Every report should be so prepared both as to its English and its mechanical get-up, that it will appeal to, and be read by the busy man at once, and not be laid aside for the leisure hour which never comes.

Such a course as here outlined will never take the place of the instruction which must be obtained in a factory or works, and will not make a finished engineer; but it will contribute mightily toward giving that method of thought and work which produces the man "who knows what to do when there is something to be done."

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BOSTON, MASS.

POINTS OF VIEW IN THE TEACHING OF INDUSTRIAL CHEMISTRY.

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When Prof. Talbot's kind invitation to present a paper on some phase of the Teaching of Industrial Chemistry was accepted it was done with a frank statement that the author would not have time to give this presentation the careful thought which the subject merits. The real object, therefore, of the author of these words is to get acquainted with the point of view of those who are contributing to this meeting whether on the program or helping in the discussion. He is of course glad to contribute his mite if it can assist in any way toward the desired end. After a few preliminary remarks, therefore, attention will merely be called to a few points of view in the Teaching of Industrial Chemistry which have been found of service under the conditions among which the speaker finds himself.

In a discussion of the teaching of any subject there would probably be almost as many opinions expressed as there were teachers present. If this is true of any subject it must be peculiarly possible in the case of Industrial Chemistry because of the well known magnitude of the range of the application of chemistry to the industries. It seems that what differences of opinion may exist among teachers of this subject are largely due to the fact that individual experience has differed so much, the range of possible experience being so great.

In the Teaching of Industrial Chemistry as in probably every other subject the problem which presents itself to the teacher may be summed up in the two questions:

What shall I teach?

How shall I teach it?

Ignoring the first in the brief time at hand with the assumption that what is meant in our topic by Industrial Chemistry is the study of the manufacture of chemical substances or the manufacture of commercial products with the aid of chemical processes, the present remarks will be confined merely to a few points of view with reference to the How.

As a student your speaker had the opportunity of receiving a course of lectures on Industrial Chemistry based on the good old historic method of taking up a more or less general account of each of a series of chemical industries. After having been out in chemical manufacturing long enough to be made responsible for the running of one of the company's processes, distinct convictions were acquired as to what additional service might have been rendered by the course in Industrial Chemistry in addition to the *much* which had been so rendered.

Lecture Work.

This experience, therefore, gives the speaker, as a teacher, more to do than the mere presentation to his classes of a series of descriptions or facts concerning Industrial Chemistry which, valuable as they are, yet often appear as interesting to the student as a chapter of genealogies in the course of ordinary reading. If the industry and its vicissitudes are merely described, that is one method. If, however, each industry is taken up as an industrial problem upon which much work has been done, and still more must usually be done, then this study becomes a different matter. Then we are giving the student an attitude of mind, we are making him accustomed to habits of thought that will add much, indeed, to his industrial efficiency.

In our lecture work, therefore, let us state the industrial demand. Discuss the chemistry available and possible in connection with the case whether it be the utilization of a by-product or the supply of a commercial requirement. Then point out the reactions used and the reasons for their selection and the objections to those rejected. Then the details of the process usually employed may be discussed and as the difficulties are encountered it becomes at once apparent why so many inventions and improvements have been suggested in most cases, for it is these latter which so cloud the main issue of the industry in the mind of the student.

Then last, and probably most important of all, it is extremely helpful to the student to insist on his taking each industry and analyzing it with reference to the operations involved, as calcination, distillation, condensation, crystallization, etc. This gives him practice in just the sort of thing each keen industrial chemist intuitively does when he works out the problem of accomplishing a given industrial performance. For instance, it is expected of each student that he shall see that the manufacture of nitric acid consists, in the main, of a series of problems which may be classified under the operations of *distillation* and *condensation*. Under these two heads fall naturally the different forms of stills on the one hand and different inventions relating to condensers on the other. A little experience with this method of analyzing and broadly classifying the operations involved in a given industry not only simplifies more complicated industries but offers a simple way of linking up the engineering problems involved in the industry with the chemical ones.

It was the good which results from this method of study which was so sorely needed when your speaker came into his first industrial responsibility. There was utterly lacking the efficient mental classification of the whole galaxy of industries by the operations involved which this point of view would have afforded.

Laboratory Work.

With regard to the laboratory work in connection with the teaching of industrial chemistry your speaker must confess he was at first quite dubious of its value. It seems now, however, that this feeling was the result of inexperience. As a student he had not had such a course and when he began the teaching of Industrial Chemistry there was no accompanying laboratory work. It did not take long, however, after giving the subject serious consideration, to recognize the opportunity it affords of making the future industrial chemist more efficient. To be sure much labor was required, indeed much more than any one, who has never started laboratory work in this subject can even imagin. The selection of suitable problems to develop and illustrate specific ideas or points of view in the mind of the instructor and still be within the scope of feasibleness in a university laboratory is a surprisingly vexatious task.

Your speaker believes thoroughly in the principle that the student should be thrown as often as possible into association with the "tools of the trade." He should learn to know a filter press for instance like a book and if the time permits nothing further than familiarizing the student with the efficiencies of such machines, much has been accomplished. He believes just as firmly, however, that the mere knowledge of tools is not the highest end to be accomplished. This familiarity should be acquired almost as a mere incident to the solution of certain definit problems. Without taking up your time with specific illustrations, of which many probably suitable ones will present themselves from the experience of any manufacturing chemist, your speaker will merely emphasize the point of view of the *chemical part* of his industrial chemistry laboratory work at Ohio State University.

As far as the student is concerned the work is *industrial research.* As an incident in this point of view he is first made to study the cost to him of making a given laboratory preparation. After a thorough discussion of the factors which influenced this cost he has a more adequate foundation for studying industrial costs and is better able to appreciate many otherwise unintelligible variations in industrial operations. He now has obtained some familiarity with the greatest factor which will influence his decisions in all his future work.

The next step is to take up problems on the industrial utilization of wastes or production of materials in commercial demand. The idea is *constantly* before the student that he is *acquiring data* which will enable him to try out on an industrial scale any experiment or operation which he decides to be most promising. He soon realizes his inability to proceed at once with any experiment on a large scale with merely the information and assistance of even the most thorough fundamental chemical principles. This acquirement of a realization of the inadequateness of relying upon any mere theoretical information which he may have acquired in order to launch *at once* upon a works experiment is a big step toward starting him into some measure of industrial efficiency.

The student then very quickly gets the realization that it is *his* business to inform himself as thoroughly as posssible as to the assistance to be obtained from all theoretical and practical work which may have been done on his problem. This forces him into a diligent use of the library. When he emerges from his search of the literature he has usually found many things of importance to him. He always emerges, however, with the realization that much laboratory experimenting must be done before he can say definitly what size crystallizing tank to order, for instance, because he must determin in many cases for himself to what specific gravity the solution must be evaporated to give the most efficient crystallization. In fact he is astonished at the multitude of such points of *evident prime* importance to the success of the object in hand, which he must dig out for himself in the laboratory. He learns at once to be glad of all the assistance which solubility tables and abstract researches afford, especially after it has been pointed out to him that so-called pure research must not be expected to sound the depths which he may often require. Since its object is usually more general than his demands it often goes deepest where he least needs to penetrate. This serves to show him that he too must ever be a research man and be prepared to take up his work where pure science leaves off.

In the time allotted to such work as industrial chemistry the amount of work performed by the student is not great, but he has at least come to a realization of a number of things which cannot well help but increase his personal efficiency.

He has become acquainted with methods of attacking problems. He has acquired some familiarity, even if only to a limited extent, with the kind of thing he may expect to meet in manufacturing chemistry. He has become acquainted with the proper attitude toward his science and has obtained especially an appreciation of the potential value which may be stored up for him in all forms of scientific research, however abstract. He has come to see that the only gap between pure and applied science is the one caused by the fact that there have been too few laborers for the harvest. This respect for and appreciation of the work of others seems to your speaker to be often a stranger to the student of pure research if the remarks and criticisms one hears so constantly are any criterion.

Finally the student acquires from day to day the conviction that by diligent application to *all* his university work he is preparing himself for the grave responsibility which the acceptance of industrial service involves.

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THE USE OF THE BLUE PRINT IN THE TEACHING OF INDUSTRIAL CHEMISTRY.

BY FRANCIS C. FRARY.

In the teaching of industrial chemistry and similar subjects the problem of familiarizing the student with the machinery used in the chemical industries is one which must always be met. If we had an ideal textbook for such a subject, with a large number of clear, accurate illustrations, well described and showing the parts drawn to scale, the problem would be much simplified. But that is perhaps too much to ask, since the cost of such a work would be large and the number of copies sold per year would be small. Frequent revision would be necessary, and there would be nothing in it for the author. Since we have no such book, and no prospects of it for several years, we must meet the needs of the student in some other way.

The simplest and easiest way of doing this, from the instructor's point of view, is to refer the student to some book or journal in the library which gives the desired information. But most of the students will have so much else to do that they will scarcely glance at the article, if indeed they go so far as to look it up at all. Another method, very widely used, is for the instructor to sketch upon the blackboard, from his notes, the important parts of the machine under consideration, and give the student time to copy the sketch. The original drawing which the instructor selected to illustrate the apparatus may have been very fine, but it would usually be hard to identify it as the source of the sketch in the student's note-book. Much valuable time is thus wasted in giving the student a very inadequate idea of what he should know. And in most cases, after the sketch has reposed in his note-book for a year, he could not tell what it was all about.

Perhaps the chart method may be mentioned as the next step in advance. Here, at least, we have finished originals, full of detail, often in realistic colors and of large size, and the student may copy them to better advantage. But the lecturer has nothing else to do while the student is copying the chart, so he usually takes that time to explain to the class the details of construction and operation of the apparatus. If the student takes time to copy the drawing, he misses the explanation, and *vice versa*. And even if he does his best at the copying, the result is still likely to fail