us specimens of this appliance as used in the days of 2000 years ago. Most of these specimens are stored in the Museum "Borbonico," in Rome.

From the illustration here shown it will be noticed that the poise-weight is in the form of a man's head, and is really artistic.

This is another Roman steelyard, and the chains supporting the pans are a particularly fine piece of work.

This is the common steelyard of the present day. There is no mistaking its resemblance to its prototypes, but the beauty has departed. In this connection, as in many others, "appearances are deceptive." There is no doubt that the modern appliance gives very much better results than its more handsome ancestor. The apparent advantages of this class of scale are its portability and its avoidance of the use of standard weights.

This is a Japanese steelyard. The beam is of ivory, and is carefully graduated. The supports of the pan and of the poise weight are of thread, and the whole fits into a small wooden box which can easily be carried in the pocket. It is used for weighing drugs and precious metals, and the results it gives are, all things considered, wonderfully accurate. This form of balance has been known to China and Japan for centuries, and it is possible that the far Orient, as some have maintained, may lay claim to the introduction of the steelyard.

This picture represents some weights in the form of goats, unearthed at Pompeii. Again it will be observed that utility and artistic design were more generally associated in ancient times than they are now.

Travelling down the centuries and coming nearer home, there is still the same dearth of information. Excavations of Roman sites in our country have brought to light a few articles bearing on the subject, but nothing anterior to the Pompeiian specimens shown has been found.

The beam and pans of an even-armed balance seen in this picture were discovered in a Viking's grave in the Island of Colonsay, Argyllshire, and are now exhibited in the Museum of Science and Art, Edinburgh. From the date of a coin found with them the scale is supposed to be of the first century.

Of our measures of capacity, the oldest unit would appear to be the Winchester Bushel. It was so called because King Edgar (958 A.D.-975 A.D.) ordered it to be kept

there. This is the Winchester Standard Bushel of Henry 7th, and it served as a model for the standard which was made by command of Queen Elizabeth.

The Winchester Bushel of Queen Elizabeth continued in force until the introduction of the Imperial System in 1824.

The Winchester Bushel contains 2150.42 cubic ins.

The Imperial Bushel contains 2219.7 cubic ins.

Therefore, the Winchester Bushel equals 0.96879 of an Imperial Bushel.

The Winchester Bushel is at the present day the unit of capacity for cereals in the United States, and, although in England it is now illegal for trade purposes, its use in the fixing of corn rents is not absolutely obsolete.

An Act of 1670 (Charles 2nd) enacted that a standard bushel of correct measure should be chained in the market place of all market towns in order that persons might test their measures. In view of this piece of legislation, the picture which comes next is particularly interesting.

It represents a bushel measure which, until a few years ago, was in the lumber room of the Weights and Measures Office of the City of Birmingham, and which was not perhaps regarded with the veneration it deserved.

You will observe that it is marked with a crown, 1674, and C. 11. The inscription on it is: "Samuel Marrow, Lord of the Manor of Birmingham." There is little doubt that this measure was the outcome of the Act of 1670.

This is another ancient measure, and is a good specimen of the Winchester Bushel. Formerly there were three separate gallon measures in use—the Winchester Corn Gallon, the Wine Gallon, and the Ale Gallon—all of slightly different capacity. These were abolished by the introduction of the Imperial System in 1824.

The variations between these various measures will be seen from the figures here shown.

The Standard Wine Gallon of Queen Anne, which represents the Wine Gallon as used from the earliest times, and is the standard from which the measures of the United States appear to have been determined. It is, roughly, five-sixths of our present gallon, and is divided, as with us, into 4 quarts and 8 pints. It will be, therefore, seen that the liquid measures of the U.S. do not now agree with those of the Imperial System.

This is a picture of the Ancient Stirling Jug or Scotch Pint; it holds about half a gallon, and is therefore something like four times as large as the present pint.

The Scotch Choppin, or Half-pint, 1555 A.D., and is amongst the collection in the Municipal Buildings in Edinburgh.

One of the great drawbacks to the Imperial system is the fact that there are three distinct and separate series of weights—the avoirdupois, the troy and the apothecaries. The exact period of the introduction of these series into this country is not known. The earliest reference to the Troy weight is in a statute of Henry II, and there is evidence which tends to show that standards of Avoirdupois weights existed in the time of Edward III. The weights most likely to remain intact and unaltered would be those weights used for precious stones and drugs, and in this connection it is worthy of note that the Pharmacopaeia of 1851 gives the weights and measures authorised to be used by Apothecaries with the same names as were used in the time of Hippocrates, 460-357 B.C.

The terms are of Greek origin, and are still used by doctors in their prescriptions, although more than 2000 years old.

Pondera.

Libra Uncia Drachma Scrupulus Granum.

Mensurae

Congius Octarius Fluid Uncia Fluid Drachma Minimum.

This is an illustration of a 14-lb. Brass Standard Weight (1,495) of the time of Henry VII. It bears the words "Henricus Septimus" in high relief, the Tudor Rose on one side and the Westminster Portcullis on the other. The portcullis is still part of the stamp used by the Board of Trade to mark instruments verified under the Weights and Measures Acts.

The specimens shown here are preserved at the Royal Mint, Tower Hill, London. The larger set are standard Troy Weights of Queen Elizabeth, and dated 1588. The small one (to the right) is the Standard Troy pound of George III., and of date 1774. At the back is an ancient tally stick. The tally stick has been in use in all countries, and in all ages, for keeping short and simple accounts. The falsification of the account is guarded against by splitting the tally in two through the notches, the debtor taking one half and the creditor the other. In the English Exchequer tallies were used from the Norman Kings until 1785 to record the debts of the State, the half of the tally given to the lender being called the "stock," and the other half retained in the Exchequer the "counterstock." These stocks were negotiable, and when redeemed were fastened to their corresponding counterstocks and deposited in the Treasury. In 1835 the tallies accumulated in the Exchequer were burned, by order of the Government, in the stoves of the House of Lords, a proceeding, it is said, that caused the fire which destroyed the Houses of Parliament.

The Queen Elizabeth set has a really graceful and royal appearance, differing greatly in this respect from the existing standards. Of course, ornamental designs may be more