The advantage of the pipe columns in warm climates is very great, the yield of acid per chamber space being largely increased, thirty to forty-five per cent., according to the number of pipe columns used. The yield of acid per quota of sulphur is also increased, and a saving of nitre is effected. These towers being made of lead, are not very expensive, so are likely to become adjuncts to many chambers, especially as they can be added to existing plants.

Since this paper was written, I have planned two new acid plants, saving chamber space by means of the foregoing device; these two plants are now under course of construction.

CHARLESTON, S. C.

THE EDUCATION OF INDUSTRIAL CHEMISTS.[1]

BY HENRY PEMBERTON, JR.

SOME years ago a chemical firm in one of our eastern cities was desirous of obtaining the services of a chemist, who should take charge of the factory. Accordingly, advertisements were inserted in the industrial journals, for a man who should not only be familiar with the analytical work necessary, but who could also assume the responsibility of overseeing the plant, checking the running of the various processes, and meeting the emergencies that are constantly arising in operations of this kind.

A large number of answers were received. Interviews were requested with those who, from their letters, appeared to be the most likely to suit. But as a result, it soon appeared that the securing of a competent man was by no means an easy matter. Some of the applicants, whose letters were most assuring, turned out to have been simply laboratory boys. Others, more promising, were of foreign birth, but unfamiliar with the language and customs of this country. Some were undesirable on account of their personal manner or character. But, by far the most general objection, was that the knowledge and experience of these chemists were limited to the field of analytical chemistry, and to the work of the laboratory. They were entirely familiar with the handling of beaker glasses and funnels, plati-

[1] Read before the Worlds' Congress of Chemists, August 26, 1893.

num crucibles, analytical balances, burettes, and flasks. But in the matter of treating material *in large quantities*, and obtaining results in the factory, they came up, as it were, against a stone wall. Many of them, in fact, were literally as unfamiliar with the operations of a chemical plant as they were with the working of an astronomical observatory.

It should be observed that the case here described, is by no means an isolated one. There is reason to believe that there is hardly a large chemical manufacturer in the country who, at one time or other in his life, has not had experiences of a nature similar to this one.

It will be admitted that the question of technical education is a most important one. It deserves at least as much attention in the United States as it does elsewhere, on account of the remarkable progress and development of industrial activity here. It will be shown in the forthcoming report of the United States Census of Manufactures, that the chemical industry has experienced a more diversified and extended growth than is peculiar to any other branch of productive industry in this country. Owing to the richness of our resources (which we have always enjoyed), and owing especially to the beneficent effects of a high tariff (which we have enjoyed for three decades) the capital invested, the wages paid, and the value of the chemicals and allied products manufactured, represent in the aggregate a degree of prosperity that is most flattering.

It is for this important field then, that the universities and technological schools of the country, prepare their young men. And it is because the quality of this technical talent is so frequently below what is called for, that I venture to draw attention to certain considerations on the subject, that may be of interest.

The method of teaching applied chemistry as now generally practiced consists in describing, in a series of lectures, the manufacture of so many of the various acids, bases, and salts as the professor can find time to present. Sometimes certain industry groups are selected, such as soda chemicals, explosives, dye extracts, coal tar products, and so on. But it is evident, on account of the endless array of chemical products, that it is impossible to cover the ground in any but the most superficial manner. It is also an even chance whether the student will ever afterwards be engaged in any of the few industries thus outlined by him in his lecture note book.

It should again be stated that the usual method of instruction consists in describing the manufacture of certain *products*: the preparation of this salt, of that acid, or of that dye. It is invariably upon a series of such products that the classification of the lectures is based, and it is because the name of these chemicals is legion that the instruction must necessarily be incomplete and the knowledge gained vague and indefinite. While such instruction is, of course, better than none, and indeed should still be continued, it should be relegated to the position in the curriculum to which it properly belongs, as being a part of the course in general chemistry adapted to all chemical students, but should not be the only groundwork for the training of the future technologist.

What is it that such a young man sees on entering one of our large chemical factories? He observes, on all sides of him, apparatus and machinery for grinding material, for elevating and transporting it. He sees materials under treatment in various ways, and at all stages. He notices that in one building or department such and such operations are performed—it may be the solution of some article here, the filtration and washing there. Here he sees the processes of evaporation, or it may be of crystallization or perhaps of distillation and condensation. Elsewhere he observes a series of calcining furnaces. In another part of the works are the drying rooms. Many other processes he notices in full operation, the object of which, and perhaps of the very name of which, he is ignorant. The thought that is likely to be deeply impressed upon his mind is—"Why was I taught nothing of this in college?" His mortification is apt to be all the greater when he perceives the number of workmen about him who understand it all. There are foremen, heads of departments, machinists, carpenters, and others, no one of whom, perhaps can write a letter correctly, and yet all experts in their several lines; while he, a university graduate, has not even been taught the use of the tools of his trade.

It is evident that some system of instruction is necessary that is essentially different from that now in vogue. And it is the object of this paper to outline such a plan, which, it may be stated at once, *consists in the teaching, not of products, but of processes, and in directing the attention not so much to the chemical, as to the apparatus.* The subject can be discussed most clearly by presenting it under three headings: The lectures, the practical work, and the text book.

The Lectures.—Prof. Tyndall once observed that a man who had thoroughly mastered a scientific principle was in possession of a key that would open many locks. A somewhat similar idea is here applicable; the important point being to place the learner in possession of the knowledge of one particular class of operations at a time, and to make that knowledge comprehensible and thorough, so that its application to any variety of purposes may be possible.

For example, let a series of lectures be given upon the reduction of materials to a fine state of division. The many kinds of crushers, chasers, mills, disintegrators, and beaters should be described, especial attention being given to explaining the peculiar adaptability of each kind of such machinery to the physical properties of the substances to be treated. A thorough description of the practical working points of each type of mill should be laid before the student. In the case of an ordinary pair of forty-eight inch buhrstones for example, he would be taught such facts as the average horse power required to drive them, the usual output of the mill per hour, the speed at which it runs, the dress of the stones, and the different qualities of materials from which they are made. The use of screens and bolting cloths would be touched upon, as well as the methods of handling the tailings. Some mills he would observe are capable of yielding a product large in quantity, but coarse in quality, while others can be used only under conditions exactly the reverse. Some forms of apparatus like the disintegrator, can treat a damp or plastic material, such as a superphosphate or sulphate of alumina, while others will handle dry and brittle substances, only, to advantage.

An understanding of the essential principle upon which each of these forms of apparatus works would thus be obtained by the student, who would be able to apply the information, it may be years afterwards, in some distant fertilizing factory in Georgia, or in some remote refining works in the far West.

Continuing the same line of thought another series of lectures would be given upon filtration, frequently one of the most difficult of technical processes. It could be shown how a coarse open substance (like black ash for instance) can be washed in masses of considerable depth, while others, of a closer or denser nature, like lime-mud, or calcium sulphate, must be handled in what, to the tyro, would appear to be amazingly thin and extended surfaces. It would be pointed out how some substances, like gelatinous hydrate of alumina or precipitated ferric hydrate, cannot be filtered at all, practically, on a large scale, but must be washed by decantation. The construction of filters, the selection of proper materials for the filter bed, the application of a vacuum, the handling of the different wash waters, the use of filter presses, and of centrifugals, all of these matters would be discussed in sequence. This would form a scientific classification of the subject that would be valuable to the student, enabling him to apply the information to the preparation of any kind of chemicals, let them be fine pharmaceutical preparations, or heavy bulky goods that are made in large quantities.

The methods of evaporation of liquids could next be studied, describing the plant necessary for underheating, for surface heating, and for coil evaporation. The treatment of solutions with gases, the methods of uniformly mixing solids with liquids, the erection and use of reverberatory furnaces, the transportation of solids by elevators, conveyors, belts or link chains, the lifting of liquids, acid or alkaline, by pumps, injectors, or compressed air; in a word, all the important processes in use in chemical engineering would each, in turn, form the subject of a series of lectures.

In teaching applied chemistry in this manner the important point gained is that the learner's mind is occupied by one class of subjects, or processes at a time, thus giving him a practical knowledge of each important department of manufacturing chemistry, *entirely irrespective of what kind of goods are produced.* This is in sharp contrast to the present systems, in which his mind is bewildered by the numerous details involved in the description of a heterogeneous series of chemicals. He perceives that the forms of apparatus in use in the factory are simply so many tools, the construction and use of which he must learn in order to obtain results, and that when equipped therewith he is "in possession of a key that will open many locks."

The Practical Work.—The study of analytical chemistry, although an excellent training for the mind, has one element of weakness: the learner is taught to depend entirely upon authority. He is obliged to follow out, to the very letter, the methods prescribed in the text book. As a result, he necessarily foregoes any attempt at original work, and as a specialist in analytical chemistry is frequently (in fact almost always), incapable of supervising any work other than that of the laboratory.

The remedy for this is to catch the chemist when he is young, and introduce him to the methods used on the large scale. It is seldom possible to obtain for a student the entrée to a chemical works. Such a request is generally declined without thanks. And as the chemical works cannot be brought into the college, it remains that there be established there certain methods of work requiring the same processes of reasoning and the same methods of attacking the problems that are in use in the actual factory.

The important facts so far as *apparatus* is concerned, can be obtained from the lectures, and still more fully from the text book. But in regard to the methods of working, valuable information can be had from synthetic experiments of the simplest nature. And it is in such investigations that the student should be well drilled. As an example of the points that can be illustrated in this manner, let a student be required to make, for instance, some copperas, for which purpose he may be furnished with a few ounces of iron nails, some oil of vitriol, a number of large dishes and a funnel. He determines the strength of the acid, using both Twaddle's and Beaumé's hydrometers, thus learning the use of these instruments. Converting this into specific gravity he obtains from the tables the percentage of actual SO_3 in the acid, and from that the volume of vitriol required for the given weight of iron. He next calculates the quantity of water necessary to supply the water of crystallization of the salt, as well as that required to hold it in solution, and by this means becomes familiar with the use of tables of solubilities. After solution of the iron and filtration, he measures the total bulk of the liquid, which is then evaporated to the crystallizing point, and again measured. The conditions most favorable to crystallization are now studied, the weight of crystals obtained and the percentage yield as compared with that of theory, computed. Analysis of the mother liquor will check this, and will familiarize him with the method of calculating milligrams per cubic centimeter into pounds per cubic foot.

He is now in position to estimate the size of the vessels necessary to treat a batch of say 1,000 pounds of iron, and can, on paper, erect a dissolving tub, filter, evaporating tank, and crystallizer, all of the proper shape and proportion. The best thickness of lead for lining these tanks can be determined, its weight calculated and also its cost. Assuming a price for the iron and vitriol, the cost of these ingredients per ton of crystal can easily be figured out. And all of this from a bottle of acid and a few ounces of iron nails.

This little example is given merely as an illustration of what kind of work can be done. It can of course be varied in many ways and with many materials. It matters not a particle upon what salt or preparation the student is put to work. As a matter of fact the above example would never be put into practice on the large scale, since copperas is nearly always produced as a by-product from other operations, or is made by the weathering of marcasite.

But the training that he obtains will teach him the importance of observing the physical properties of substances in the various stages of treatment. By discovering the difficulties to be met he acquires the art *of making mistakes on the small scale.* The lack of such experience has undoubtedly been the cause of the loss of immense sums of money in many instances.

The Text Book.—To this entire subject of industrial education, as herein described, there is one objection that may be made, namely: What is to prevent such a series of lectures becoming antiquated and out of date in the course of a few years? The answer is to be found in the literature of the subject. How many text books on qualitative analysis are there in existence? As every chemist knows, they are numbered by the score, if not by the hundred. In what important particular does any one of these text books differ from the others? What new fact does it contain? If, now, a subject so utterly thrashed out as qualitative chemical analysis can thus be again and again discussed, what is to prevent the establishment of a series of treatises on chemical technology, by which the whole subject can be brought under control and properly classified? It is important to note that such treatment of the subject would of necessity be *cumulative*. The experience of one writer would thus be collected and embodied in the treatise of another. The weak points of one text book would be made good in its successor, or in the second edition. The mere fact that no such treatises are in nse to-day is precisely the most imperative reason why they should be introduced.

Such a manual would follow the methods indicated in the foregoing. Its object would be to describe not products, but processes, and it would be to the apparatus and methods of treatment that attention would be given. It is needless again to go over the ground previously covered, more than to say that each particular class of operations in use in a factory would be treated separately in its proper chapter. In other words, the book would supplement the lectures. The illustrations and plans to scale would describe actual working apparatus and the student would be taught how to handle precipitates and solutions by the ton, just as, in analytical work, he learns to manipulate them in quantities represented by the gram and cubic centimeter.

In addition to such a treatise, the student should be allowed the use of the various journals on chemical technology that are published in the English and German languages. To these should be added the trade journals, of which there are quite a number, and even such material as manufacturer's catalogues and illustrated price lists will be found to contain information of much value upon subjects relating to the supplies needed in all factories.

In conclusion it may be acknowledged that this plan of instruction is essentially a utilitarian one. This is in accordance with the general drift of the scientific education of to-day. To use Lord Bacon's expression the aim is to gather fruit, not flowers. The training of the mind will incidentally be one of the results of such a system. But the main object will be the imparting of actual knowledge and the teaching of specific facts. The manufacturing chemist who has to meet the difficulties that constantly arise in the practice of his profession is like a man who is lost in the Alps. What he wants, is not to improve his mind, but to find the way. The present system of instruction does not meet the requirements made upon it. It teaches the principles of the science but does not go far enough. As Macaulay said of the ancient philosophers, every trace of intellectual cultivation is there except a harvest. The subject of industrial chemistry evidently has not received the attention it deserves in our schools of science.

PHILADELPHIA, PA.

THE DETERMINATION OF CASEIN IN COWS' MILK.

BY L. L. VAN SLYKE.

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THE methods originally proposed by Hoppe-Seyler and Ritthausen have been commonly employed for the separation and determination of casein in cow's milk. In both methods, the milk is diluted with water and a small amount of acetic acid is added. The precipitation is rendered complete, in one case, by raising the temperature to 40° C., and, in the other case, by passing a current of carbon dioxide through the mixture at ordinary temperatures. The precipitate is filtered, washed first with water, and then with ether to remove fat and is finally dried and weighed on the filter. The absence of specific directions touching several steps of the operation led me to investigate some of the conditions pertaining to the determination of casein, among which were the following: