in its various grades, lard oils, tallow and tallow oils, etc., was improved if not by the chemist, at least with his coöperation. All the daily runs were checked up constantly in the laboratory until the quality of the products was worked up to a high standard. This same thing applies to all by-products as you know."

The work of the present-day chemist, chemical engineer or technologist in these industries in addition to analytical work for control of product and supplies, may be summed up as follows:

I—Waste prevention.

II—Improvement of existing methods and processes of operation.

III—Utilization or recovery of products in a more valuable form.

IV—Initiation of new processes.

V—Direction of industrial research and application of the results of the researches until placed on a commercial basis.

VI—Investigation of and putting on a commercial basis new industries and lines of activity allied and associated with the packing industry.

UNION STOCK YARDS, CHICAGO

CONTRIBUTIONS OF THE CHEMIST TO THE ELECTRO-CHEMICAL INDUSTRY

By W. S. LANDIS

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When I was first requested to say something about the relation of the chemist to the electrochemical industry I thought I was being handed one of Goldberg's Foolish Questions. The spontaneous answer that occurred to me—he has been the foundation and is at present the mainstay of the industry, however, on mature thought requires reconsideration, for while his present status is well provided for, we should pay some attention to the growing tendency of the industry to replace his services by other classes of engineers.

An analysis of the industry, directing our attention only to that part concerned with the production of compounds, in distinction to the branch concerned with the extraction of metals, shows it to be of comparatively recent origin, beginning largely with the installation of the Niagara power developments in 1896. Most of the men who founded the industry are still alive and occupying prominent positions in the operating departments of the present plants. No one seems to have cared about compiling their biographies, though an attempt was once made in the first volume of "Electrochemical Industry." For some reason only five Americans were included in the series before the work was abandoned. Of these five, three possessed special chemical training, and while the other two would be more properly classed as electrical engineers, they were men well versed in chemical principles and were closely associated with other well-known chemists. It is unfortunate that this series of biographies was so abruptly terminated, for it would have made this note of mine superfluous.

As before mentioned, the chemist played by far the most important part in the development of the industry, and to-day I estimate that he occupies over 90 per cent of the more prominent positions in the plants in the Niagara district, which I take as typical of the industry as a whole. He grew with the industry, and with a few exceptions where others have been brought in for office, sales, and executive positions as the plants enlarged, all the staffs are still predominated by men of essentially chemical training.

But among the younger men now taking their places in the Niagara plants one notes an increasing number of men with mechanical training. This seems to surprise many not directly informed as to the present status of the industry, for next to

the chemist it is not unnatural to suppose that the electrical engineer would closely press the chemist for place. It must, however, be remembered that the power companies maintain most highly organized electrical engineering staffs, which at all times are available for consultation, and many times force, I may add, almost unwelcome attention upon us when in our endeavor to push things we unbalance their circuits, or cause some other equally unintelligible trouble. It is thus seen that there is really no need for the chemical plants to carry highly specialized electrical departments. They have standardized their electrical equipment to forms of installation which demand little highly skilled attention. Most of them use low tension currents with simple distribution systems, and when the electrical equipment has once been properly installed there are very few electrical problems arising. They are much more concerned with the handling of solids, liquids and gases, the transportation and preliminary treatment of raw materials, the finishing of the product, than with their power departments, all of which emphasizes the fact that in the training of the newer electrochemists too much stress can be laid on complicated and involved alternating current theory at the expense of the elements of chemical engineering.

My experience in this field is not large, but I cannot help but remark my discouragement with many recent electrochemical graduates who seemingly are well informed about high tension electrical engineering, but cannot instal a simple pipe line for delivering a definite amount of gas or liquid under given conditions, and a conveyor system for moving a given tonnage of raw materials in some new and unheard of device. When they come into the industry they will probably find that the 10,000 volt circuits are already installed and need no further attention from the plant management, but they will meet every day with problems of moving materials faster and more cheaply, particularly as plants enlarge and efficiencies increase.

In my opinion, it is therefore necessary to the chemist, if he is to hold his own in the present development of the industry and not give way to the mechanical engineer, to familiarize himself with the advances of the industry along mechanical lines, preferably by leaving the narrow confines of the school laboratory and spending some of his time in the other departments of technical education. Analysts will always be in demand, for chemical control of the electrochemical industries is very rigid, and particularly in the field of electric furnace products is there an unlimited opportunity for highly trained analytical chemists.

The chemical engineer possessing a representative training need have no fear on first entering the industry of finding himself in foreign parts. At Niagara the sky is just as clouded with smoke as any similar chemical center in the vicinity of New York City, all of which goes to show that combustion, steam generation, heating, evaporating, crystallizing and other well-known chemical operations have not been completely replaced by electricity. The standardization of the electrical end of the plant can be assumed before his arrival, and the new agent electricity will be found a much more tractable reagent than many of the purely chemical ones he is familiar with. But this reagent rarely starts with a crude material as such, or turns out a ready finished product from the furnace or cell, and the chemical equipment used in the preparation and the finishing is the same old apparatus found in most other branches of the pure chemical industry.

My greatest regret is that the secrecy that is maintained about the electrochemical plants cannot be withdrawn just long enough to bring in the chemical faculties of our schools, so that in the formation of the courses designed to train men for this industry a proper balance of chemical, mechanical, and electrical work may be incorporated. The future of the chemist in the industry would then be assured, and not at the

expense, either, I desire to emphasize, of sacrificing that very essential of all mechanical training—fundamental general principles to specialized details.

NIAGARA FALLS, ONTARIO, CANADA

CONTRIBUTIONS OF THE CHEMIST TO THE EXPLOSIVES INDUSTRY

By CHARLES E. MUNROE

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The explosive industry is essentially a chemical industry and is most efficiently conducted under close chemical supervision. It is true that a large part of the explosives used or proposed for use in commerce are mixtures of various components, that variations in the proportions of the components or modifications of the physical conditions of the components, or of the product, may fit it better for certain of the multifarious uses to which explosives are put, and that this has given large opportunities for the exercise of empiric ingenuity which practically controlled the industry for centuries; but modern developments have proven that these mixtures can be most economically, uniformly and satisfactorily produced when their manufacture is supervised by skilled chemists who prove the degree of purity of each ingredient and, by a systematic scientific series of tests, determine quantitatively the characteristics of the product.

As a fact, while the empiricist has dominated the industry up to recent times he has nevertheless benefited from the altruistic services of the chemist, for gunpowder, the mixture which almost alone served man's purpose as an explosive through five centuries, was brought to the attention of western nations by Roger Bacon, whom E. von Meyer includes as an alchemist in his history of chemistry, and it was brought to a higher state of usefulness and reliability through the researches of Lavoisier, Berthollet, Gay Lussac, Violette, Chevreul, Bunsen, Linck, Karoyli, Debus, and other chemists, and a variation in the oxidizer was wrought when Berthollet proposed in 1785 the substitution of a chlorate for the nitrate.

With the discovery of picric acid by Woulfe in London in 1771, its confirmation by Hausmann in 1788, its identification

as trinitrophenol by Laurent in 1843 and the demonstration of its explosiveness *per se* by Sprengel in 1873 began the era of strictly chemical explosives. This was followed in 1800 by the discovery of mercuric fulminate by Howard, and the elaborate investigations of the fulminates by Liebig and his students; by the discovery of guncotton and the cellulose nitrates in 1845 by Schönbein and in 1846 by Böttger; by the discovery of nitroglycerin by Sobrero in 1846; by the discovery of diazo compounds by Griess in 1858; and by the discovery of hydro-nitric or triazoic acid and its salts by Curtius in 1890.

With the demonstration by Berthelot of the explosiveness of other nitrosubstitution compounds than picric acid there came a widely extended and constantly increasing use for them; and the number of different compounds made use of is constantly growing for while the cellulose nitrates, with nitroglycerine, are playing the rôle of propellants, the nitrosubstitution compounds are the explosives which are being made use of in the high explosives shell now working such devastation in the present war.

I believe I have said enough to make it obvious that only by the liberal employment of trained chemists can this industry be continued or extended, and in recent years this view has been accepted and followed by manufacturers.

It may be worth while to recall here that when the Census of the Chemical Industries was taken in 1900 an inquiry was made as to the number of chemists employed, because it was then recognized that this afforded a criterion by which to determine the intelligence and foresight with which the businesses were conducted. As shown in Bulletin No. 210 of that Census there was reported but 276 chemists employed in 1740 establishments then reporting, and that but 32 chemists were employed in the 97 explosives works from which returns were secured. It is not known what effect, if any, this inquiry had but it is understood that at present a single explosives company in the United States employs alone many times this number of chemists. This improvement is gratifying to record but it should serve only as an example to be emulated.

WASHINGTON, D. C.

ORIGINAL PAPERS

THERMAL REACTIONS OF PETROLEUM HYDROCARBONS IN THE VAPOR PHASE¹

By WALTER F. RITTMAN

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One of the most widely studied and important chemical problems of the present day is the thermal decomposition or "cracking" of petroleum hydrocarbons. A considerable number of investigations have been undertaken along this line, most of which were conducted with the primary intention of developing commercial processes. The data thus obtained have been necessarily of a rather special character and, in addition, are not particularly available to the scientific world. In view of the widespread need for clear-cut and comprehensive information concerning the "cracking" reaction a series of experiments has been outlined for the purpose of studying the problem consistently and impartially in all its phases.

The first experiments² were conducted in connection with the problem of oil-gas production and were limited to such conditions as might apply in that

field. Attention was given to the influences of temperature, pressure and concentration on the end products of the reaction, a maximum of care being bestowed upon the properties of the evolved gases. Liquid products were examined only with regard to general physical and chemical properties.

In the present experiments it has been found unnecessary to give more than a minimum of attention to quantitative relations among gaseous products. The results of the earlier experiments were so definite and so exactly in accord with theoretical considerations that little has been added to them in the present connection. It has been possible, however, to learn facts of the greatest importance concerning liquid products of the cracking reaction and, in addition, valuable information has been obtained regarding the course and mechanism of the process.

The results at hand have led to the following conclusions with regard to the cracking reaction:

1—The nature, both physical and chemical, of an oil is of secondary importance, compared with the influence of temperature, time, and pressure, in controlling the products of the cracking reaction. Under

¹ Published with the permission of the Director of the Bureau of Mines.

² Whitaker and Rittman, *THIS JOURNAL*, 6 (1914), 383 and 472.