EARLY MEASUREMENTS AND UNITS OF MEASUREMENT, AND HOW WE OBTAINED THE SYSTEMS WE USE TO-DAY.

Part II. British Units of Mass.

IN a previous article[1] I discussed the growth of our ideas of length and of time, and how our present British Standards were fixed by Act of Parliament in 1855. Now we require to consider our units of *mass*, or *quantity of matter*, and we find that all untrained people confuse mass and weight, and many people have no conception at all of " mass," because they have never thought about it.

Everyone is familiar with the idea of length ; everyone thinks they are familiar with the idea of time ; but very few people know, even generally, what they mean by the mass of a body. It is *not* weight ; it is *not* volume. Unfortunately, having confused the ideas of weight and mass in our earlier years, we find great difficulty in separating them again.

If I take a lump of iron and hold it in my hand, I can say " I estimate that weighs about four pounds." I can put it on a beam type balance, and find that it weighs just over four pounds, by comparing it with some sub-standard masses—" weights " as you call them—which I have in the laboratory. In each case I am considering the pull of the big world mass on the lump of iron—the *force* with which it is pulled towards the ground—its *weight*, that is. We know that at a given spot the pull towards the earth on different bodies, their weights, are, provided we weigh them in a vacuum, proportional to the amount of matter in them, which amounts of matter are termed their masses. So that, if under those conditions, and under those conditions only, we *compare* weights, we are at the same time *comparing* masses. Even if the materials are *not* in a vacuum, but in air, the error introduced is generally small. We have grown so accustomed to gauging the relative quantity of " matter " in a body by its weight, that the very idea of mass has become hidden behind our conception of weight. A pound weight is a force, the pull on a one pound mass of matter towards the earth.

If I now put my lump of iron in water, and estimate the pull on it, I would say that it appeared to weigh less ;

[1] ENVIRONMENT, Vol. I, No. 1, pp. 23-35.

as you know, if the comparison "*weights*" on the other side of the balance were still in air, we would require less of them than before to balance the lump of iron. Yet the same lump of iron is still there—the quantity of matter it represents is unchanged. Its mass is constant. If I now put that lump of iron into mercury, I would have to apply a force downwards to keep it below the surface—it wants, apparently, to bob up and float on the surface. So that whilst immersed in mercury it appears to have actually a *negative* weight—if liberated, it falls *up* instead of *down*; and when floating on the surface, it appears to have no weight. The lump of iron is still the same. The quantity of matter it represents has not been changed.

If I happened to have been asked to fix a Standard quantity of matter for future comparisons, I could have picked up any lump of material and said, "The quantity of matter in this is the Standard quantity. This lump of material *is* the Standard Mass." I would not choose iron, because iron rusts and adds to the quantity of matter it originally possessed, by snaring some from the atmosphere. I would choose something which did not change.

The actual choosing was done by the Commission to which I have referred in an earlier article,[1] which decided to introduce as the Standard the Avoirdupois pound. This Standard, a Standard pound, was made under the direction of that Commission, and became *The Standard* by Act of Parliament in 1855. It is a lump of platinum, and is a cylinder approximately 1·35 inches high and 1·15 inches in diameter, with a groove round it for the insertion of the points of the ivory fork, by means of which it may be lifted. It is marked "P.S. 1844. 1 lb." This acts as The Standard Mass on the British System, the quantity of matter represented by that lump of platinum being the standard of mass on the British System. As in the case of the Standards of Length, copies known as "Parliamentary Copies" are deposited at the Houses of Parliament, at the Royal Observatory, in the Royal Mint, and with the Royal Society. If, by some misfortune, anything should happen to The Standard, a new Standard can be created by reference to, or by the adoption of, one of the Parliamentary copies.

To compare one of these secondary standards with The Standard, their weights in vacuum at the same place are compared, because that is the simplest method. We know that the quantity of matter in bodies is directly proportional to their weights at *precisely* the same position

[1] ENVIRONMENT, Vol. I, No. 1, p. 30.

in a vacuum, and use that knowledge to make our comparisons. When we say a thing "weighs" a pound, we mean that its weight, or the pull on it towards the earth, is precisely the same as would be the pull on The Standard pound, *if we had that Standard pound at the spot where we are.* In other words, that there is just the same quantity of matter in it as there is in that lump of platinum called the Standard pound.

In most cases we are really interested, commercially, in the home, in the laboratory, in the matter present; and its pull towards the earth does not concern us. Be careful, therefore, not to confuse the idea of the quantity of matter present with that of weight, merely because we have found a comparison of weights, under identical conditions, a convenient method of comparing masses.

Now we will see why the Commission chose that particular amount of matter represented by the platinum cylinder and called the avoirdupois pound.

One of the earliest difficulties facing races which introduced precious metals in trade was to establish a given mass of gold as a standard in exchange, and later in a coin. So that our units of mass are linked with the coinage of the country. Another object of interest even to early peoples was the consideration of the mass of food which they put inside themselves; so we find that our mass units are linked also with that of grains of wheat (corn). We find also that a natural object to take as a fixed standard was a large stone, when it came to considering big masses; so that many countries adopted such a "Stone" as a unit of mass. One of these old "Manet" or "Mina" masses, a little over two modern pounds, is a green stone found in Egypt and now deposited at the British Museum. It bears a cuneiform inscription, "One Manet standard mass, the property of Merodach-sar-ilami, a duplicate of the mass which Nebuchadnezzar, King of Babylon, the son of Nabopolazzar, King of Babylon, made in exact accordance with the deified mass of Dungi, a former king." Another mass, made of stone (porphyry), and now in the Metropolitan Museum, New York, bears the Egyptian inscription "Senusert, giving life eternally, 70 gold debens." Masses are found in the remains of the first dynasty of Egypt (3500 B.C. ?), though the first inscribed one belongs to the period of the building of the great pyramid. The "deben" appears to have been equivalent to about half our ounce avoirdupois.

The Babylonians appear to have taken the mass of a "cubic foot" of water as their standard, the "talent";

their " maneh " was one-sixtieth of a talent, and, consequently, very approximately our pound avoirdupois.

The Greeks adopted the talent, varying slightly in mass from country to country, but still about the mass of a cubic foot of water. You will remember that the " foot " was also a variable at this time. A talent of silver was used as a unit of value—some £250 stg., though that is hardly a fixed value today. It was the value of about fifty-seven pounds of silver.

The Hebrew talent was a mass of about ninety-four pounds avoirdupois, and so their talent of silver was worth correspondingly more.

The Greeks divided their masses up as follows: 1 talanton=60 mnai=6,000 drachmai=36,000 oboloi=288,000 chalkoi; correspondingly, coins were used, not necessarily of silver, but representing the same silver value. We still find the drachma in use in Greece.

The Roman unit of mass was the pound (libra), which was divided into twelfths (unciæ); this Roman ounce seems to have been 1·09 of our present ounce avoirdupois.

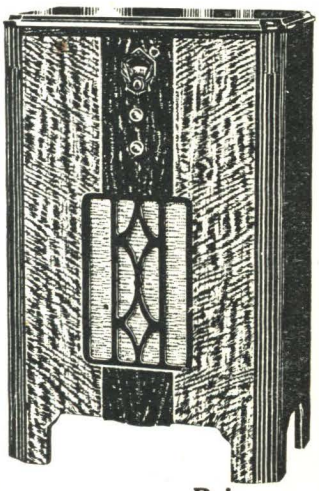
In the Far East and in India masses and currency values seem to have been founded upon the masses of seeds and grains. In England, in very early times, the small unit of mass was the grain, the *mass* of a barley corn, or barley grain; the Latin " granum " has the same root (gar) as our word " corn." Comparisons were made then, as usually now by the weights or pulls towards the earth.

During the Roman occupancy of England, doubtless we did as the Romans did. With the arrival of the Angles and Saxons, we adopted many mass measurements brought with them; and it is quite probable that in the early days of measurement there were many standards and units of mass throughout the country. We do not really know where our " pound " came from originally. Certainly our present ounce avoirdupois is approximately that of the Roman ounce—but we have sixteen of those ounces to the pound, whilst the Romans only had twelve to the libra. From all I have read I feel that the historians who claim that the Saxons brought in with them that standard from which our present standard pound is derived have the best arguments on their side. We used Troy weights as freely as avoirdupois weights for many centuries, and are not satisfied as to how those comparison masses were derived. There have been so many standards derived from different old measurements and developed by different

nations that we may be glad that the confusion is only one of historical development, and not one of present standards. Our present Standard Pound is derived from that of Queen Elizabeth ; and that was derived from the Standard Pound of Henry VII, which takes us back to the fifteenth century. If we slip back to the thirteenth century we find an Act of Henry III, in 1266, ordaining that the English penny, a " Sterling," should have a mass of " thirty-two grains of wheat, well dried, and gathered out of the middle of the ear . . . that twenty pence do make an ounce, and twelve ounces a pound."

Today we have the Standard adopted by the Act of 1855, which I described early. There is no other Standard of Mass on the British System, though all countries have their own verified copies of that Standard.

In Part III, included in the next issue, we will consider the derivation and legalising of the Standards of the metric system, which give us the c.g.s. system of units.



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