energy which should be transformed into work escapes transformation simply because of the low terminal pressures of the engine at the lowest temperatures of its range. It is this loss which is sought to be reduced by the series-fluid engines and which, so far as the thermodynamic and the dynamic questions are concerned, may be actually saved in large degree. The uncertainty remaining is that regarding costs, safety and convenience.

Du Trembley, about two generations ago, built binary-vapor engines, with ether as the secondary fluid, for a line of transoceanic steamers and 'broke the world's records' for his time in economy of power-production; but the compound engine came in and his secondary fluid proved dangerously inflammable. He lost one of his ships, Randolph & Elder bettered his record and the matter dropped out of sight. Later, many inventors have gone through the same experience in one way or another. Ether, chloroform, alcohol, ammonia, carbon-disulphide and sulphur-dioxide, among other volatile substances, have been tried, usually with some apparent gain but never yet with permanent success.

Recently, however, Professor Josse, at Berlin, has again 'broken the world's record' in heat-engine operation by producing the horse-power with an expenditure of less than eight and a half pounds of moderately superheated steam per hour. The experiment has been made with the utmost care and repeated under varying conditions, until there can remain no doubt of the fact. He further states that the steam and sulphur-dioxide, binary-vapor system adopted by him can be constructed at no greater cost than the standard triple-expansion engine which it rivals, that, properly cared for, it is not subject to injury by corrosion as had been anticipated by engineers generally, and that it can be safely insured against loss or accident through leakage. If experience confirms this claim, this means that the long-sought utilization of the waste heat of the steam-engine may be practically accomplished.

Time and experience will confirm or refute these expectations and it is for time and experience to settle the ultimate questions of the engineer relative to cost, reliability, safety and *net* gain or loss by the substitution of the series-vapor engine for the compound, the single-fluid, series-engine.

R. H. THURSTON.

*WHAT ARE THE REQUIREMENTS OF A COURSE TO TRAIN MEN FOR WORK IN TECHNICAL CHEMISTRY.**

THE subject before us may be discussed in two parts; first, what sort of instruction in chemistry should be given to men who are to become technical chemists, and, second, what work in other subjects should be required? Our consideration of the question will perhaps be more definite if we have before us a list of the occupations followed by a number of young men who have received training of this sort.

During the past twelve years twenty-three men have graduated from the chemical course of the Rose Polytechnic Institute. These have been employed as follows: One is inspector of coke for a large steel company, three are chemists in iron or steel laboratories, two are assayers, two are teachers, three chemists in soap factories, two employed by a firm manufacturing liquid carbon dioxide, two are draftsmen, one is superintendent of a gas company, one chemist for a firm manufacturing photographic supplies, one chemist for a paint oil company, one chemist for an electrical company, one manager of the paint department for a wholesale

* Read at the meeting of the Indiana College Association, December 27, 1901, and also at the Philadelphia meeting of the American Chemical Society.

house, one chemist for a packing company, one chemist in a testing laboratory, and one in charge of the technical science department in a large library.

No doubt the list of graduates from other technical schools would show a similar, or even greater, variety of occupations. It is at once evident that it would have been impossible to fit these men for the specific occupations which they now follow. Only in very rare instances could the occupation be predicted before graduation. Work spent upon the details of technical processes would, in the large majority of cases, have had no direct practical value. When we consider the ever-broadening scope of the chemical knowledge of our time, and the time limits which are practically set for the student's work, we cannot doubt that time spent in laying broad and solid foundations will be much more useful than any great amount of time given to the details of industrial chemistry.

At the basis of all must come a thorough training in analytical chemistry, and especially in quantitative analysis. While I think that the laboratory work should begin with work in general chemistry and that should be followed by qualitative analysis, no very large amount of time should be given to either by students who are to become chemists. Fifteen hours a week for one half to two thirds of a school year should be sufficient. The work given in general chemistry should be directed toward the illustration of fundamental principles and instruction in accurate manipulation with varied forms of apparatus, rather than to a large amount of detailed demonstration of the properties of elements and compounds. Beyond a very limited amount of the latter kind of study, the attention of the student will weary and he will acquire the fatal habit of performing experiments as directed, writing descriptions in his note-book and straightway forgetting all about them. The same is even more true of some kinds of work often given in qualitative analysis. The greater length of time required for quantitative operations, and the comparative simplicity of the processes involved, are better suited for training the beginner in the accurate memory of detail which is so useful for the chemist.

In the selection of topics in quantitative analysis I heartily believe in beginning with pure salts, which give a rigorous test of the student's accuracy. After a limited number of such determinations, however, the student's work is best directed to the analysis of various commercial products, the object being to give as varied a training as possible and a knowledge of the most practical methods. In general, a reasonable economy of the student's time should be considered and long and tedious methads should not be used, especially when shorter methods give as good or better results. The determination of the principal constituents of iron and steel, determination of iron, copper, zinc and lead in ores, assaying for gold and silver, the determinations of sanitary water analysis, coal analysis, and gas analysis should be included for every student. One or more complex analyses, as a clay analysis or an analysis of a mineral water are also very desirable, and beyond this many special topics may be assigned to individual students. No hard and fast course should be laid down to be followed by all alike. At some point the quantitative work should be broken off and a few weeks given to inorganic preparations, and a few weeks, at some other point, to organic preparations. There should, of course, be lecture courses in general and organic chemistry and in the history and theories of chemistry. The lecture work in physical chemistry should be supplemented by laboratory work.

It is the custom, at all of our best technical schools, to require a thesis for graduation. This thesis should always be based on careful experimental work continued for some months. It should, if possible, contain some real addition to the world's knowledge. The student cannot be expected to select, independently, a suitable topic. Indeed, where the higher degree of Doctor of Philosophy is concerned, students rarely select their own subjects. The wish of the students as to the nature of the topic should, however, be consulted. Subjects pertaining to industrial chemistry are especially appropriate, but topics pertaining to the pure science are not to be excluded, and indeed are often to be preferred because of the broader and deeper insight which they give to the student. Every technical school should hold before itself not only the purpose of giving to its students a sound preparation for industrial pursuits, but it should also contribute constantly to the increase of knowledge in those fields with which it has to deal. The reflex influence of such ideals on the instruction given is of the greatest possible importance.

The second phase of our question pertains to the accessory studies which the chemist should have. There seems to be a very prevalent notion that a chemist needs very little mathematics. With the rapid development of physical chemistry and the application of that branch of chemistry to technical problems which is soon to come, if not already here, such a view is no longer tenable. Every chemist, and indeed every one dealing with physical science, should have, at least, a knowledge of the calculus. In physics, a thorough knowledge of fundamental principles should be given and especial attention should be devoted to the subject of electricity. The methods used by engineers in testing structural materials should be acquired by actual use of the instruments employed for the purpose. Free-hand and mechanical drawing are almost necessary and some work in machine design is very desirable. In language, a reading knowledge of German and French should be acquired and the knowledge should be practically used in connection with current chemical journals. Except for lack of time I should advocate some work in biology. But, while there are fields in industrial chemistry where some knowledge of biology is absolutely essential, and while all chemists should know something in a general way about bacteriology, room can scarcely be found for these subjects without displacing something of more vital importance. In conclusion, I would say that the accessory subjects, especially, should not be slighted by the student. If he becomes a chemist he will certainly learn a very great deal about chemistry after he leaves school, but much of this other knowledge he is far less likely to acquire afterwards, and very much of it he will find practically useful if it is at his command.

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SCIENTIFIC BOOKS.

Plane and Solid Geometry. By Arthur Schultze, Ph.D., and F. L. Sevenoak, A.M., M.D. The Macmillan Company, New York.

The results of geometrical teaching in England are rather disappointing, if we are to judge by the reports and criticisms that have appeared in educational journals and scientific reviews. The blame is laid entirely on the system adopted, which is Euclidean pure and simple, and from which the universities and other examining bodies are unwilling to depart. It is good to be conservative; but it is also easy to overdo it. "Surtout pas trop de zèle" was Talleyrand's famous injunction. It applies as well to conservatism in pedagogics as it does to conservatism in politics. Euclid's text was excellent in his