

tem some most subtle influences have been overlooked because unrecorded by the index of the thermometer?

Professor Tait says: "The energy of vibrational radiations is a transformation of the heat of a hot body and can be again frittered down into heat, but in the interval of its passage through space devoid of tangible matter, or even while *passing unabsorbed through tangible matter, it is not necessarily heat.*" And Mr. Pattison Muir in his work on "Thermal Chemistry" asks: "Must all energy which is lost by a changing chemical system during a definite operation make its appearance in the form of heat? Energy appears in chemical operations in forms other than that of heat—electrical energy, for instance. We must distinguish in chemical processes between that part of chemical energy which is freely changeable into other forms and that which can leave the system only in the form of heat."

The most recent researches thus point to the probability that while the bacterium carries on through nature its never ending work of reducing chemical antecedents to chemical consequents, it must as continuously set free energy in forms other than that of heat.

One of the most pregnant discoveries made of late is that which demonstrates that, even in the case of the powerful friction requisite for boring iron, heat ceases to be recognizable as heat when the iron operated on is strongly magnetized: that is, that heat developed by friction in a magnetic field disappears in some form other than heat. By this the idea is suggested that heat energy impinging upon the sentient extremity of a nerve in action may be taken up and carried in a form other than heat to the central brain, just as sound is conveyed in a form other than sound across the interval between the telephone and the receiver; and if the multiple wave lengths which produce the subjective sensation of heat can be thus transferred from the surface to the center, why not fractions of that multiple which when taken together make the whole?

Since, then, science cannot specify the difference between the energy contained in dead carbonic acid and that of the living hydrocarbon, neither can it draw a line more definite than the equator between those series of decompositions which on the one side are termed life and on the other are designated death. In each and all the compound descends from instability toward stability, and in every degradation is energy evolved.

Yet that energy, no matter in what companionship it may be found, or through how many existences it may have transmigrated, has still but one original source, and consequently it is impossible to conceive a condition in which that energy, primarily possessed of such "phenomenal modes of action," can be regarded as absolutely inert.

So far, then, it is claimed that grounds have been established for asserting that from the surface of every decomposing swamp forms of energy must be momentarily poured forth, the potency of which is as yet unknown.

Again, while it is at present impossible to isolate the fractions of energy the sum of which make heat, still it would contribute vastly to the proof of their independent existence if it could be shown that the nerves of sensation are specialized in sections, each reacting separately, to different gradations of heat.

This has been apparently accomplished.

"Dr. Goldscheider, at a meeting on April 9 of the Physiological Society of Berlin, discussed the action of menthol on the sensory nerves. He therefore concluded that the sensations in some places of cold and in other places of heat, produced by menthol, were purely subjective, and consequent on the direct stimulation of the special nerves of temperature, those usually cognizant of cold being far more sensitive to its influence than were those adapted to receive impressions of higher temperatures."—*Brit. Med. Journ.*, August 21, 1886.

Here, then, is strong evidence that the sentient nerve endings over the surface of the body are graduated to respond to the various rates of energy that may impinge thereon; and if so, how can it be admitted that the varieties of energy by which these nerve endings are stimulated must be limited to those already identified?

That some such idea has shaped itself in the minds of observers may be gathered from the independent opinions expressed by several of the members of the Cholera Commission of 1885.

Prof. Aitken sums up his valuable contribution in these words:

"Some influence (as yet unknown, and therefore so far mysterious) seems to create in cholera times and places an epidemic activity. It is probable that this may be due rather to some meteorological condition—some peculiar state of the atmosphere, electrical or other—combined with unwholesome conditions of surroundings and conditions of life; a co-existence of physical phenomena rather than anything in the individual. It is well known that electrical conditions such as prevail in a thunderstorm will cause milk to become sour, the formation of the acid being associated with, or due to, the formation of the bacterium lactis, and thus confined to very definite areas."

In the last paragraph lies the key to some of the foregoing mystery.

The mode in which to use it can be learned from the marvelous researches of Pasteur.

It is obvious that if the cause of sourness be the bacterium, the cause of greater sourness will be the bacterium still, and that the reason for the increased reduction by the bacterium of chemical antecedents to chemical consequents, which produces the additional sourness, must lie in some condition affecting the life of the bacterium too.

Pasteur has shown that a fundamental difference exists in the mode of action of the beer and grape ferments when "the introduction of the free oxygen of the atmosphere is permitted and when such introduction is prevented." When free oxygen is admitted, "the ferment shows an activity *even more extraordinary* than it did in the deep vats; the life of the ferment is singularly enhanced, but the proportion of the weight of the decomposed sugar to that of the yeast formed is absolutely different in the two cases; while for example in the *deep vats* a kilogramme of ferment sometimes decomposes 70, 80, 100, or even 150 kilogrammes of sugar, in the *shallow troughs* 1 kilogramme of the ferment will be found to correspond to only 5 or 6 kilogrammes of decomposed sugar. In other words, the

more free oxygen the yeast ferment consumes, the less is its power as a ferment; the more, on the contrary, the life of the ferment is carried on *without the presence of free oxygen*, the greater is its power of decomposing and of fermenting the saccharine matter."

Here, then, is the clew to the cause of the increased sourness of milk during electrical conditions such as prevail in a thunderstorm. The bacterium lactis evidently finds itself in a situation in which the free oxygen of the atmosphere has, owing to some atomic disturbance in its molecules, become less available as an energy provider.

The organism is consequently compelled to revert to the condition of the ferment in the deep vats, and to find in the increased decomposition of the constituents of the milk that energy which is necessary for its existence.

Further, it is known that electricity does affect the condition of oxygen, that the conversion of its molecules from the diatomic to the triatomic state can be brought about by its influence, and that this latter state has been recognized as ozone.

If, then, it can be thus proved that the presence or absence of oxygen so materially alters the mode of existence of microscopic organisms, is it not reasonable to accept changes in the lives of the organisms as evidence of the altered condition of oxygen? And since certain conditions of free energy are thus found to interfere with the mode of nutrition of the minutest forms of life, can it be doubted that similar forces may exercise a material influence upon the most complex being, who, after all, is but a larger multiple of the original protoplasmic element?

Thus it becomes possible that energy existing in forms other than those of light or heat exerts a power which has up to the present been ignored.

By this reasoning too, based on the altered mode of nutrition of the bacterium lactis during a thunderstorm, much that has been hitherto obscure in the history of the diseases, or blights, of the vegetable world becomes intelligible.

When it is found that all the bacteria lactis over a considerable area at the same moment change their mode of existence, and, from leading a comparatively sluggish life in the milk substance, suddenly break up almost the whole of that substance at a time when electrical disturbances are present, it is easily conceivable that in the case of potato blight, which is almost invariably accompanied by obvious atmospheric changes, like conditions may arise. In fact, that the universally present bacteria, which, under ordinary circumstances, continue to exist without apparent injury to the tuber and leaves with which they are in contact, may, when driven by the stress of altered atmospheric conditions, turn upon the tissues of the plant for nutrition as the bacterium lactis upon the milk.

If, then, these effects of certain unrecognized forms of energy be established, it will go far to help the elucidation of the mysterious subject of cholera.

Dr. Bryden, from prolonged study of the cholera statistics of India, arrived at the following conclusions: "That the disease was endemic in the Soonderbunds, and that its cause was *earth-born and air-born*"—to repeat the words of Prof. Aitken, "due rather to some meteorological condition, some peculiar state of the atmosphere, to a co-existence of physical phenomena;" and Deputy Surgeon-General Marston has added: "Cholera spreads along rivers, but against their current in Bengal. It invariably advances from Bengal proper to the Himalayas, and never the reverse."

Here, then, are the conclusions arrived at by some of the most skilled observers on this subject.

It is thus admitted that cholera is endemic in the Soonderbunds, and that its track from thence lies in a northwesterly direction. That is, that its home is a surface of 12,000 square miles of decomposing tropical vegetation, and its direction that from whence the Ganges and its tributaries flow.

From this it may be inferred that its cause is such that it can be carried atmospherically, and that its course is the line of the least resistance.

Were the cause of cholera solid or liquid, it would doubtless long ere this have been demonstrated. Were it gaseous, it must follow the law of the diffusion of gases. What, then, remains to be sought for over the surface of the Soonderbunds? Naught but some form of that universal energy which fell as a sunbeam upon the growing plant, but which, when filtered through its substance, is evolved in a less vivid but still a potent form from its decaying structure.

That such returned energy has the power of incorporating itself with water, till it passes upward as a vapor, every steaming dung heap shows, and in what prodigious force it can be again eliminated may be understood from the calculation of Prof. Haughton, that the condensation of vapor sufficient to afford one gallon of rainfall gives out sufficient heat to melt 45 pounds of cast iron.

From this may be estimated the enormous output of bottom heat which must day and night pass from a decomposing surface of 12,000 square miles to the vapor-carrying air above.

To comprehend the distance to which this energy may be transported before doing visible work it is only necessary to consider the Gulf Stream, which is described by Prof. Tait as "a vast convection current whereby the solar heat of the tropics is carried into the North Atlantic." And to measure the work done thereby it needs but to weigh the luxuriant vegetation of the United Kingdom against the frigid barrenness of Labrador.

If, then, such vast stores of force can be transported from the tropics to England, it cannot be irrational to assert that from the surface of the Soonderbunds, and like places, much of the energy of decomposition must ascend with the rising vapor, and that whether drawn landward by the heated earth surface, or pushed inward before the advancing monsoon, this vapor must follow the line of least resistance along the course of the river beds.

Again, when it is remembered how intense are the effects on the nerves of the animal body of the chemical affinity evolved as electricity from a few square inches of decomposing zinc, it may well be contended that the energy of chemical affinity evolved from so great an area of decomposing organic substances cannot be innocuous, and the fact of its action not being acknowledged by the subjective sense of feeling is no proof that it is non-existent.

Thus it becomes conceivable how the energy evolved in the Soonderbunds may, when vapor-borne across the interval, affect the inhabitants of Oude, and so alter the individual condition as to admit of local causes producing foreign effects.

Many of the most careful observers have asserted that malarious fevers arose from chill. Yet, while this did not solve the question, it at least established one fact, that malarious fevers arose under circumstances which necessitated vapor condensation, one gallon of which would set free energy sufficient to melt forty-five pounds of cast iron.

Familiarity with malaria will furnish many arguments in support of the contention that fever infection is at least coincident with vapor condensation. A boat's crew ashore at night on a West African station will often be affected, while those but a few miles seaward will remain exempt.

In the deep valleys of Zululand leading from the St. Lucia swamp, fever is contracted at a distance of many miles inland, while high ground much nearer to the swamp may be occupied with impunity. In the Terai, at the foot of the Himalayas, a night's sojourn brings to the unseasoned traveler certain fever, while a day journey is almost free from risk.

Since, then, the search for a material cause of cholera and of malaria has been as unsuccessful as if one sought a material cause for sunstroke, it may legitimately be suggested that, as the more rapidly fatal affection is the result of the action of direct solar energy upon the sentient nerve-endings, so the less rapid maladies may result from subordinate rates of the same energy acting upon subdivisions of the nerve-endings, which, as Dr. Goldscheider has shown, are specialized to respond to lower velocities of that force, and that the chill to which so many attribute the origin of fever is really the acknowledgment, by what Dr. Goldscheider terms "the special nerves of temperature usually cognizant of cold," of that obscure energy hitherto unregarded as a factor in the production of disease, but which the investigations of thermoelectricity may one day bring within the ken of man.—*Nature*.

SEPARATION AND ESTIMATION OF BORIC ACID.*

By F. A. GOOCH.

IN all successful methods for the estimation of boric acid, its comparative isolation is a necessary preliminary. Fortunately the removal of nearly everything which interferes seriously with the proper execution of methods is not particularly arduous, but of ordinarily occurring substances, two, silica and alumina, both very commonly associated with boric acid, are especially annoying in this regard. In the separation of alumina the trouble lies in the tendency of the precipitated hydrate to carry and retain boric acid,† so that the two cannot be parted by means of ammonia or ammonia salts. With silica, the difficulty is in removing it completely.

The volatility of boric acid stands, of course, absolutely in the way of treating with acid and evaporating to dryness, and every chemist knows the vainness of attempting to precipitate silica by means of ammonia, ammonia salts, or zinc oxide in ammonia. In Stromeyer's method‡ the presence of silica is peculiarly harmful, since in passing to the condition of potassium fluo-silicate this substance nearly quadruples its weight, and to free the potassium fluo-borate from containing fluo-silicate requires, according to Fresenius,§ at least six treatments by solution in boiling water, the addition of ammonia, and evaporation to dryness. Wohler|| recommends evaporating the hydrochloric acid solution to dryness in a flask fitted to a condenser, collecting the distillate, reuniting the latter with the residue, and filtering from silica, and the operation is successful so far as the complete removal of silica is concerned, but the alumina, if present, is still in condition to give annoyance, and the other bases are yet to be separated.

Advantage has long been taken of the volatility of free boric acid with hydrofluoric acid or with alcohol to secure its removal from fixed substances, but so far as I know, no attempt has been made heretofore to secure its complete volatilization and estimation in the distillate. The experiments which I proceed to describe are the result of an effort to accomplish this end.

Aside from the difficulties in manipulation and in the construction of apparatus which the use of hydrofluoric acid would involve, this reagent is otherwise plainly inapplicable to the purpose in view, and of other agents with which boric acid is known to volatilize freely, methyl alcohol seems to present the most desirable qualities. Methyl alcohol, ethyl alcohol, and water are effective in the order in which they are named. Thus to volatilize 1 gm. of boric acid—the equivalent, speaking roughly, of about 0.5 gm. of boric anhydride—two treatments with 10 cm. of methyl alcohol and evaporation to dryness in each case were adequate. For the volatilization of 0.2 gm. of boric acid were required two treatments of 10 cm. each of ethyl alcohol, succeeding an evaporation with 50 cm. of the same alcohol; and the residue of five evaporations of water over 0.4 gm. of boric acid, taking in each case 50 cm. of water, followed by ignition, weighed 0.08 gm., or one-fifth of the original weight. In the presence of water, methyl alcohol is not equally effective. Amyl alcohol and sulphuric acid restrain its action similarly, doubtless by dilution simply, and hydrochloric acid seems to possess no advantage over water alone in developing the volatility of boric acid.

As an example, an experiment may serve in which a solution of 0.4 gm. of boric acid in 50 cm. of water, after being heated three times successively with 25 cm. of methyl alcohol until the boiling point rose in every case nearly to that of water, and then evaporated to dryness, left a large residue which disappeared with a single charge of 25 cm. of methyl alcohol applied by itself.

From the residue of the evaporation of borax with

* Proceedings of the American Academy of Arts and Sciences, 1886-87.

† Wohler, *Ann. d. Chem. u. Pharm.*, cxlii., 268.

‡ *Ann. d. Chem. u. Pharm.*, c., 82.

§ "Handbook of Mineral Analysis," under datholite.

|| "Quant. Chem. Anal.," p. 424.

hydrochloric, nitric, or acetic acid, methyl alcohol, as would naturally be predicted, volatilizes the boric acid freely, though the presence of foreign material acts to a certain degree protectively and tends to diminish the rapidity with which the alcohol would otherwise effect extraction and volatilization. In case, however, that acetic acid is used to break up the borate, the tendency of sodium acetate to lose acid and become alkaline simply by exposure to evaporation in its aqueous solution makes it necessary to insure the acidity of the residue of evaporation by adding a drop or two of acetic acid before repeating the treatment with methyl alcohol.

On the whole, methyl alcohol shows itself to be an excellent agent by which to secure the volatilization of boric acid.

To retain free boric acid, magnesium oxide naturally suggests itself. According to Marignac* it is effective, and, if in the course of analysis it may have been partly converted to the chloride, it is easily regenerated by the action of heat and moisture. Marignac, it will be remembered, makes use of magnesia mixture—the chlorides of ammonium and magnesium with free ammonia—to fix the boric acid, evaporating the solution to dryness, igniting, extracting with boiling water, filtering, and weighing the residue, while the filtrate is again treated as before to recover traces of the borate which have yielded to the solvent action of the water.

During the drying and ignition the magnesium chloride yields hydrochloric acid, and it would seem scarcely possible that the magnesium borate should fail to show some loss of boric acid when both hydrochloric acid and moisture exert their action. Further, the presence of ammonia during evaporation does not prevent the volatilization of boric acid,† and Marignac regards the addition of it from time to time as of doubtful use. So it appears natural to look for some loss under such conditions, and Marignac fully recognizes the fact that the apparent accuracy of his method is due to the balancing of errors, the inclusion of foreign matter by the magnesium borate, and the deficiency of the magnesia when precipitated as ammonio-magnesium phosphate, together compensating for the loss of boric acid by volatilization.

To bring the matter to the test, the following experiments were made. In them and in all succeeding experiments the boric acid was weighed in solution, the standard of this having been fixed by dissolving in a known weight of water a known weight of fused boric anhydride prepared in a state of purity by frequent recrystallization. The magnesium oxide employed was made from the pure chloride by precipitating by ammonium carbonate and igniting, and was free from lime and alkalies, and, as far as could be determined, otherwise pure.

The whole operation of each experiment was conducted in one vessel, so as to avoid transfers. In all cases a weighed platinum crucible of 100 cm. capacity received a weighed portion of magnesia, and after ignition and subsequent weighing, the weighed solution of boric acid was introduced. In experiments 1 to 4 the magnesia was thoroughly stirred in the solution of boric acid, the evaporation carried at once to dryness, and the crucible and residue ignited and weighed. In experiments 5 to 8, the magnesia was dissolved, after the addition of the boric acid, in hydrochloric acid sufficient in amount to prevent the precipitation of ammonium hydrate on the subsequent addition of ammonia, ammonia introduced in considerable excess in 7 and 8, in distinct excess in 5 and 6, the whole evaporated and ignited, the residue moistened and again ignited, and this last treatment repeated until the residue ceased to yield vapor of hydrochloric acid when heated.

	B ₂ O ₃ taken, Grm.	MgO taken, Grm.	MgO+B ₂ O ₃ found, Grm.	B ₂ O ₃ found, Grm.	Error, Grm.
(1)	0.1734	0.5005	0.6607	0.1602	0.0132—
(2)	0.1804	0.4973	0.6660	0.1687	0.0117—
(3)	0.1793	0.4949	0.6640	0.1691	0.0102—
(4)	0.1794	0.4941	0.6327	0.1686	0.0108—
(5)	0.1807	0.4984	0.6542	0.1558	0.0249—
(6)	0.1789	0.4974	0.6687	0.1560	0.0229—
(7)	0.1806	0.4944	0.6684	0.1740	0.0066—
(8)	0.1789	0.4959	0.6672	0.1713	0.0076—

From these results it appears plain that under the conditions of the experiments neither magnesia alone nor the magnesia mixture is efficient in fixing boric acid, but in experiments 7 and 8, in which ammonia was employed in large excess, the loss of boric acid is least, so that it would seem to be the case that though ammonia is not a perfect preventive of volatilization it does exert a restraining action on the boric acid. That the magnesia mixture should be incapable of retaining entirely the boric acid present is, as has been pointed out, not surprising, but that the loss should be so great is rather startling, and more than suggests that the errors of Marignac's process are seriously excessive.

The failure of magnesium oxide to hold back boric acid under the conditions of the experiment must be due to a cause other than that which determines the loss during the evaporation and ignition of the magnesia mixture, and for this it is natural to turn to the insolubility of the oxide—a quality likely to oppose some difficulty in the way of establishing complete contact between the boric acid and the magnesia during a short exposure. Direct tests of this point showed distinctly that mixtures of boric acid in water and magnesia, when submitted at once to distillation, yielded boric acid to the distillate, but that, if the mixtures were permitted to stand some hours before distilling, the oxide passed to the semi-gelatinous condition of the hydrate, and retained the boric acid so firmly that turmeric failed to show the presence of the latter in the distillate.

It is plain, therefore, that with sufficient preliminary exposure, magnesia might be relied upon to retain boric acid, but inasmuch as long and perhaps somewhat indefinite periods of waiting are objectionable in any analytical process, it was thought best to try the effect of substituting lime for magnesia. Experiments 9 to 12, conducted like the previous ones, excepting only the use of carefully prepared and ignited

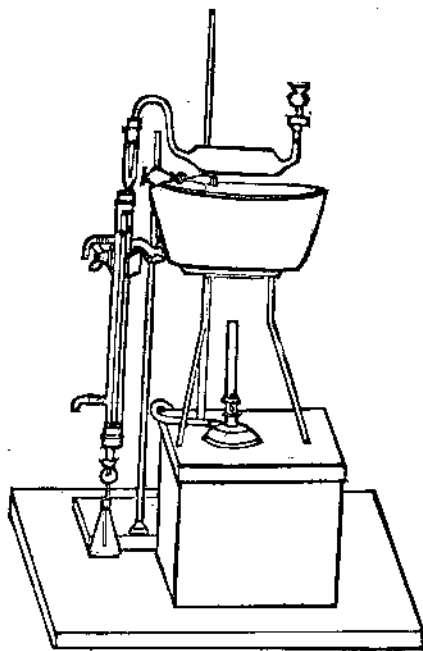
calcium oxide instead of magnesium oxide, were made with this end in view.

	B ₂ O ₃ taken, Grm.	CaO taken, Grm.	CaO+B ₂ O ₃ found, Grm.	B ₂ O ₃ found, Grm.	Error, Grm.
(9)	0.1810	0.9737	1.1560	0.1823	0.0013+
(10)	0.1819	0.9750	1.1583	0.1833	0.0014+
(11)	0.1808	0.9923	1.1810	0.1818	0.0010+
(12)	0.1833	0.9715	1.1560	0.1845	0.0012+

These figures indicate sufficiently that there is no loss of boric acid by volatilization when its aqueous solution is evaporated in contact with calcium hydrate; but, inasmuch as the comparative solubility of the latter is the quality which makes it effective where magnesia is not, it seemed desirable to test the action of calcium hydrate in alcoholic solutions, in which it is very insoluble. The experiment showed that when the solution of boric acid in methyl or ethyl alcohol is put upon lime and distilled at once, loss is apt to take place, and sometimes to a very considerable amount, but that a short period of digestion with occasional stirring—from five to fifteen minutes—is sufficient to obviate danger of volatilization of boric acid.

It appears, therefore, that free boric acid being easily volatilized by means of methyl alcohol and fixed completely by calcium hydrate, the separation of the acid from almost everything with which it occurs ordinarily and its estimation subsequently depend only upon the practicability of distilling it from its compounds in such company that it may be retained by lime and its amount determined by the increase in the weight of the latter. Unlike magnesium chloride, calcium chloride does not yield its chlorine readily under the action of heat and moisture naturally retained; so that hydrochloric acid must not be present with boric acid which is to be estimated in the manner described. Calcium nitrate and calcium acetate both yield the oxide without difficulty upon ignition, and nitric and acetic acids are suitable agents, therefore, for the liberation of boric acid previous to distillation.

The actual distillation presented at first some difficulty—for the repeated, thorough, and rapid evaporation of a liquid charged with soluble or insoluble solid matter is apt to involve some mechanical transfer to



the distillate of material which should remain in the residue—but the device of the following description solves the problem successfully.

The apparatus, which is shown in the accompanying cut, consists essentially of a retort, condenser, and bath for heating. For the last I have used a paraffin bath, as being on the whole the most convenient. The condenser is set vertically, to facilitate changing the level of the retort within the bath, and to secure at the same time continual and thorough washing of the tube by its own condensations. The retort, somewhat like the well known drying tube of Liebig in general shape, is easily made of a pipette by bending the tube at one end to a right angle, at the other to a goose neck, as shown. To the former end is fitted, by a rubber stopper or section of tubing, a glass funnel tube provided with a stop cock. The end of the goose neck passes tightly through a rubber stopper in the upper end of the condensing tube. This is essentially the apparatus, but it is convenient to attach to receive the distillate a small Erlenmeyer flask, which moves with the condenser and is joined to it, in the manner indicated in the figure, by means of a thistle tube and a rubber stopper grooved to permit the free passage of air. In carrying out a distillation, the liquid to be distilled is introduced into the retort either by the funnel tube or previous to its insertion, the glass cock is closed, the water started through the condenser, and the retort lowered into the hot paraffin, care being taken to begin the operation with the retort not more than half full and so inclined that only the rear dips below the surface of the bath. If the precaution to heat the retort at the start in this manner be overlooked, it may sometimes happen that the sudden and violent expulsion of the air through the liquid will carry portions of it bodily into the goose neck, and even into the condenser. With this point considered, the remainder of the operation presents no difficulty, and requires little care.

The size of the retort may suited, of course, to the particular case in hand, but for most purposes a 200 cm. pipette makes a retort of convenient dimensions, neither too large for the distillation of small charges nor too small to permit the treatment of 100 cm. of liquid comfortably. The tube of the goose neck should be wide enough to prevent the formation of bubbles in it; 0.7 cm. is a good measure for the interior diameter. It is of advantage to heat the bath to a point considerably above the temperature at which the liquid which is to be distilled boils—something between 130° C. and 140° C. does very well for water, and is not too high for methyl alcohol—and under such circumstances, and when the retort is entirely submerged, it often happens that evaporation takes place with extreme rapidity

from the surface of the liquid in perfect quiet, without actual boiling.

With such an apparatus the following experiments were made. The boric acid was weighed, as before, in solution, and to bring the condition of the experiment to that of an actual analysis, 1 gramme of pure sodium hydrate was added in solution, nitric acid or acetic acid to acidity and a little more, and the whole was introduced into the retort and distilled to dryness.

In those experiments in which nitric acid was employed, the methyl alcohol was introduced upon the residue thus dried in six successive portions of 10 cm. each, and distilled to dryness; but in order to break up the residue of sodium nitrate, which by its insolubility might effect to some extent the protection of the boric acid from the action of the alcohol, 2 cm. of water were introduced and evaporated between the second and third, and again between the fourth and fifth distillations.

When acetic acid was made use of to free the boric acid, the six distillations with methyl alcohol were made as before; but, sodium acetate being soluble in methyl alcohol, the intermediate treatments with water were unnecessary. With the fourth portion of methyl alcohol a few drops of acetic acid were added to preserve the acidity of the residue, which, as has been pointed out, tends to become alkaline under the treatment.

The residues of both processes of treatment were found to be free from boric acid by the exceedingly delicate test with turmeric, care being taken in the series of experiments in which nitric acid was used to oxidize nitrites by means of bromine (expelling the latter before making the test), and in the acetic acid series to acidify with hydrochloric acid sufficiently to counteract the tendency of the acetate by itself to brown the turmeric on evaporation.

The lime to retain the boric acid in the distillate was ignited in the crucible in which the evaporation of the distillate was to be made subsequently, and then transferred to the receiving flask attached to the condenser, so that the boric acid might be fixed during the distillation. To prevent the caking of the lime by the action of the alcohol, it was slaked with a little water before the distillation was begun.

In experiments 13 to 16 nitric acid was employed, and in 17 to 20 acetic acid was used, with the precaution noted, to liberate the boric acid.

In experiments 13 to 16 the mean error amounts to 0.0012+ gramme; the experiments 17 to 20 the mean error is a little more than 0.0010+ gramme. Throughout the entire series of experiments the tendency to yield figures slightly larger than the truth is manifest,

	B ₂ O ₃ taken, Grm.	CaO taken, Grm.	B ₂ O ₃ +CaO found, Grm.	B ₂ O ₃ found, Grm.	Error, Grm.
(13)	0.1738	0.9647	1.1392	0.1745	0.0007+
(14)	0.1806	0.9639	1.1456	0.1817	0.0011+
(15)	0.1779	0.9665	1.1450	0.1785	0.0006+
(16)	0.1824	0.9739	1.1587	0.1848	0.0024+
(17)	0.1806	1.4559	1.6371	0.1812	0.0006+
(18)	0.1812	0.9720	1.1543	0.1823	0.0011+
(19)	0.1788	0.9986	1.1781	0.1795	0.0007+
(20)	0.1813	0.9527	1.1358	0.1831	0.0018+

but the error is quite within legitimate limits. The greatest care was taken to secure similarity of conditions under which the crucible and lime were weighed before and after the evaporation and absorption of boric acid, and the weight after ignition was taken in every case after cooling over sulphuric acid during a definite period of ten minutes, in order to eliminate as far as possible the effect of atmospheric condensation upon a large surface of platinum. Ignitions were always finished over the blast lamp, and constancy of weights secured.

The results of both modes of treatment are, on the whole, satisfactory, and equally so.

In the presence of chlorides, it is of course impossible to employ nitric acid to free the boric acid. Oxalic, citric, and tartaric acids also liberate hydrochloric acid to a considerable extent from alkaline chlorides. It was found, however, that when acetic acid was distilled over sodium and potassium chlorides, only traces of hydrochloric acid passed into the distillate, and experiments 21 to 23 were made to determine whether these amounts are sufficient to vitiate the separation of boric acid from alkaline chlorides by distillation in the presence of free acetic acid. The details of treatment were identical with those of experiments 17 to 20, excepting only the addition of 0.5 gramme of sodium chloride to each portion before distillation.

	B ₂ O ₃ taken, Grm.	CaO taken, Grm.	B ₂ O ₃ +CaO found, Grm.	B ₂ O ₃ found, Grm.	Error, Grm.
(21)	0.1834	0.9842	1.1675	0.1833	0.0001—
(22)	0.1831	0.9755	1.1593	0.1838	0.0007+
(23)	0.1761	0.9740	1.1523	0.1783	0.0022+

The mean error of these results is about 0.0009+ gramme, and it is plain that the presence of sodium chloride does not materially change the conditions of the experiment. There seems, therefore, to be no reason why boric acid may not be separated by distillation from alkaline chlorides in presence of free acetic acid; but it was found that the presence of any considerable amount of potassium acetate is disadvantageous. Sodium acetate to a reasonable amount does not interfere with the favorable progress of the separation; but potassium acetate appears to require a much higher temperature for the expulsion of its water, and longer distillation.

When, therefore, chlorides are present in the salts from which boric acid is to be removed by distillation, the choice is open between two methods. The distillation may be made directly with an excess of acetic acid; or the hydrochloric acid may be first removed by means of silver nitrate, and the distillation of the filtrate proceeded with at once, or after precipitation of the excess of silver salt by means of sodium hydrate or carbonate, care being taken to acidify again sufficiently with nitric acid after the removal of the silver. Of these two modes of proceeding, I incline to the treatment with nitric acid and the removal of the chlorine by precipitation; and this method has been used with success by others as well as myself, for some months, in the analysis of waters carrying boric acid and natural borates.

The process in either modification is fairly accurate and easily executed, and admits of very wide applica-

* Zeit. für Anal. Chem., i., 406.
† Rose, Pogg. Ann., lxxx., 362.

tion. Insoluble compounds in which the boric acid is to be determined may be dissolved in nitric acid at once, or, if necessary, first fused with sodium carbonate; and, fortunately, nearly everything which is volatile in the subsequent treatment and capable of forming with lime compounds not easily decomposable by heat may be removed by known processes. The combination of fluorine, silica, and boric acid is perhaps most difficult to treat; but the precipitation and removal of the first as calcium fluoride from the aqueous solution of a fusion in alkaline carbonate may, it is believed, be effected with care, and the mode of procedure from that point is simple.

The number of distillations necessary depends, of course, upon the amount of boric acid treated. To remove 0.2 gramme of boric anhydride completely to the distillate, six charges of methyl alcohol, of 10 cm. each, proved, as we have seen, to be ample.

The apparatus by the aid of which the distillation processes which have been described were carried out has found useful application in a number of other processes. In the determination of free and albumenoid ammonia in waters which can be boiled quietly with difficulty, in the methods of estimating hydrofluoric acid which involve the expulsion of silicon fluoride from

Through the kindness of Mr. Thos. Jones, superintendent, a portion of the commercial spelter was charged into one of the upper retorts of the furnace and redistilled at a less heat. Analysis of which gave:

Lead.....	0.0225
Silicon.....	0.0019
Iron.....	0.0121
Carbon.....	none.
Arsenic.....	none.
Sulphur.....	0.0006
Zinc, by diff.....	99.9629

It, therefore, appears that while other impurities are largely removed, the small amount of iron is scarcely diminished by redistillation from a fire clay retort with iron front, such as is usually employed in the Belgian process. This metal answers excellently for most of the laboratory processes in which zinc of high degree of purity is demanded.—*Amer. Chem. Jour.*

THE GREAT REFRACTOR OF THE VIENNA OBSERVATORY.

The successful application of photography to the representation of the starry heavens has awakened

Dublin, and cost in round numbers \$33,600. The entire instrument, including the protecting dome, etc., and exclusive of the foundation of masonry, cost about \$84,000.—*Illustrirte Zeitung.*

A CARD—CORRECTION OF ESTIMATE OF COST.

"Improved Methods of Heating Railway Trains," *SCIENTIFIC AMERICAN SUPPLEMENT*, April 9. By the inadvertency of a misplacement of the decimal point, the cost of heating a standard passenger car per hour was made to read 10¹⁰ cts.; the average price of coal per lb. is 0.00115 ct. per lb., and not 0.115 ct., and for 9¹/₈ lb. of coal consumed per hour per car, it would amount to 0.01073 ct., or one cent per hour per car, which is the correct result. The error was discovered after the edition had gone to press, too late for correction. The mistake was made by the writer, and not by the printer.—

C. POWELL KARR, C.E.

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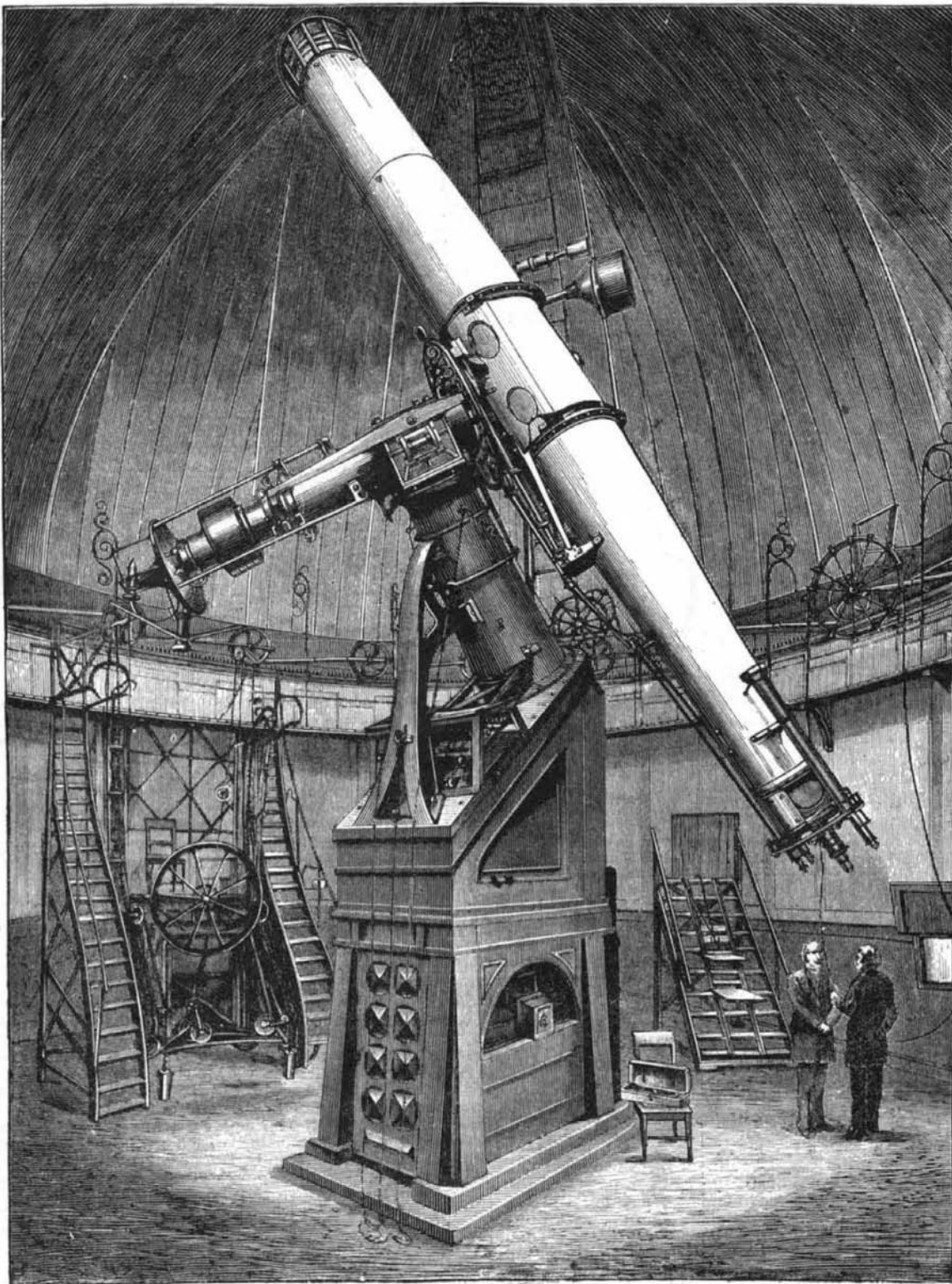
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THE GREAT REFRACTOR OF THE VIENNA OBSERVATORY.

a mixture of the fluoride with sulphuric acid and silica, in the separation of iodine from bromides and chlorides by distilling with ferric sulphate and sulphuric acid, and of bromine from chlorides by means of permanganic acid, it has proved of value, and will doubtless be found convenient in many analytical processes in which quantitative separations by the distillation of liquids liable to spatter or boil explosively are involved.

ANALYSIS OF "PURE ZINC" MADE BY THE BERTHA ZINC COMPANY, PULASKI COUNTY, VIRGINIA.

By G. B. BIRD.

THE above mentioned company manufactures from ore, essentially calamine, an excellent grade of zinc, which afforded on analysis (by F. P. D., in 1881) the following:

Lead.....	0.0500
Silicon.....	0.0168
Iron.....	0.0140
Carbon.....	0.0580
Arsenic.....	0.0001
Sulphur.....	
Zinc, by diff.....	99.8611

universal interest in the work of astronomers, and we believe, therefore, that we comply with the wishes of many when we illustrate one of those immense telescopes which enable astronomers to explore the vast distances of the universe from which light reaches us after a journey of thousands or even millions of years.

Until lately the gigantic telescope in the Vienna observatory was the largest in the world, for it surpassed in size even the Washington refractor, in comparison with which all other telescopes had seemed like dwarfs, but it did not enjoy this reputation long, for the construction of the Vienna telescope seemed to call forth a universal competition for the possession of the largest instrument, and several observatories ordered telescopes of dimensions equal to or larger than the one in Vienna. The diameter of the lens in the Vienna instrument is 27 inches, of that in the telescope at Pulkowa (near St. Petersburg) 30 inches, and of the lens in the refractor in the Lick Observatory, California, 36 inches.

As the accompanying cut may not give a correct idea of the proportions of the Vienna telescope, we will give the following figures: The length of the tube is about 36 ft., and, with its movable axis and counterweights, it weighs about 10,000 lb. The entire instrument, with its cast iron base, weighs more than 36,000 lb.

This telescope was constructed by Howard Grubb, of