UNITED STATES NATIONAL BUREAU OF STANDARDS. ITS STANDARDS OF MASS.

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In making any ordinary measurement, as for example of a length, or in weighing a quantity of a substance, it is quite usual for the average person to take for granted the accuracy of the scale or rule, or the correctness of the weights. So generally is this the practice among non-technical people, that it is only some such unusual occurrence as when municipal inspectors or other persons detect people using fraudulent weights and measures, that attention is directed to their accuracy. Assuming, as he does, and usually with justice, that his weights and measures are correct, the average man may desire to know how this is brought about and the reason for his confidence. By correct is meant that the weights or measures must be equivalent to certain standards which duly constituted authorities have adopted as representing the national units, and to them all other standards of measurement must be directly or indirectly referred. Thus the maker of two-foot rules sees that each individual rule he makes conforms to his shop standard, and this in turn must correspond with, or be known in terms of, the national standard of length. And now if there is any doubt about any weight or measure, a citizen of the United States can send it to Washington, and on payment of a nominal fee have it determined and certified to under seal by a branch of the national government established for this purpose. This is the Bureau of Standards, which was constituted in 1901 to care for the national standards and for performing other duties involved in scientific measurement and research. Succeeding as it did to the duties of the old Office of Weights and Measures, for many years a part of the Treasury Department in charge of the superintendent of the Coast and Geodetic Survey, this new bureau on its organization was also attached to that department; but in 1903, on the establishment of the Department of Commerce and Labor, it was made a part of the organization of the latter. This bureau has during the year moved into new and specially-equipped laboratories located in the suburbs of Washington, where its rapidly-increasing work is now in active progress.

The first function of the bureau is to care for the national standards, and arrange for their comparison and reproduction. Thus the standard of mass for the United States, by executive order of April 5, 1893, is the international prototype kilogramme as represented by the standard kilogrammes received from the International Bureau of Weights and Measures at Sèvres near Paris. Despite the fact that the Anglo-Saxon weights and measures are customarily used, a legal avoirdupois pound must be derived from the kilogramme by using the ratio 1 pound avoirdupois = 1/2.2046 kilogramme. The standard kilogramme, which is illustrated in Fig. 1, is one of two owned by the United States, and is made of platinum-iridium, being of cylindrical shape. It is preserved under two glass bell jars, whose edges are carefully ground so as to make a practically air-tight joint, the general arrangement being as shown.

It is obvious that standards such as this kilogramme cannot be used constantly or exposed to changes of temperature and atmospheric conditions, but must have the most careful treatment, and be reproduced in the form of secondary standards, whose constants are all accurately known and which can be used in the laboratory. Accordingly the national prototypes of length and mass, together with other standards of historic value, are preserved in a vault in the Bureau of Standards, which not only is fire-proof, as is the entire building, but can be entered only through steel burglar-proof doors, the combination of whose locks is known only to the director and the physicist in charge. The outer door bears the coat of arms of the United States, and while the vault is safe from any danger, yet it is artificially heated and ventilated, so that its temperature and humidity are kept constant through automatic thermostats. In this way conditions are realized that are superior to those in subterranean constant temperature vaults, where dampness is often an unpleasant characteristic. This apartment contains nearly all the standards that have figured prominently in the United States since the foundation of the government, and among them are various metric, British, and other weights and measures standardized in these countries, and often the

gifts of the respective governments. When the standard kilogramme is removed from the vault, it is for

British Bronze Standard Avoirdupois Pound.

Presented to the United States in 1855 by the British government.

Silbermann Kilogramme.

Presented to the United States by the French government in 1852.

Fig. 2.—Stückrath Vacuum Balance for Comparing Standard Kilogrammes.

Sensitive to a small fraction of a milligramme. The cover is removed.

Fig. 3.—Stückrath Balance of National Bureau of Standards.

With a load of 20 kilogrammes this balance will show a difference of 1 milligramme in the two weights.

Fig. 1.—International Standard Kilogramme.

One of forty constructed by the International Bureau of Weights and Measures and the standard of mass of the United States.

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the comparison of secondary standards of mass, and this operation involves the use of a delicate vacuum balance, from which the air is exhausted before a weighing is made. This type of balance, of which the bureau possesses several in its most recent form, is shown in Fig. 2, though the photograph does not show the telescope through which the vibrations of the beam are observed, or the mechanism by which the experimenter controls the various operations; for the observer stands at a distance of twelve or fourteen feet, and is able to perform all the necessary operations merely by manipulating a series of rods and levers. Thus the balance can be released, the rider added to or taken off from the beam, and the two weights interchanged on the pans without approaching the apparatus or opening the case. This eliminates effects due to the temperature of the observer's body, while the mounting of the balance itself, either on a firm wall bracket or on a massive pier with independent foundation, reduces to a minimum any vibration. Nearby in the balance room is a similar balance (see Fig. 3) but arranged for the comparison of masses up to 50 pounds or 25 kilogrammes, the mechanism in this case being also inclosed in glass and largely automatic, though of course the refinements are not required in this instrument that are involved when the national standards are being used. Such a balance would be used in standardizing the heavier weights of inspectors of weights and measures. The bureau has in its collection numerous standards of mass, among which perhaps the most interesting are the British gun-metal standard pound of 1855 and the earlier standard kilogramme shown in the illustration.

One of the important functions of the bureau is to standardize weights for local sealers of weights and measures and inspectors, as well as for such other purpose as they may be required, and it makes a specialty of adjusting weights which have been constructed by instrument makers to serve as standards. These must be plated with gold to prevent oxidation before they are submitted to the bureau for test, and in case they meet the requirements, suitable certificates are issued to accompany them. The weights tested are both the Anglo-Saxon or usual weights and those of the metric system, and in this way a connection is made between the national standards which are metric and those of ordinary use. While the standards of weights and measures for the United States are national, and are

fixed under the authority of Congress, yet the legislation dealing with their use and providing against fraud is enacted by the various States. Consequently, each State has its own sets of standards, both customary and metric, which in the majority of instances have been supplied by the national government; and in addition to statutes providing against the use of false weights and measures, there are in each town or county local sealers or inspectors of weights and measures, who inspect the weighing and measuring appliances of the tradespeople. Thus a comparison is made with the official measures and weights,

so that on the vigilance of these officials and the accuracy of their standards depends the correctness of the weights and measures of a community. Therefore it has seemed fitting to the officials of the Bureau of Standards to devote considerable attention to the best apparatus and methods for such testing, and it is now prepared to assist local sealers and inspectors, and standardize for them the weights and measures they employ. In addition the bureau is aiming to secure uniformity of method and increased precision by the distribution of information and by practical co-operation wherever possible. Thus by working through manufacturers both of standard and ordinary weights, and then by co-operation with the local authorities, it hopes to preserve and increase the accuracy and reliability of the weights and measures of the general public. Furthermore, if a change to the metric system should ever be made, as is constantly being urged by various metrological reformers, the machinery to carry out such an innovation with maximum efficiency will be found to be in complete and practical working order.

The masonry of the Simplon tunnel and ballasting of the line are to be completely terminated by the end of the present year, and it is hoped that the opening will take place on April 1 following, so as to coincide with the opening of the Milan International Exhibition.