On account of the presumably extreme smallness of its molecules as compared with those of glass, etherion probably passes through the latter when any considerable difference of pressure exists on opposite sides, though the passage may be very slow. It seems to be condensed or compressed in glass as before indicated, and may evaporate on the side of lower pressure, and be absorbed on the side of higher pressure, after the manner of hydrogen in passing through palladium. In my own experiments, the heat transmission ascribed to the ether may be due to the presence of the new gas inside the bulb. A small fraction of a millionth would be sufficient, and this might escape detection by the pressure-gauge, on account of the necessary compression in the gauge head causing absorption by the glass. Again, etherion must always be present to some extent in all "vacuum tubes" (as well as in my own conduction bulb) on account of its long-continued evolution from glass; and may be the medium of propagation of the Roentgen rays in the vacuum glass and air.

ON THE FACILITIES FOR STANDARDIZING CHEMICAL APPARATUS AFFORDED BY FOREIGN GOVERNMENTS AND OUR OWN.[1]

BY LOUIS A. FISCHER.

Received October 17, 1898.

IT is at the invitation of your esteemed president, Dr. C. E. Munroe, that the Office of Standard Weights and Measures submits for your consideration and information this paper, stating what facilities are afforded by foreign governments and our own for the standardization of chemical apparatus. It is but proper that such information should be furnished by this Office; for it, more than any other bureau of the government, is called upon to make the determinations referred to. But before going further, a brief history of the Office will be given, in order that its position and condition may be understood.

The origin of the Office may be said to date from May 29th, 1830, when the Senate passed a resolution calling upon the Secretary of the Treasury to cause to have made a comparison of the weights and measures in use at the principal custom-houses.

1 Prepared and read before the American Chemical Society, Boston, August, 1898, by direction of Dr. Henry S. Pritchett, Superintendent U. S. Coast and Geodetic Survey, and Standard Weights and Measures.

This task was entrusted to Ferdinand R. Hassler, the then superintendent of the Coast Survey, who discovered large discrepancies among the standards in use. His report led to the establishment of a shop and laboratory, in which copies of those standards adopted by the Department were made and compared. The task was entered upon by Mr. Hassler with his usual foresight and energy; and early in 1836 we find the statement in one of his reports that "forty weights, two pint measures, and four sets of yard standards are ready for final adjustment."

When we consider that the zinc used in the construction of these standards was mined and purified by Mr. Hassler; that machinery and apparatus had to be designed and built; and that the proper working force had to be organized, we cannot help admiring the tremendous energy of the man. So satisfactory were the operations that in June, 1836, Congress passed the following resolution:

"*Resolved*, That the Secretary of the Treasury be, and he hereby is, directed to cause a complete set of all the weights and measures adopted as standards, and now either made or in the progress of manufacture for the use of the several custom-houses, and for other purposes, to be delivered to the Governor of each state in the Union, or such person as he may appoint, for the use of the States, respectively, to the end that a uniform standard of weights and measures may be established throughout the Union."

For the first ten years the entire efforts of the office were devoted to the construction and verification of standards of length, weight, and capacity. These operations required the construction and investigation of comparators, balances, thermometers and barometers; and the determination of the expansion of water and metals, and the solution of other physical problems.

About 1842 the questions of hydrometers and sugars were referred to the Office, then under the direction of Prof. A. D. Bache. The exhaustive report,[1] made in 1848 by Prof. R. S. McCulloh, who had charge of the investigation, has become standard; and the alcoholometric tables now used by the Treas-

[1] Reports from the Secretary of the Treasury of Scientific Investigations in relation to Sugar and Hydrometers, by Professors Bache and McCulloh, 1846; Executive Document No. 50; 30th Congress, 1st session.

ury Department in the collection of duty on spirits differ but slightly from those submitted in the report.

The passage of the law of 1866, legalizing the Metric System, and directing that each state in the Union be supplied with copies of the metric standards, again imposed duties upon the Office which occupied its attention for many years.

In 1891, and again in 1897, the Office was represented on scientific commissions appointed for the purpose of discovering and reporting upon the cause of discrepancies in sugar determinations, by means of the polariscope, at the various ports of entry. As was suspected at the time, much of the trouble was traced to the use of erroneous standards, especially of capacity. Errors were also caused by the use of erroneous values assigned to the quartz control plates by their manufacturers; and, also, by ignoring the effect of temperature on the rotation of the sugar solutions and plates.

As a result of the report of the first commission, the Office was called upon to standardize control plates, and to devise means for rapidly verifying the large number of tubes, weights, and flasks used in sugar laboratories. No apparatus is now used by the Customs Service unless it has first been examined by the Office of Weights and Measures. Nothing illustrates the necessity of having verified apparatus more than the case just cited. In many instances flasks supposed to contain 100 Mohr cc. were found in error as much as one-half cc., and it soon became manifest that if the flasks were to be used without appreciable error they would have to be graduated by the Office. Accordingly, the arrangement here shown[1] was devised for graduating the flasks; and between 2,000 and 3,000 have been graduated during the past six years.

The flasks, samples of which are afterwards tested, must not show a greater error than 0.05 cc.; and no difficulty has been encountered in keeping within this limit. The Office is, therefore, prepared not only to standardize flasks, but also to mark them, provided the interior diameters of the necks do not exceed fifteen mm. or fall below ten mm. There is no reason, however, why this kind of work should be done for the general public, for the same accuracy may also be attained by

1 For description of device see pages 924 et seq.

manufacturers. No special skill is required to manipulate the device used by us, and a speed of twenty flasks per hour may be maintained without extraordinary effort.

The Office of Standard Weights and Measures is not required by law to make comparisons for other than official purposes; but inasmuch as we have in our care the national standards, it has been the policy of the Office for years past to endeavor to meet all demands. Our means, however, are very limited, compared with those provided by other governments for bureaus doing similar work. Germany has its 'Physikalisch-Technische Reichsanstalt', where both scientific and technical research are carried on. This institution has two sections, the duties of which are as follows:

SECTION I.

1. The performance of physical investigations and measurements which tend, preeminently, to the solution of physical problems of great scope and importance in a theoretical or practical direction, and which demand a greater outlay of instrumental equipment, consumption of material, or time of observers and computers, than can, as a rule, be offered by private individuals or educational institutions.

2. The solution of matters referred to it by Section II, in so far as the equipment of the latter is insufficient for their accomplishment.

SECTION II.

1. The execution of such physical or physico-technical investigations as are directed by *official authorities* or designed to promote precise machine construction, or other branches of German industry.

2. Verification of measuring apparatus and instruments of control, so far as they do *not* lie in the domain of weights and measures; the determination of the errors of graduation of such instruments, and the issuance of certificates of results.

3. Construction of instruments and parts of instruments, as well as the execution of other mechanical work for German state institutions and authorities, in so far as their construction by private workshops gives rise to difficulties.

4. In special cases the construction of parts of instruments for

Germans in business, in so far as their construction in private shops necessitates extraordinary means.

In all cases where work is done for individuals or for foreign governments charges are made, designed to cover the cost to the Reichsanstalt. In order to meet the demands there were regularly employed in 1897 seventy-eight persons, many of the scientific attachés being men of international reputation.

The purely weights and measures matters of the Empire are under the control of the Kaiserliche Normal-Aichungs Kommission, with a central office in Berlin, and three branches at Köln, Ilmenau, and Gehlberg, respectively. The commission prescribes rigorous rules and regulations concerning the construction and verification of all forms of measuring apparatus, chemical included, and also defines the tolerance or allowable errors. If the tolerance be not exceeded, and the apparatus otherwise conforms with requirements, it receives the stamp of the commission, and may then be used anywhere in Germany.

Austria, likewise, has its Normal-Aichungs Kommission, with duties and authorities similar to those of its German prototype.

In England the supervision of weights and measures is the work of the Standards Department of the Board of Trade. The verification of every weight and measure is provided for by law, and penalties are prescribed for using apparatus not in conformity with the regulations of the Standards Department.

The inspectors, who in 1897 numbered 1099, are appointed by local authorities, but are required to work under regulations provided by the central office.

In addition to having under its control the standards, which include those of electricity, the office collects information in regard to weights and measures in foreign countries, which is published in its regular reports. Authority is also given to the Board of Trade by law "to conduct all such comparisons, verifications, and other operations with reference to weights and measures, in aid of scientific researches or otherwise, as it may deem expedient."

The Kew Observatory, also, has a standardizing department, and in 1897 about 300 hydrometers, and over 20,000 thermometers, were examined there. Provision is also made for experiments and researches in connection with the work of the various departments of the observatory, and considerable experimental work has been done with platinum thermometers at high temperatures with gratifying results.

Recently a committee was appointed by the British Government "to consider and report upon the desirability of establishing a National Physical Laboratory for the testing and verification of instruments for physical investigation, for the construction and preservation of standards of measurement, and for the systematic determination of physical constants and numerical data useful for scientific and industrial purposes; and to report whether the work of such an institution, if established, could be associated with any testing or standardizing work already performed wholly or in part at public cost." The consideration of this question by the government is due, no doubt, to the demands of scientific investigators, who are at present much inconvenienced by being compelled to resort to Berlin or Paris when the more refined comparisons are required. It is also largely due to the fact that the Reichsanstalt has, by reason of its high standing, done much to assist the German manufacturer in disposing of scientific apparatus.

In France the national standards are in the care of the Conservatoire des Arts et Métiers in Paris, where splendid facilities are provided for the comparison of other standards with them. All trade weights and measures are verified at suboffices, of which there is a large number. While the suboffices are under the control of the Verification Department of the Conservatoire, and while that department is required to verify their standards at regular intervals, it is not required to do their work, but is left free to undertake the more refined comparisons demanded by those engaged in technical and scientific investigations.

Splendidly equipped laboratories for various branches of technology are under the control of the Conservatoire, and these laboratories are at the service of engineers, constructors, and others who desire to use them. The reports of the Conservatoire do not indicate that *special* provisions or regulations are provided for the standardization of chemical apparatus, and the same statement applies to the British institutions. This is no doubt due to the fact that the demand for this character of work is not sufficient to make special facilities necessary.

This brief résumé of the means provided for the standardization of measuring apparatus by the principal governments makes manifest our own deficiencies. It was plainly the intention of Congress, when in 1836, and again in 1866, it directed the distribution of standards to the states, that each state should establish an office where at least the commercial weights and measures could be verified. This is actually the case in but few states, and the Office of Standard Weights and Measures, with an appropriation of less than $8,000,[1] is called upon to standardize county and city weights and measures, and also do other work plainly not that of a national office. The result of this condition of affairs is that the more important investigations and verifications demanded by chemists, physicists, and engineers, are made to suffer. But even if our whole efforts could be devoted to the character of work referred to, our means would be entirely incommensurate with the requirements of a country whose industrial and scientific progress during the last two decades has been, to say the least, extraordinary.

However, this is a matter for Congress to decide ; and until that body deems it proper to provide better means, the Office will continue to make the best use of those at hand.

For the benefit of those who desire more detailed information, the following description of our methods and apparatus is given :

WEIGHTS.

Two copies of the "International Kilogramme," both of which are identical in form and material with that prototype, are in the custody of the Office. We have, also, a kilogram balance, constructed by Rueprecht of Vienna, by means of which the relation of two kilograms may be determined within their one hundred millionth part.

For smaller weights we have a set of the best chemical balances on the market ; and by making and computing the weighings in the manner indicated in Appendix No. 10, U. S. Coast and Geodetic Survey report for 1892, we are able to secure more than necessary accuracy, say 0.001 of a milligram for a milligram weight. The appendix referred to gives the least square adjustment of the weighings, which are so arranged as to bring

[1] About one-third of this amount is for the electrical department.

a precise result.[1] With the aid of this publication, and with the largest weight of such sets as are commonly used properly determined, any chemist may determine his smaller weights.

While all of those present are aware that weights and other bodies are buoyed up by the air, all do not perhaps, realize, the magnitude of the effect produced. We are led to make this statement by the complaints frequently made by chemists and assayers that the values given by this Office are incorrect. The International Kilogramme is a standard of *mass*, and hence, to express the values of other masses in terms of it, the weighings are referred to *vacuo*. If, therefore, some of the weights of a set are made of brass and some of platinum, the values given are not those that would be found by unreduced weighings made in the air. The difficulty would not be overcome by referring the weighings to air under standard conditions, for if the weights were compared at, say Leadville, at an elevation of 10,000 feet, they would not agree with results obtained at lower altitudes. The difference for 10,000 feet would be, if the weights were platinum and brass, about 3/100 of a milligram per gram, a quantity which a good chemical balance would readily show. Agreement of the *weights* under all conditions would be secured if they were all made of one metal, and, for many reasons, platinum is to be preferred, at least for weights of one gram and less, where the cost of the metal would not be a matter of much consequence.

Some years ago the Office adopted an official stamp, which is placed upon weights meeting the following requirements:

(*a*) Each weight must be made of one piece of metal.

(*b*) The weights, if brass, must not be lacquered, but should be gold-plated or platinized.

(*c*) The finish must be such as to readily show any abrasion, either accidental or otherwise.

VOLUMETRIC DETERMINATION.

No special facilities are required for this kind of work. Furnished with a set of weights, a balance, a thermometer, distilled water, and a table of densities of water, any one may determine his

[1] By this statement is meant that the most reliable results, obtainable from the particular set of observations, are deduced. If the observations are poor the results are correspondingly so.

own apparatus. The reduction to *vacuo* of weighings may be made with sufficient accuracy by assuming that a liter of air weighs one and two-tenths grams at sea-level, and diminishes 0.04 gram for each 1,000 feet of elevation. The density of the weights, if of brass, may be taken as 8.3; if of platinum, as 21.5. This data will certainly satisfy all requirements when dealing with apparatus, the capacity of which is determined by filling or emptying to a mark.

The reduction to *vacuo*, under normal conditions, affects the result by about 0.10 of a per cent., if brass weights be used to weigh the water; and by about 0.11 of a per cent. if platinum weights be used. It is evident that if the result is affected by only 0.01 of a per cent. in changing from one metal to another whose density is two and a half times greater, no appreciable error can possibly be introduced by assuming the densities given above.

Likewise, the assumed weight of air is not subject to variations of more than five per cent., and hence the reduction to vacuo (which, as before stated, affects the final result by about one-tenth of a per cent.), is not affected by more than 0.005 of a per cent. by probable variation in the weight of air adopted. In calibrating specific gravity bottles, and capacity measures provided with ground-glass covers, greater accuracy is, and may be, attained; and an accuracy of one part in 100,000 is not too much to expect, if verified weights and thermometers are used, and if the proper precautions be taken.

In all the work of the Office the capacities are, for convenience, originally found in milliliters, and if the measures are graduated according to some other system the proper factor is used to convert into that system. The liter referred to was defined by The International Committee of Weights and Measures in 1880, in the following language:

"The International Committee of Weights and Measures adopts for its publications and official use the word 'litre' to express the volume of a kilogramme of pure water at its maximum density."

A recently completed determination of the mass of a cubic decimeter of water, made at the International Bureau, confirms what was suspected by the committee when the above definition was adopted; namely, that the original determination, made a century ago, was in error. The recent results indicate that the liter is larger than the cubic decimeter by one-tenth of a milliliter, or 0.01 of a per cent. This difference may be ignored for most purposes, and the cubic centimeter and milliliter still be considered synonymous terms; but when we adopt a unit of volume we should be careful to distinguish between the two.

THERMOMETRY.

All temperatures are referred to the standard hydrogen thermometer of the International Bureau of Weights and Measures by means of mercurial thermometers made by Tonnelot, of Paris, and compared directly with the hydrogen thermometer. These thermometers give us a continuous range of 80° C.; from —28° to +52°, with a sufficient degree of accuracy to more than satisfy our ordinary needs.

Thermometers submitted for verification are placed between two standards in a trough filled with water, which is thoroughly mixed by propellers operated by the observer, just before the readings are made. Means are provided for rapidly raising and lowering the temperature of the water in the trough, by letting in either cold or hot water, as the case requires. The indications of the thermometers are read by means of a low power microscope, which may readily be moved into position over each instrument. Some idea of the accuracy with which the readings are made, and also of the uniformity in temperature of the water in the trough, may be formed from the statement that after the readings of the two standards have been corrected[1] they do not differ on the average by more than 0.005°, a quantity which cannot be read on any but the most perfect instrument.

Considerable experimental work has been done at the International Bureau with thermometers at temperatures as low as —70° C., and also between +100° and +200°; but, as yet, the work is not complete. As soon as it has been finished the United States will acquire, like other contributing governments, copies

[1] The corrections consist of the calibration corrections for inequality of bore; the correction for errors in graduation of the stem; the zero correction, which depends upon the temperature to which the thermometer has been exposed; the correction for exterior pressure on the bulb, which depends upon the height of the barometer; the correction for internal pressure (if the thermometer be in a vertical position), which depends upon the height of the column of mercury in the stem; and finally, the reduction to the standard hydrogen scale.

of the new thermometers, and our range will then be correspondingly extended. Recent results obtained with the so-called platinum thermometers in England and on the Continent, lead us to hope that this range will soon be much extended. At present, however, the Office is compelled to limit the comparison of thermometers to temperatures between 0° and +50° C., and the following rules will govern the acceptance of thermometers for verification :

(*a*) The stem and bulb must be made of one piece of glass.

(*b*) The graduation must be ruled directly upon the stem.

(*c*) The graduation lines must not exceed in width one-tenth of the space between them.

(*d*) The graduations must not be more than 1° apart.

(*e*) The upper part of the capillary tube must be enlarged ; that is, there should be a small chamber in it.

These requirements are essential, even in thermometers of ordinary precision ; and until they are fulfilled by our manufacturers, those requiring instruments of superior construction will continue to seek them abroad.

POLARISCOPIC APPARATUS.

Quartz control plates, polariscope tubes, and polariscopes are also examined for sugar chemists, by the Office. Control plates, to be accepted, must be free from imperfections, and must be properly mounted. The values will then be determined by comparison with the standard plate of the Treasury Department. This plate has the value, 99.06° on a scale, the 100° point of which is determined by a solution of pure sugar and water at a temperature of 17.5° C., that contains a mass of 26.048 grams of sugar per 100 milliliters of solution. This solution differs slightly from that used in Germany to determine the 100° point of the Ventzke Scale ; but if the samples of sugar be polarized as prescribed by the Treasury Department regulations, and with apparatus tested by the Office of Weights and Measures, the results will agree with those obtained by the German method with German apparatus. If the solutions are made up and polarized at any other temperature than 17.5° C., the effect of temperature must, of course, be considered. The report of the commission of 1897 has not yet been made public, but I understand that the question of bringing our methods, as well as results, into accord with the Germans, was considered.

HYDROMETERS.

Hydrometers, graduated according to various authorities, are used in this country, but no tables of densities corresponding to the graduations have been adopted, except in certain cases by the Treasury Department for its own use. For this reason the table to be used must be designated by those submitting their instruments. The Baumé hydrometers are used, perhaps, more than any others in this country, and the statement made in 1881 by Prof. C. F. Chandler in a report to the National Academy of Sciences is as true now as it was then. His statement was as follows: "Although Baumé described, with great accuracy, the method which he employed to secure the scale for his hydrometers, and it would seem, therefore, as though no difficulty existed to prevent the reproduction of his instruments, nevertheless, it is a fact that among instrument makers the scale has been so modified from time to time that we have the greatest variety of instruments purporting to be Baumé, each one of which has a set of degrees of an entirely different value from that exhibited by any other. I have found twenty-three different scales published by as many different writers for liquids heavier than water, the highest of which gives as the value of 66 Baumé, 1.8922, and the lowest 1.730, no one of which can be said to be correct, or to have been obtained by following Baumé's directions." At the conclusion of this report he offered the following resolution: "*Resolved*, That a committee be appointed to consider what action, if any, is desirable, with a view to establishing a legal value for the degrees of the Baumé and other hydrometers of arbitrary scale, the committee to report at the next meeting." A committee was appointed, but I have been unable to find any report made by it.

It has often been suggested that the only safe plan would be to abandon all arbitrary scales and to use only instruments which record the true densities. This proposition is usually opposed by the so-called practical men; but I see no reason why such instruments should not be used for scientific purposes. We already have in use by the U.S. Coast and Geodetic Survey, and by the U. S. Fish Commission, hydrometers so graduated, and I have never heard of any complaint from those who are required to use them. What is wanted is the density of sea-water, and the instruments give it directly.

If the apparatus submitted for verification were limited to certain forms, and if the limit of error were in every case stated, the work of the Office would be simplified. We are, therefore, much interested in the movement inaugurated by this society to secure uniformity in the more important measuring apparatus used by chemists, and would be pleased to cooperate with the society in bringing about the desired result. Of course, measuring instruments of all kinds must be designed, primarily, to suit the needs of those who use them, but the uncertainties introduced by having them graduated according to various systems and standardized at various temperatures does not serve any good purpose.

In conclusion, I beg leave to recommend that the following units of measurement be adopted by the society, as they already have been by almost the entire scientific world.

(1) The liter, as defined by the International Committee of Weights and Measures; *viz.*, the volume of the *mass* of a kilogram of pure water at the temperature of maximum density, and under a pressure of 760 mm. of mercury.

(2) Density, defined as the ratio of the mass of a substance to that of an equal volume of pure water at its maximum density (4° C.).

(3) The centigrade degree of the hydrogen thermometer of the International Bureau of Weights and Measures.

I also recommend that some convenient temperature be adopted, at which all volumetric apparatus shall contain their stated capacities.

DESCRIPTION OF DEVICE FOR MARKING FLASKS.

Referring to Fig. 1, *a* is a hollow steel cylinder which fits into the neck of the flask where it is held and centered by the three springs shown in the figure. Its upper end is terminated by a milled head which must be in contact with the top of the flask whenever the device is in use. The diameter of the opening in *a* is such that the rod *b* fits in it without play. *b* and *c* are round rods

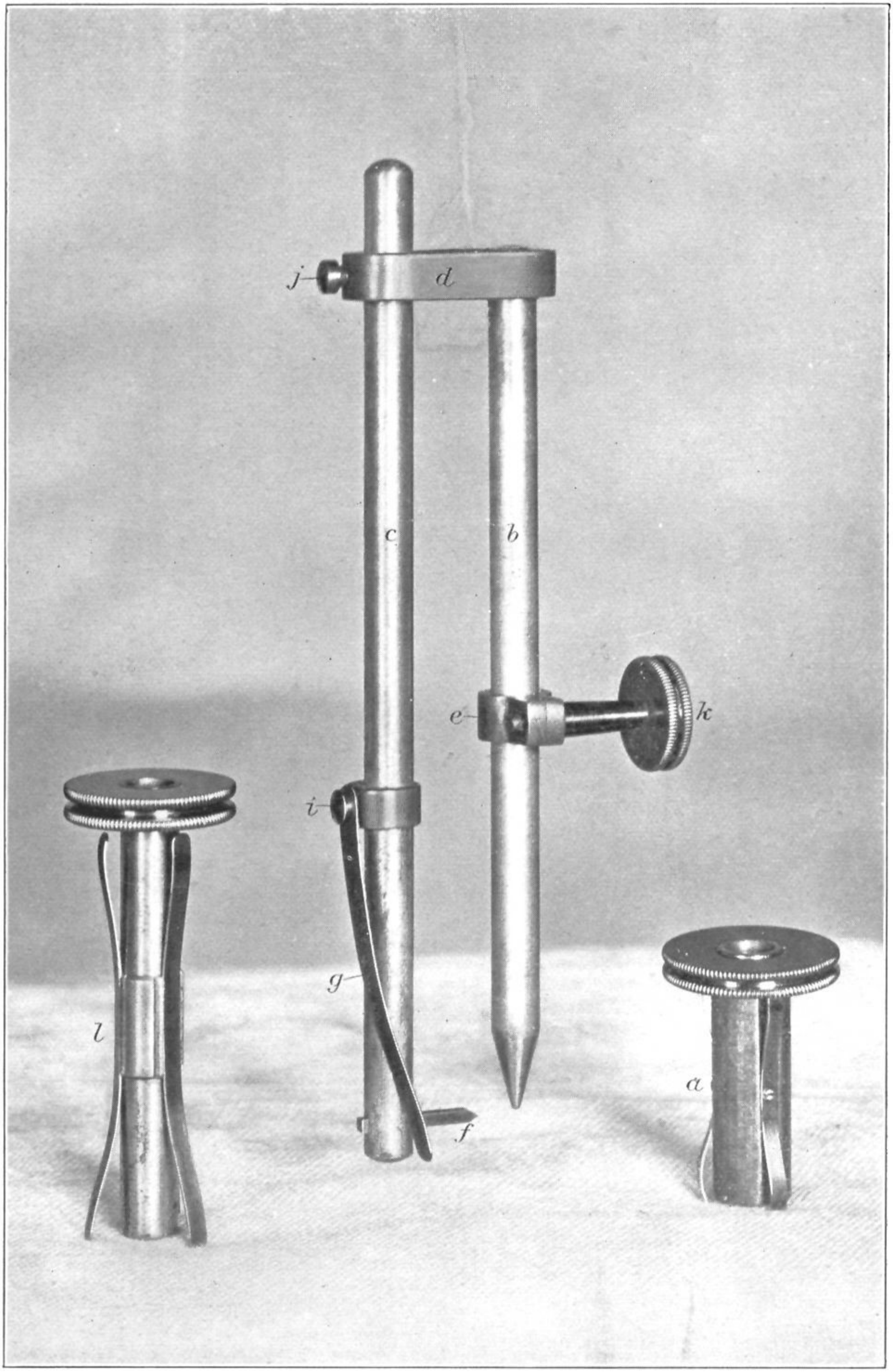

Fig. 1.

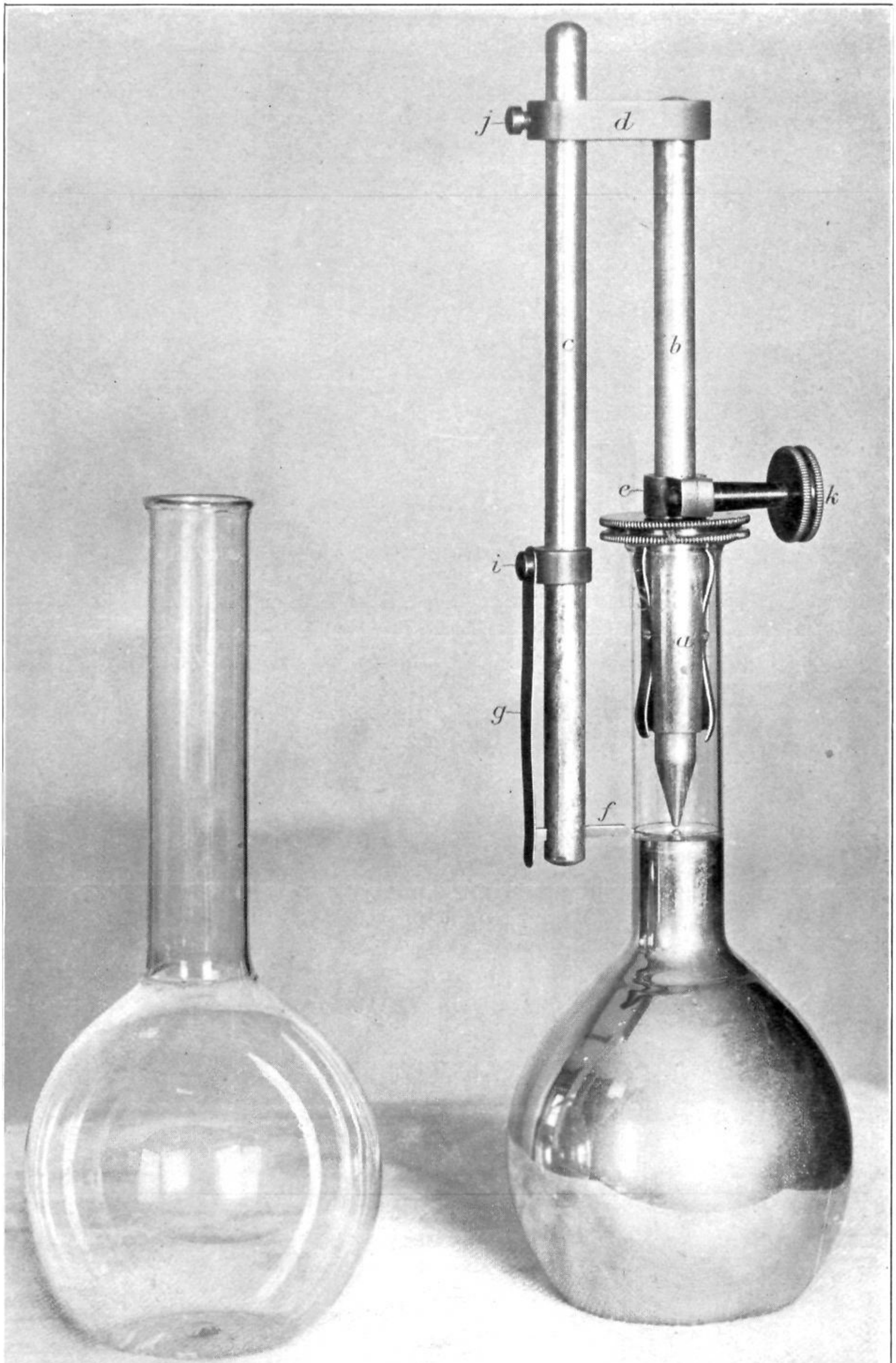

Fig. 2.

made of Stubbs' steel, parallel to one another and rigidly connected by *d*. The cutter *f* is made of square steel, and while it must slide freely back and forth in the opening provided for it in *c* it must not have appreciable side play. By means of the screw *j* which clamps *c* to *d* the height of the cutter must be adjusted so that the edge of the cutter operates in the horizontal plane tangent to the pointed end of *b*. The clamp *e* forms a stop on *b* and may be clamped at any point by the screw *k*. The spring *g* is swivelled at *i* and its function is to press the cutter towards *b*. *l* is an extra bearing for flasks having necks of smaller diameter than could accommodate *a*.

The operation of marking is illustrated in Fig. 2. The flask on the right represents a standard, which is essential as the device is only designed to reproduce the volume of some flask assumed to be correct. The standard is represented filled with mercury up to the point where it is tangent to the lower end of *b*. The order of operation is as follows: The bearing *a* or *l* as the case requires is pushed into the neck of the empty *standard* until the milled head comes in contact with the top of the flask. Then the rod *b* of the device is put in the bearing and pushed down until the cutter falls into the mark on the neck of the flask. The clamp *e*, which should always be kept in contact with the upper end of the bearing, is then clamped. The device may now be rotated in the bearing and if this be done the cutter will follow the mark on the neck. The whole arrangement is now removed from the neck of the standard and clean mercury is poured in until it fills the flask to the mark. This may be determined by putting the arrangement back in its original position in the standard and if the mercury is tangent to the lower end of *b* we have in the proper quantity. This is not, however, an easy matter to accomplish, but sometimes requires a little skill and patience. If the clamp *e* has not been disturbed the cutter will still travel in the mark when the mercury has been adjusted to tangency. Having secured the proper quantity of mercury the whole arrangement is again removed from the neck of the standard, and the mercury is poured into the flask to be graduated. Usually there will be a number of air bubbles in the second flask which must be removed before we attempt to mark it. Having removed the air bubbles, which must be done without raising the temperature greatly, the bearing is placed in the neck of the flask and the point of *b* is adjusted to tangency by means of the stop *e*. The neck of the flask in the vicinity of the cutter is then covered with paraffin by means of a camel's hair brush which is kept for the purpose in a dish of melted paraffin. The paraffin will cool almost instantly, and as soon as it does the spring *g*, which has heretofore been to one side of the cutter, is now adjusted to press the cutter against the paraffined flask. The arrangement is then rotated in the bearing and the cutter removes the paraffin in its course and exposes the glass. After a couple of revolutions the spring is pushed to one side, the cutter pulled back, and the whole arrangement removed from the neck of the flask which is now ready for etching. The mercury may be poured back into the standard in order to test whether its volume has changed by reason of the handling it has received. Usually such tests will show an increase in the volume of mercury, which must again be adjusted before it is used to mark another flask. If, however, we have a number of flasks to graduate, the volume of the mercury will be found quite constant after the first half-dozen have been marked, due to the fact that it finally acquires a fixed temperature, which is determined by the amount of handling it receives and the temperature of the room. After this state is reached, ten or a dozen flasks may be marked without the volume of the mercury being appreciably changed. The etching is done by applying hydrofluoric acid to the cut in the paraffin by means of a small camel's hair brush. The flask is then set aside for about ten minutes, when the acid is washed off with water. Finally the neck is heated over a Bunsen burner and the paraffin is wiped off with a cloth.

The arrangement here described was devised for the special purpose of marking the 100 cc. flasks used by the United States Treasury Department. The interior diameter of the cylindrical portion of these flasks (the necks) is approximately thirteen mm. Any variation of this diameter from that of the standard flask introduces an error in the capacity of the marked flask, due to the fact that the height of the meniscus of the mercury depends, within certain limits, upon the diameter of the tube containing it. It is therefore important that a standard be provided for each form of flask to be marked. This may always be readily accomplished by placing a temporary mark on any flask and then determining the capacity to this mark. With this and the interior diameter of the neck of the flask known we may compute where the mark should be placed to give the correct capacity. When this point has been determined a permanent mark may be made with the device by adjusting the cutter to travel across this point.

The use of this method of marking flasks is restricted on account of the pressure exerted by the mercury on the walls of the flasks, which is sometimes sufficient to cause them to break. This does not occur often with 100 cc. flasks, but it is doubtful whether ordinary flasks of greater capacity than 500 cc. would sustain the pressure with safety.

THE CYCLICAL LAW OF THE ELEMENTS.[1]

BY THOMAS BAYLEY.

Received September 7, 1898.

WHEN the elements are arranged in a line in the order of their atomic weights, it is apparent that there is from lithium to fluorine an orderly transition from the intensely positive alkali-metal type to the intensely negative halogen type, and then a sudden reappearance of the positive type in sodium, after which there is a second orderly transition to the negative type (chlorine), and then another change to positivity (potassium). Up to this point, therefore, two complete cyclical changes have been established, the first cycle from lithium to sodium—in all its essential details—being analogous with the second from sodium to potassium. If then we proceed with the lineal arrangement, it is clear that we must first of all look for transitions and for reappearances of the alkali-metal type; in other words, for the continued development of the cyclical arrangement. And since analogous but modified transitions actually recur, and halogens followed by alkali metals reappear, it is evident that the law of progression is actually cyclical. The first and fundamental feature of atomic progression is a progression in cycles.[2] The lithium-sodium cycle is a cycle involving the seven elements, lithium, beryllium, boron, carbon, nitrogen, oxygen, and fluorine,

1 Reprinted from *Chemical News*, April 7, 1898.

2 Bayley: *Phil. Mag.*, January, *1882*.