society without the railway, telegraph, telephone, and even the steam engine, but it is difficult to conceive of such operation after the disappearance of paper.

Mr. De Boutarel, in a communication made to the Academy of Moral and Political Sciences a few months ago, gave the following figures:

In Europe, the annual production of paper reaches a million tons. In the United States, where it was nil at the beginning of this century, it exceeded 500,000 tons in 1883. It has become necessary to look for new raw material, and to utilize an extraordinary number of substances, from second-hand paper up to straw and wood, and from moss up to the Algerian alfa, of which the English consume more than twenty million dollars' worth, while we do not know what to do with it.

The first elaboration of all these raw materials is capable of giving 1,500,000 tons of paper, whose net value is two hundred million dollars. Of these 1,500,000 tons of paper, writing paper represents about 120,000, of an approximate value of thirty-two million dollars. As for the consumption of paper in printing, that reaches fabulous figures: 800,000 tons for book printing; 300,000 tons per day for periodicals; and 120,000 tons for printed matter for public and private administrative services.

Including work and the second elaboration due to printing, this makes something like three hundred and fifty million dollars.

Let us add 60,000 tons of cardboard, 60,000 tons of wall paper, 60,000 tons of papers of secondary importance, such as blotting, tissue, filtering, tracing, and cigarette, and finally 700,000 tons of wrapping paper—say one hundred and twenty million dollars, which, with the value of the writing paper and of the products of the second elaboration coming from printing offices, gives a total of five hundred million dollars, to which may be added three hundred million more, representing the work of the freight and retail industries.

It is not an exaggeration, says Mr. De Boutarel, to suppose, in the absence of authentic documents, that the production of paper in Asia reaches half the above figures. It would then be a value of about one thousand million dollars that human industry annually extracts from a pile of debris, straw, shavings, and rags, which, without that, would be good for nothing.

But these are merely the ordinary uses of paper. In addition, it is now being made into collars and cuffs, and we shall soon make of it sheets, Chinese napkins, etc. It is even being converted into sugar. There are also being manufactured from it shoes, boats, barrels, gas pipes, bottles, flooring, doors, ceilings, roofs, and architectural ornaments, and at Breslau there is a spinning mill which has a paper chimney fifty feet in height.

Paper has the advantage over wood of not warping or splitting. Strongly compressed, it can be polished like ivory, and will resist fire better than any other material. It is also capable of being used as a substitute for metal, and it is already being used for making guns, locomotive wheels, and rails.—*Le Genie Civil*.

OIL OF PEPPERMINT.*

By ALBERT M. TODD.

IN the paper which I have the honor to present you, the history of the plant will be briefly noticed, and attention directed to some characteristics of the essential oils as observed in the practical manufacture, some being of such phenomenal nature as to invite further investigation.

Mentha piperita, from which the true oil of peppermint is derived, was first introduced or noticed in Hertfordshire, England, and given the name "peppermint" by Ray in his "Historia Plantarum," published in 1704. Its commercial history dates from about the year 1750, when its cultivation was commenced in a very small way at Mitcham, in Surrey, England. Fifty years later the amount under cultivation was about 100 acres, but the growers having had, as yet, no distilleries built, still continued to convey the plant to London for the distillation of the oil.

The industry in England reached its zenith about 1850, just one hundred years after its introduction, when the area cultivated was about 500 acres, but, owing to successful American competition, it was reduced during the next fifteen years to about 250 acres. From personal observation when visiting the peppermint districts of England in 1875, I attribute the success of American competition to a more perfect system of distillation and apparatus therefor (which I will again refer to), and the more healthful growth of the plants in our country.

Distillation of oil of peppermint was first accomplished in America by a Mr. Burnett, in the year 1816, in the county of Wayne, State of New York, who collected on the banks of a little stream sufficient wild plants to produce about 40 pounds of the oil. In the year 1835, the industry was established in Michigan, in St. Joseph County, on White Pigeon Prairie, about two miles north of a village of that name, a distillery being erected the following year. Up to this time, and for ten years later, the distilling apparatus used was very crude, being the same as has been used in England, with but slight modifications, consisting of a copper kettle in which the plants were placed, immersed in water, to which direct heat was applied by a furnace from beneath, a condensing worm of the usual character being connected with the kettle by a pipe from its apex.

The year 1846 marks a new and important era in the evolution of a more perfect system of distillation and the apparatus therefor, viz., that of distillation by the diffusion of steam through the plants, which were now, for the first time, placed in large wooden vats, to which steam was conveyed by a long pipe entering at the bottom; the kettle which had been used heretofore as the still being now used for the generation of steam. Distillation was now effected in a much more perfect manner, as the scorching of plants and the consequent formation of empyreumatic products was rendered impossible. Furthermore, distillation could now be conducted with much greater rapidity and economy. The primitive stills had a capacity of about 15 pounds of essential oil in the twenty-four hours, the new form a capacity of 75 to 100 pounds. This system of steam distillation originated in St. Joseph County, Michigan, and was soon introduced into New York.

I might state here that nearly every improvement in

the construction of the stills has originated in St. Joseph County, Michigan, and it would be of great interest to mark the further development of these improvements to their present high state of perfection, but the limits of this paper render it impossible. On some other occasion I may have the honor to give some practical and technical information relating to the methods of erecting the more perfect plants of distilleries.

Briefly as to the cultivation of the plants. In early spring the ground, having been plowed, is marked out in furrows $2\frac{1}{2}$ ft. apart. In these furrows are placed the roots and runners which have multiplied from the setting the preceding year. One acre of good roots usually furnishes sufficient to set from 5 to 10 acres of new ground. These roots and runners are from one-eighth to one-fourth of an inch in diameter, and from 1 to 3 feet in length when in the healthy state. In setting, they are carried in large sacks, strung over the shoulders of the workmen, who place them in the rows so that there shall be one or two living roots or runners at every point in the row. While placing the roots with their hands, they at the same time cover them with their feet. It is quite an interesting sight, owing to the queer motions of the workmen, to see these roots planted. A good, experienced workman, in mellow ground, with good roots, can set about one acre per day. New plants appear above the ground about two weeks after setting, and are carefully hoed and cultivated until July or August, when, if the season is fair, the plants have thrown out such a quantity of runners as to render further cultivation very difficult, and indeed unnecessary.

The proper time for distillation is when the plants are in full bloom in the case of the new crop, that is, the crop which has been set the preceding spring. This usually occurs in September. What is known as the "second crop" (which has sprung up spontaneously, from being the second year's growth) matures usually in August. For distillation, the plants are cut down and allowed to dry for a while in the sun before being drawn to the distilleries. Many growers, however, believing that a loss of the oil is sustained by diffusion in the atmosphere if the plants are fairly dried, bring them to the still in the green state. As distillation can be effected with much greater rapidity from dry plants, this question of thorough drying is one in which the owners of distilleries and the producers in general have long been greatly interested. For, if the plants are worked in the green state, it will require, ordinarily, about ninety minutes for distillation, with a yield of perhaps 5 to 7 pounds of oil to the charge, whereas, if thoroughly dried, distillation can be effected in about thirty-five minutes, with a yield of from eight to nine pounds, since the dried plants will pack much more closely in the vats than the green ones. Each owner of a distillery on the average distills the crops of ten other growers with his own, charging therefor twenty-five cents for each pound of oil obtained, whereas in England the charge is made for each vat of plants, whatever the amount of oil produced.

The former method is much more equitable for the grower, since, if his crop is poor, he is not obliged to pay an exorbitant rate per pound, and the latter method is more equitable for the distiller, since it requires as much labor to distill a charge of poor plants as green and productive ones, and, as stated, much more when the plants are green.

To test the question as to whether a loss of essential oil occurred by diffusion in the atmosphere when the plants were thoroughly dried, I made a careful experiment, the results of which may be found in the September number of the *American Druggist*; the dried plants used having been exposed to atmospheric action for six months, and having been reduced by such exposure 49.4 per cent in weight. As there are about 15,000 tons of the plants produced annually in America, the settlement of this question is of material interest to owners of distilleries and growers; saving the former greatly in manufacturing and the latter in transportation.

The average yield of essential oil varies greatly, according to the quality of the plants, depending mostly on the fact whether they are fine and well covered with leaves and blossoms (in which the essential oil is entirely contained). The difference in quality of plants is so great that, while from 2,000 pounds of well-leaved plants I have distilled 18 pounds of essential oil, but 1 and $1\frac{1}{2}$ pounds have been obtained in some instances from a like quantity of coarse plants devoid of leaves. The average yield, however, is about one-third of 1 per cent. from green plants.

There are now in America about 175 small distilleries, where the natural oil is distilled. The average annual production in America for the last ten years has been about 100,000 pounds of oil. The average yield per acre of the crops of the first and second year is about 11 pounds; this would show an annual area under cultivation of about 9,000 acres.

As to the nature of the essential oil: regarding this there are many tests, which are so generally known as not to require notice at this time. Some of them may, however, be briefly stated. Oil of peppermint, when freshly distilled, or when two or three years of age, if kept in well-filled vessels, should dissolve readily in alcohol in all proportions, making a clear solution without need of filtration. When a few drops of the oil are placed upon white paper and held over a lamp or gas jet, it should volatilize quickly and perfectly without undergoing change or leaving any residue. When 3 drops of peppermint are placed upon 4 grains of resublimed iodine (or such quantity as will thoroughly saturate, but not drown, the iodine), there should be but a slight reaction, and what little vapor is produced should be almost invisible, becoming entirely so after having arisen about twelve inches above the mixture, the color of the vapor assuming a bluish cast. The color of the mixture in this test should be carefully noticed, which, in the case of pure peppermint, is of a brown or brownish-black color, the iodine dissolving slowly and imperfectly. If oil of turpentine, erigeron, fireweed, ragweed, or other terebinthinate oils are present, there will be quite a violent reaction (according to the quantity of the adulterant), with the evolution of considerable heat, and a red or reddish-yellow vapor will be produced, of a rank odor, partaking considerably of the nature of the adulterant, and the mixture will change to a bright violet. If the color of the mixture is most carefully noted, a very slight quantity of such adulterants can be detected. When to 25 drops of alcohol 1 drop of nitric acid, specific gravity 1.2, is

added, and then 1 drop of pure oil of peppermint, there will be produced, within about half an hour, a blue or bluish-green color, which will remain permanent for a long time. Oil of pennyroyal and *Mentha arvensis* produce no coloration. A much more intense coloration will be produced when 1 drop of nitric acid, of the strength as stated, is mixed with 50 or 60 drops of the essential oil, without alcohol. Some specimens of oil of peppermint imported from Germany and England showed by this test a mixture with *Mentha arvensis*. To make this test valuable, however, to chemists and pharmacists, they should first operate upon samples of known purity, and notice the depth of coloration required.

Another test for the detection of pennyroyal, which also indicates *Mentha arvensis* when in sufficient quantity, is the following: Take 1 drachm each chloral hydrate and pure sulphuric acid, adding 12 drops of alcohol. When this solution is mixed with a like quantity of pure oil of peppermint, a dark cherry color is quickly produced and maintained for a long time. Pennyroyal (or oil of peppermint heavily adulterated with this oil) gives no such color, being more of a yellowish cast, and changing to an olive green. With *Mentha arvensis* a yellowish-brown color is produced, which is maintained for ten or twelve hours, and, thirty-six hours later has a slight tendency to assume a cherry color or one intermediate between the cherry and the brown. It was noticed that, when the true oil of peppermint was mixed in equal proportions with that of the *Mentha arvensis*, a deficiency in the intensity of the cherry color was plainly observable. Whether the significance which I have discovered in these tests, showing similar reactions in pennyroyal and *Mentha arvensis*, has a bearing on the chemical relationship of the oils of these plants, which are related botanically, is a question of interest.

I will now refer to the two physical tests, those of specific gravity and boiling point, in which the results of my experience vary greatly from the tests published in official and standard works.

The difficulty which scientific men seem to have experienced in establishing accurate tests for the purity of essential oils has been that they could not conveniently obtain the plants from which they themselves could distill the specimens used in their investigations; and while undoubtedly every possible precaution was taken, the result shows that they have in many instances operated upon impure samples; and although pure specimens undoubtedly were, in some instances, received, yet they had, in many cases, no positive knowledge, *per se*, which were pure and which were impure; hence too great a range of differences has been allowed in physical characteristics and chemical reactions. In correspondence with some well-known chemists, they give it as their opinion that a wide range of specific gravity, etc., might result from variations in soil and climate. On account of this we took greater pains to verify our determinations by testing samples grown under much varying conditions of soil and climate, both in Europe and America. Forty-three samples were examined, including oils produced in St. Joseph, Wayne, Ionia, Hillsdale, and Kalkaska Counties, Michigan, Wayne County, New York, and vicinity (all of which were produced from American roots long acclimated), also one specimen grown in America from roots imported from England, and one specimen grown and distilled in England. The specific gravity has been variously stated in the dispensaries and other standard works at from 0.840 to 0.950 at 60° F. But there were none of the samples which were pure which had a specific gravity below 0.910 at 60° F., except the two last mentioned, grown from English roots; the one grown in America being 0.9085, the one distilled in England being 0.9088. Nor were any specimens of pure oil found having the specific gravity above 0.917 which were in a perfectly soluble condition. One sample distilled by myself in 1875, and consequently eleven years old, had, on account of its age, a specific gravity of 0.924; one sample from New York 0.933, and from the same district 0.940 for another. However, those three samples were found to be not readily soluble; the latter sample, when submitted to rectification, being found to contain 9 per cent. of insoluble resin. Of five samples imported from Europe, but one was found pure; two from Germany were found to contain mentholized *Mentha arvensis*; one from London, which bore a fraudulent and forged label (as Michigan oil of peppermint, manufactured at Evart, Michigan County, U. S.), had the specific gravity 0.899. This oil, when submitted to fractional distillation, was found to contain 50 per cent. oil turpentine and no Michigan peppermint whatever. The sample imported from London as German oil of peppermint consisted chiefly of pennyroyal and *Mentha arvensis*. Allowing a slightly wider range of difference than was really intended, it is evident that whether from English or American plants, pure oil of peppermint is never below 0.908 specific gravity, nor when fresh and soluble, above 0.917 specific gravity, so that the difference formerly allowable, that is, from 0.840 to 0.950, is reduced to one-tenth.

As to the boiling point: this is stated in the dispensaries at 365° F. and 374° F. By placing the oil of peppermint in a distilling flask, the body of which was immersed in a mercury bath, and attached to the condenser, the following times and temperatures were noticed, the distilling being divided into eight fractions. Applying the heat slowly, the slightest possible ebullition was noticed at 363° F., but so slight as to be almost imperceptible. Ten minutes later the temperature had risen to 401.5° F., at which time but 2 drachms of fluid were collected, one-half of which was found to be water. It will hence be observed that the true boiling point of the oil could hardly be placed below 400° F. Ten minutes later the temperature had risen to 406.9° F., with distillation progressing at the rate of but 6 drops per minute, and it was found, upon reducing the temperature to 406°, that the speed of distillation was reduced to 1 drop in forty-two seconds; so that the first fraction could not be recovered easily, except at a temperature higher than this. Counting from the time when the oil commenced to drop into the receiver, the distillation of the first fraction of 1 ounce occupied fifty minutes, being concluded at a temperature of 412.8° F. It would seem, then, that the true boiling point should not be placed below 400° F.

I would here call the attention of the association to the need of a more definite and complete method for recording experiments in fractional distillation, in which

* Read at a meeting of the American Pharmaceutical Association.

not only the form of apparatus and method of applying the heat should be noticed, and the temperatures of each fraction, but also the speed at which it is affected in its various stages. This matter would form a very interesting matter for discussion. I will now call attention to one phenomenal characteristic observed in fractional distillation, and which I briefly alluded to one year ago, that is, the changes of direction from the ascending to the descending scale in the specific gravity of the different fractions. It had formerly been supposed that the specific gravities increased constantly after the first until the last fraction was obtained. The law discovered is that when the distillate is divided into a number of fractions, the specific gravities continue to rise only until about half the oil is recovered, they then strangely commence to descend until 80 per cent. or 90 per cent. is obtained, and the point is reached of the specific gravity about as low as that of the third fraction. The direction now again changes to an ascending scale, increasing with great rapidity. To illustrate this, I will give you the specific gravities obtained in the distillation of 300 pounds oil of peppermint by the diffusion of steam. The times and temperatures and other conditions will be referred to in some future paper.

The specific gravities were as follows:

Number of fraction.	Specific gravity.	Number of fraction.	Specific gravity.
1.....	0.89423	8.....	0.91275
2.....	0.90650	9.....	0.91175
3.....	0.91000	10.....	0.91100
4.....	0.91275	11.....	0.91075
5.....	0.91375	12.....	0.91065
6.....	0.91400	13.....	0.91050
7.....	0.91425	14.....	0.91265

There now remains in the still one full fraction of 20 pounds not yet recovered; subdividing this fraction, the following specific gravities are found: The first 5 pounds is 0.925; the next 2 pounds 0.955, and the distillation being continued as far as possible, the last portion obtained is 4 ounces specific gravity 0.970. There now remain in the still 12 pounds 14 ounces of resin, which, if mixed with 7 pounds 4 ounces last obtained, would raise the specific gravity of the last full fraction to about 0.980.

In calling the attention of Professor Fluckiger, of Strassburg, to the subject, he attributes it to the splitting up of the component parts. This, however, seems hardly possible when the aroma and chemical reactions of the fractions are investigated.

There are other tests and characteristics of interest which I would gladly notice if time permitted, but which will better form the subject of a future article.

BORACIC ACID, BORAX, AND THEIR USES.

FOR nearly forty years I have been engaged more or less in promoting the introduction and useful application of borax. I have also visited many of the districts where it is found in its crude state, and have gained much information respecting its valuable properties and important uses—an almost inexhaustible subject, into which it would take too long to attempt to enter fully. I will therefore try, as briefly as possible, to give an outline of its mode of occurrence in the natural state, describe how it is collected and manufactured, and explain as briefly as possible its uses. Borax is no new article of commerce, but was known to and used by the ancients from time immemorial. Nero used it. Pansa regretted that he was not sufficiently rich to buy borax to cover the arena after the death of the combatants at the time of the combat between the gladiators Lydon and Tetrades. Doubtless its use on the arena was to deodorize the blood. At this time there is no record of borax being found in its crude state in any part of Europe, but it was known to the Arabians, who called it baurach. Hence its name. They used it to assist in reducing the oxides of metals. The conclusion at which I have arrived is that the borax used by Geber, who lived in the eighth century, was made from tincal, or crude borax, which is found in many lakes in Thibet.

In some of these lakes are numerous hot springs, the vapor of which contains boron, and the surface water is impregnated by it. Evaporation taking place, the tincal is found crystallized at the sides of the lakes. In addition to this, solid borax is found in some form or other in the soil around this district, and there is ample proof that unlimited supplies can be obtained. Tincal has been obtained from Yandok Cho from time immemorial. It is exported in small quantities hence to Lassa, where it is used by various workers in metal. After the tincal has been collected it is bartered for cowrie shells, Sheffield cutlery, and Birmingham ware. It is then sold to the Kassawaris and Khampos traders, who arrange for its transport to India on sheep's backs. Each sheep carries from 40 to 60 lb. The transport across the Himalayas takes about nine weeks. Each driver carries a distaff, which they use to spin wool dragged from the sheep's back, to make bags in which to pack the tincal. Should a sheep die on the way, its flesh is eaten by the drivers, and the wool taken off and spun as described. On the way vegetation is sometimes so scarce that boughs of trees have to be cut down and the leaves stripped, to feed the sheep.

From Moradabad and other parts of the foot-hills of

the Himalayas the tincal is sent to Calcutta, and shipped from thence to Liverpool, where it is refined into borax, and used in making the glaze for china and earthenware. I may mention that tincal was the only form in which borax was known in Europe until the year 1743, when a Tuscan traveler and geologist paid a visit to Monte Cerboli, Castel Nuovo, where he discovered a large number of hot springs, and noticed dense vapors arising from them; but it was not till the year 1777 that Hoeffer found out that the steam contained boracic acid at Monto Rotondo and Castel Nuovo. In 1816 Hoeffer and Mascagni proposed to make borax from them, but the latter was too much engaged with other scientific labors, although he had obtained a patent during Napoleon's rule in Italy to make boracic acid from the fumeroles. This right he ceded to Fossi, who was the first to make it in any quantities. Gazzeri and Browet worked some of the lagoons at Monte Rotondo, but made only about 3½ tons in twelve months—a most unfortunate speculation for them.

In 1818 Laderet, a Frenchman, who was staying in Italy, hit upon the brilliant idea of utilizing the natural steam jets oozing up so plentifully from the soil, to evaporate the water, and so increase the supply of borax at a much cheaper rate, as the great cost hitherto had been the wood for fuel. I must now try and describe the very simple mode of preparing this boracic acid, and when I first visited Italy I was never more astonished in my life. I made my headquarters Castel Nuovo, which is the very center of these curious steam puffs or fumeroles, and visited the most important places of production, Sasso, Lustignano, Ladarello, Lago, and San Federigo. Scarcely any one could give me any idea why the steam puffs contained the boracic acid, and, as I am neither a scientific nor a learned man, I can but give you what I think may be the cause, though I may be altogether mistaken in my supposition.

My exact meaning will be best understood from the accompanying diagram—all that is seen below the surface being, of course, imaginary, but, I believe, correct. The subterranean lake, A, is supposed to be surrounded with crude borax vapor generated from the lake by deep-seated heat or fire; the vapor rises through the crevices, B, of the rocks; C are artificial lakes on the surface of the earth; D is a tank wherein any impurities fall to the bottom, boracic acid still remaining in solution; F is the evaporating house; E is a soffione vaulted over with stone and firmly bound with wrought iron bars; and G are the crystallizing tubs or casks. Now, it appears to me that for many miles round this district there exist subterranean lakes and seas—the sides containing borax in some solid form; and that the internal heat of the earth affects the water, dissolving the borax. The steam forces its way through crevices and fissures, sometimes puffing up to a height of eight or ten feet.

To utilize the steam jets, a wooden chimney is constructed round those selected, which conducts the steam high up in the air, in order to protect the workmen while preparing the lagoon or lake. Around this is dug an artificial lagoon, about six feet in depth and twenty feet in diameter. This lagoon is faced with bricks or tiles. The wooden chimney is then removed, and clear water run into the lake from an adjacent stream. When it is full the water is turned off, and the steam which comes up in the center of the lagoon soon heats the water, which quickly boils, the vapor rising with such force as to cause it to bubble up to a height of three or four feet.

This is allowed to continue for about thirty hours, during which time the water gives off a perfume like that arising from rotten eggs. It is then conducted from the lagoon by a wooden trough into a large iron tank, placed near to, but slightly below, the level of the lake, when any impurities sink to the bottom, while the boracic acid remains in solution. From the tank the solution is conveyed through pipes to a series of leaden pans or evaporators standing in a large building open at the ends and sides, but having a roof to keep out rain. These evaporators are placed over a brick built chamber, into which steam from another fumerole is conducted by a pipe at one end of the building, and after traversing the entire length of the building, escapes through a pipe at the other end. By this means the leaden pans become heated, and drive off a good deal of the superfluous water, the solution thus becoming more dense, and while in this condition it is run off through wooden pipes into large casks. When cool, the boracic acid forms on the sides of the casks in a thickness of about five inches. The liquor being drawn off, the boracic acid is removed and put into wicker baskets. After a short time it is carried to the drying chamber and placed on a brick floor, which is heated by one of the steam jets. When dry, it is packed in casks and conveyed to Leghorn for shipment to England, and refined into borax.

About 3,000 tons of boracic acid are produced annually in Italy. Besides the districts I have already mentioned in Italy, there are others, but they are insignificant.

Chili is the next important district where borax is found in a crude state. It is also found in Peru and Bolivia, but the largest deposits are in Chili. There exist large numbers of dried-up lakes containing great quantities of borate of lime. The most important is known as the Laguna de Maricunga, which, besides

borate of lime, contains solid masses of salt. It is situated between the two highest ridges of the Andes at an elevation of 1,300 ft. In some parts of the lake there are deposits of borate of lime twenty feet deep, so that when the business gets thoroughly established, borate of lime may be collected and sold comparatively cheap; and when the uses of borax are better known, and more demand for it created, this crude borax will be sent home in thousands of tons. The cost of collecting it is trifling, but the carriage from the place of production to the sea coast is expensive. In my next I will fully refer to the wonderful deposits of borate of soda and borate of lime existing in Nevada and California, United States of America.

I believe I am correct in stating that no case of cholera was ever known to have taken place in any of the villages where the boracic acid is made, the vapors arising from the lagoons acting as a charm against this terrible epidemic.—Arthur Robottom, *Industrial Review*.

APPARATUS FOR OBTAINING THE DENSITY OF SOLIDS.

THE specific weight of a body, which is usually confounded in physics with density, is the ratio of the weight of such body to the weight of an equal bulk of water, or, what amounts to the same thing, the specific weight of a body is the weight of the unit of volume of such body. The following classical formula,

$$D = \frac{P}{V},$$

which is well known, shows that, in order to obtain D, it is necessary to know P, that is to say, the weight of the body, and V, its volume. The methods ordinarily used for such determinations are those of the hydrostatic balance, the bottle, and aerometers of constant volume. All such methods take time, and require a certain amount of dexterity on the part of the operator. Messrs. Brasse & Vlasto have devised a very simple little apparatus for rapidly estimating the density of solid bodies. With this, it requires but a single weighing, which may be effected up to within a decigramme. A reading once made, the volume is known.

The apparatus is constructed as follows: A burette, B, graduated to tenths of a cubic centimeter, and the

APPARATUS FOR OBTAINING THE DENSITY OF SOLIDS.

upper extremity of which is ovoid, while the lower one is provided with a cock, R, is connected by a rubber tube, C, with a balloon, A, having the shape of the bottles used for taking densities. The aperture is ground and fitted with a hollow stopper surmounted by a capillary tube provided with a datum mark. The lower part of the balloon terminates in a slender tube to which the rubber tube is affixed. The burette and balloon are supported by clamps that are movable around the rod, D.

The mode of using the apparatus is as follows: It is first filled with water, whose temperature should be as near 15° C. as possible. Then the balloon is raised by causing its clamp to slide along the supporting rod, and things are so arranged that when the level of the water reaches the datum mark, the water shall enter from the other side at the base of the burette. Then the division at which it stops is read. Let us suppose that we find it to be 5 cubic centimeters. We then weigh the body whose density we wish to take. For the sake of example, we shall take statuary marble. We put on a scale several fragments of this, that are small enough to enter the neck of the balloon, and we find it to weigh 25.4 grammes.

We raise the balloon, and the water then lowers therein, and rises in the burette, filling a portion of the bulb as it does so. We then open the balloon, introduce the fragments of marble, insert the stopper, and lower the balloon again until the water returns to the datum mark of the capillary tube. The body has displaced a volume of liquid equal to its own, and the water has therefore risen in the burette, and has reached a second level. A new reading is now made, and we find 14.4 cubic centimeters. Upon obtaining the difference between the two figures read, we have the volume of the body, which, in the example above selected, is 14.4—4.5 = 9.4 cubic centimeters.

Applying the formula,

$$D = \frac{P}{V},$$

we have

$$D = \frac{25.4}{9.4} = 2.702.$$

By the bottle method, we find 2.709, say an error of <0.01.

With bodies soluble in water, or upon which water exerts an action (such as cements, for example), some other liquid (kerosene, for example) is substituted.

The apparatus is simple, and easily and quickly maneuvered.—*Le Génie Civil*.

BORAX: ITS OCCURRENCE AND PREPARATION.