phenomena of the Triassic. Before the meeting a more extended trip was taken by a good sized company. Professor Wm. H. Hobbs guided them through the interesting metamorphic region of the Berkshire Hills. They were met at Pittsfield by Professor Emerson, who took them to Chester, Bernardston, Turner's Falls, and other points of interest in the Connecticut Valley.

On the whole the meeting was an interesting and well attended one, but, as in previous summers, the fellows of the Geological Society to a very great extent returned to their homes on its conclusion. The meetings of Section E of the American Association are thereby crippled, and the question was raised in the minds of not a few, who have the interests of Section E likewise at heart, whether it is on the whole wise for the Geological Society to hold other than a business meeting, in the summer, for which there would always be a sufficient number of fellows on account of the meetings of the American Association. It is also a question whether it is wisest for the American Association to have for its meetings a week broken by Saturday and Sunday. The temptation for members to go to their homes on Saturday is well-nigh irresistible and comparatively few return. As a result the final sessions have few attendants and the available candidates for sectional officers who are actually present on the day of election are few. A session beginning Tuesday and closing Saturday would have many advantages.

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*THE RELATIONS OF THE INDUSTRIES TO THE ADVANCEMENT OF CHEMICAL SCIENCE.**

WE justly congratulate ourselves that development and progress in chemistry, both in science and technology, have been more rapid in the past three decades than ever before, and that as much has been accomplished in this period as in all the years preceding since reactions have been known and applied. New elements, new compounds, new theories and new laws have followed each other in the manifold directions with such enormous rapidity that few have been able to keep informed of all, and most of us of only a few, of the discoveries and generalizations that have been made. It is for the purpose of exchanging information on these subjects that we come together at the present time, and it has been the custom of the Chairman to discuss one or another of these lines of progress, setting forth the most important of what has been developed in the more recent times. In many of the discussions and addresses on similar occasions by those more or less closely allied with or engaged in the study of so-called pure chemistry, much has been said of the practical value of the results obtained in the scientific laboratories devoted to research, and the uses they have found in daily life. No one has arisen to question the truth of what has been said, nor could it be questioned, for the men who have been working with the most unselfish devotion to the pursuit of truth for truth's sake, and with little hope of reward for the service they have rendered, have acquired and disseminated a store of knowledge which has added so largely to the capacity of all men for work that only the most grateful acknowledgments may be offered. While all this may be accepted, it is seldom that anything is heard regarding the reciprocal influence of the industries and the ordinary occupations of daily life upon the development or advancement of chemical science, and it has seemed that, in this period of relaxation, it would be well to stop and consider what are the relations of the industries to the science from the other

*An address before the American Association for the Advancement of Science, August 29, 1895, by the Vice-President, Section C.

side of the question, and what aid has come from the former to the latter to promote its advancement, if, indeed, any distinction can be made so far as the additions to human knowledge are concerned. For science is cosmopolitan, as it were, and omnivorous, and facts from whatever source, and of whatever kind, are greedily absorbed to form a part of the grand structure of human knowledge, whether they come from efforts made at leisure and in the quiet of the study or private laboratory, or whether they are developed in the struggle for existence and the daily bread.

In its earlier development, substantially beginning with the present century, chemistry was the newest of the physical sciences. It grew up out of the empiricism of the preceding centuries and had its foundation in the facts to be found in the daily practice of those engaged in the endeavor to meet the demands of the current needs. As civilization progresses, culture extends, demands consequently grow, and it is one of the inevitable laws of sociology and political economy, as of nature, that these demands shall be met. To meet them human ingenuity must be taxed for the determination of methods and means; and whether it be to secure immediately useful results or to establish more abstract truths, intellectual endeavor is required, knowledge must be increased and science therefore advanced. Literature is filled with description of the service which the science of chemistry has rendered to the industries and the commercial world, and the development of the tar color industry is the favorite example of this so frequently cited. History, so far as it is written, for the most part deals with the subject from this standpoint. But it may properly be questioned whether the industry was wholly the outcome of scientific research or whether science received much, at least, of its inspiration, its suggestion, its original material from the industry already developed in an intensely empirical way. It is this side of the question that will occupy us at the present time, and we shall endeavor to call attention to some of the influences which operate from one side or the other to bring about the results indicated and to the reciprocal influences which flow from the results themselves.

The true fundamental principles of the science were not developed and set forth through the classic researches and deductions of the great leaders, Dalton, Priestley, Cavendish, Black, Wenzel, Richter, Lavoisier, Gay Lussac, Avogadro, Dulong and Petit until the close of the last and the earlier years of the present century. But even before the beginning of the last century the rapid progress of civilization and culture in other lines had made demands for the products of the chemical arts, and they were met in ways that were empirical it is true, but by reactions which were as positive then as they are now, even though they were unknown, and they furnished fertile food for study and speculation on the part of the philosophers in fields quite new to them, led them out from the libraries of the monasteries to the active work of the busy world, furnished them with facts for collaboration and classification, from which they were amply able to construct the hypotheses and build up the theories which have been of so much value to the civilized world. During the entire century the industries thrived and grew, met the demands put upon them and brought about the establishment of facts that long since were recorded as new discoveries.

The acknowledged fathers of the science of chemistry, although eminent scholars and connected with the institutions of learning, were many, if not most of them, directly interested in the manufacture of chemical products, and by their general education and higher intelligence were enabled to contribute to their material advancement. At the period in which these men lived and worked, these industries could with difficulty meet the demands of the advancing civilization, and that they were profitable then, even as they were later, we learn from the experience and writings of Chaptal,* who was turned from the profession of teaching to establish at Montpellier, as he tells us, large works for the manufacture of sulphuric, nitric, muriatic and oxalic acids, alum, copperas, sal ammoniac, sal saturn, white lead and the preparations of lead, mercury, etc. He declares that he had made 'mountains of alum without being able to crystalize it,' until he had, through the analysis of Roman alum, determined the presence of potash in the crystallized product. And in order that he might have proper apparatus for his works he undertook the manufacture of the porcelain and pottery he required. A little later he became interested in dyeing and calico printing in a commercial way. How profitable this manufacture was may be gathered from the fact that after the political reverses which brought about his deposition from the public life in Paris which had consumed his entire fortune, he returned to his manufacture at Montpellier and in a single year realized from it a handsome net profit of 350,000 francs. He further relates that, encouraged by his success, other chemists of France established large manufacturing works and entered into their management. He was closely associated with Lavoisier, Berthelot, Monge, Fourcroy, Carny, Vandermonde, Guyton de Morveau and others in the manufacture of gunpowder near Paris, and his memoirs show that during his residence at Montpellier he was in constant correspondence with the chemists of Paris and elsewhere. Dubrunfaut† states that at the instigation of the Comptroller-General, Turgot, the Academy of Sciences of Paris offered a prize in 1776 for the invention of a method for the production of niter and that Stahl and Lavoisier did not disdain to take an interest in the subject of the prize. It amounted to £3000 and was awarded to Thouvenel, who was required, we are told, to justify experimentally the theory of Lavoisier. At that time Lavoisier was director of the Royal Saltpeter Works. Berthollet* was interested in bleaching and dyeing, suggested the use of chlorine for the former and in 1791 published a work entitled 'Elements of the Art of Dyeing.' Guyton de Morveau† was devoted to analytical and technical chemistry, and among other things he founded saltpeter works in 1773 and soda works in 1783.

Much of the work, therefore, not only of Chaptal but of other chemists of his time, was doubtless done in response to demands made upon them by the exigencies of the manufactures, but how many of the results they communicated to the journals and learned societies flowed directly therefrom we are not told. Certainly they could not have failed to study closely the phenomena thus offered for their observation and which in many respects could not have been as efficiently exhibited in any other way.

So also, as we are told by Meyer‡ and other historians, the earlier contributors to the new science, Boyle, Kunkel, Bergmann, Scheele, Margraff, Macquer, Duhamel and others, were largely devoted to the development of certain chemical processes in the industries. With all these men, the other great leaders of the science were closely associated; the problems constantly arising and the results obtained in their solution were doubtless subjects of frequent dis-

* La Vie et l'Oeuvre de Chaptal. p. 31.

† Le Sucre. II., 95, note.

* Schaedler, Handwörterbuch der wissenschaftlich bedeutenden Chemiker.

† Schaedler, Handwörterbuch der wissenschaftlich bedeutenden Chemiker.

‡ Geschichte der Chemie, Zweite Auflage, 1895.

cussion and led them to profitable study regarding them and the fundamental and natural laws upon which they were based. And what was true of that earlier period of the history is true to-day and to an increasing degree must find illustration in future work. The industries are still pushing forward with earnest competition to supply the demands which grow with the years, and the hard questions which come from managers and proprietors to professional men are as numerous and as difficult in their way as those which puzzled the early philosophers and stimulate an earnestness in endeavor and investigation that brings the highest and most useful results. We must admit that without these hard questions the advances in the science itself would be less rapid and the intellectual activities of investigators less alert.

Beautiful illustrations growing out of such demands are everywhere to be seen at the present day even as they were in former years, although they are not often to be found recorded in the pages of published history. Many of us will remember the incident cited by Hoffmann* in his necrological notice of Dumas describing the circumstances which led to the discovery of the absorption of chlorine by organic bodies, in which he declares that it "is not generally known that the theory of substitution owes its source to a soirée in the Tuileries." Dumas has been called upon by his father-in-law, Alexander Brogniart, who was director in the Sèvres Porcelain Works, and, as Hoffmann says, in a measure a member of the royal household, to examine into the cause of the irritating vapors from candles burned in the ball room, a demand to which Dumas readily acceded, because he had already done some work upon the examination of wax which could not be bleached and was therefore unmerchantable. He was readily led to the conclusion that the candles used in the palace had been made with wax which had been bleached with chlorine and that the vapors were hydrochloric acid generated in the burning of the candles. But examination of the wax of the candles showed that the quantity of chlorine found was greater than could be accounted for by its presence as a mechanical impurity, and from it Dumas was led to experiments which showed that many organic substances when heated with chlorine have the power to fix it, and from these results he was in turn led to the further generalization concerning the law of substitution. In this connection Hoffmann says: "This information upon the origin of substitution, which the author of this sketch had from the mouth of Dumas himself, is more than an interesting incident. We frequently see that like the Luxembourg palace, the Tuileries, besides their historical legends, have likewise scientific memories. How wonderful! A ray of sunlight reflected from the window of the Luxembourg, and accidentally seen by Malus through a plate of calcspar, revealed to him the phenomenon of double refraction, adding a new province to the domain of physics; while the acid vapors from a smoking burning candle in the ball room of the Tuileries led Dumas to study the influence of chlorine upon organic bodies, and finally led him to speculation upon this action, which for many years had controlled the science and even to-day has a mighty influence upon its development."

*Berichte der Deutschen Chemischen Gesellschaft. 17 R. 667.

It would be difficult to follow Dumas through the hundreds of investigations he made in all the fields of chemical activity, clearing up the the questions arising in the various occupations of daily life and in all its departments, even as it would that of other men active in progressive work. Much of the work of Dumas, as shown by Hoffmann and the published records, was devoted to the solution of such questions, and much of his inspiration was drawn from them. It was an incident similar to that already described that brought Dumas to the reaction whereby hydrogen sulphide may be oxidized to sulphuric acid. He found the walls of one of the bath rooms at Aix les Bains covered with crystals of calcium sulphate, which could have no other source than the vapors liberated from the hot water. No trace of sulphuric acid could be found in the atmosphere of the room. The portières of the room soon acquired an acid reaction, which proved to be due to sulphuric acid. Dumas concluded that the combination of hydrogen sulphide with oxygen had occurred upon the wall itself, the porous surface exercising an influence similar to that of platinum black upon hydrogen and oxygen. A subsequent investigation showed that when air steam and hydrogen sulphide are passed over porous substances at from 40° to 50° C., and still better at 80° to 90°, sulphuric acid is quickly formed without in-intermediate formation of sulphurous acid or separation of sulphur.

Similar instances are set forth by Hoffmann*—who seems to have recognized the value of the influences we here have in mind—in his necrological address upon Liebig, whose well-known devotion to the industries and their advancement is so familiar and interesting. Hoffmann says: "No branch of chemical industry has failed either directly or indirectly to receive benefit from Liebig's works." He calls attention to the study of the fat and acetic acid industries, and declares that the key to their peculiar operations is of his making, that the preparation of the prussiates and fulminates, the manufacture of the cyanides, the production of the silver mirror, were the result of Liebig's work. His interest in the problems of agriculture and of the nutrition of plants and animals, of physiology and pathology, led him not only to the development of many new industries, but to the establishment of many of the truths of science as well. His method for the production of artificial foods and concentrated animal extracts were not the smallest of his contributions to the industry, and the possibilities of their value and wide application in turn led to further investigation. Meyer,* quoting from Hoffmann, says: "If we could hold to view all that Liebig has done for the well-being of the human race in the industries, in agriculture or in the promotion of health, one can scarcely declare that any other scholar of his time has left a richer legacy to mankind."

And what Hoffmann has said of Liebig is also applicable to himself, for in many respects he rivalled Liebig in his intelligent comprehension of commercial and industrial needs and their value in suggesting new and fruitful lines of work. No question could be proposed to him that had not for him some germs of useful thought, and it was the utilization of such possibilities as came to him in this way that made him great. His genius for this will be illustrated in connection with the incidents in the coal tar color industry which show the relation of that great branch of human endeavor to the subject in hand.

It seems to make little difference to which branch of chemical work we turn for illustrations of the ideas just presented. The enormous losses suffered by Italy and France by the diseases of the silk worm, the deterioration of the wines and the diseases of farm animals, made demands upon the genius of Pasteur, and through his brilliant work and magnificent results attention has been directed to the field of bacteriology and fermentation, and almost a new science has been built upon it. What a mass of material has through this one branch of

* Hoffmann, Berichte der Deutschen Chemischen Gesellschaft, VI., 647.

* Geschichte der Chemie, 231.

work been added to the sum of human knowledge and what an impetus has it given to the advancement of science! The industries demanded relief from their losses, but the path to that relief is strewn with facts which have been utilized for the establishment of new principles; and the new principles, extended to the other industries, have widened still further the field and led to the study of the products developed in the growth and nutrition of the lower organisms with results the spread of whose influence it would be difficult to define.

Some of us will remember that a little more than a decade ago many of the leading chemists of this country were called upon to settle a commercial dispute in Chicago, turning upon the question of an admixture of fats in the adulteration of lards and that, on account of the lack of knowledge then prevailing regarding the exact constitution and reactions of various fats, it was impossible to arrive at satisfactory conclusions with regard to the mixtures submitted. It was embarrassing for chemists to admit the weakness, but it nevertheless had useful results. Since that time the development of knowledge concerning these products has been such that it is possible readily to determine in many cases, not only the components of such admixtures, but even the quantity of each component present.

Such illustrations in increasing numbers will occur to every one who may consider the history of the science and the industries from this point of view. The coal tar color industry, which has so frequently been cited and described as the direct outcome of scientific investigation, will serve admirably to illustrate further the relations we are considering. No one of the industries has been so rapid in growth or has attracted the same degree of attention from both scientists and technologists, or has had so wide an influence upon the progress of the other industries and scientific work. A brief review of the conditions of its development from the standpoint of this discussion will be of interest and will serve to show how much the purely scientific side of chemistry may be found to owe to the development of the technical side.

The origin of the crude product of this industry, the manufacture of gas, is comparatively modern. Though it was known in the latter part of the last century it did not find extensive application permanently until between 1830 and 1835. But from the time of its first extended application, its by-product, tar, became a troublesome nuisance and many endeavors were made on all sides to find some means for its disposition and utilization. It was consumed by burning, it was boiled down in open vessels and its residues used as preservative paint for wood and metals; its lighter and more volatile products were subsequently collected by condensation and put upon the market as a solvent for fats, waxes, rubber, etc., and this was used in the manufacture of varnishes. According to Lunge,* Accum was the first to boil tar down in close vessels and thus obtain volatile oil which could be used as a cheap substitute for turpentine. Dr. Longstaff declares that, in conjunction with Dr. Dalston, he erected the first distillery for coal tar in 1822 near Leith, and that the spirits obtained were sent to Mr. Mackintosh, while the residue was used for making lampblack. Roscoe states that the distillation was carried on near Manchester in 1834, the naphtha obtained being used for making black varnish with the pitch. So that the lighter distillates had been furnished to the markets some years before Mansfield began, in 1847, the distillation of the lighter oils to obtain products which might be used for lighting purposes. It was in the course of this work that he de-

* Lunge. Coal Tar and Ammonia. 189.

termined the composition of the lighter oils in the market and found that they contained a considerable quantity of benzene, a fact discovered by Hoffmann two years before. Supplies for the subsequent uses in the color industry were therefore possible.

It may be observed here that the discovery of this compound by the dry distillation of coal, *de novo*, in the laboratory, would have been practically impossible* since, according to Perkin,† 100 lbs. of coal yields only 0.85 oz. of coal tar naphtha, and 0.275 oz. of benzene. The operations of the industry carried out on a large scale are necessary to this,‡ and such operations we know and shall see have furnished to those working in purely scientific lines materials for study which has given the most important results and without which many of the relations would still be unknown.

But to proceed. With the commercial production of benzene, its derivative nitrobenzene was readily obtained in large quantities. It had been made, it is true, years before by Mitscherlich in 1834, from benzene of benzoic acid, and by Laurent a little later by the action of nitric acid upon light oil of tar. Collas, a French pharmacist, made it in 1848 in a large way in Paris and later Mansfield took up its manufacture from the product of his stills, putting it on the market as artificial oil of bitter almonds, or oil of Mirbane, to be used in scenting soap.

So aniline which Unverdorben produced in 1826 by dry distillation of indigo and called krystallin, and Runge first separated from coal tar by treating it with hydrochloric acid in 1834 and called blauöl, and Fritsche produced by digestion of indigo with potash and distillation of the product in 1840 and called anilin, and Zinin produced in 1842 by reduction of nitrobenzene with ammonium sulphide and called benzidam, remained a scientific curiosity the true constitution of which was not fully determined until some years after it had been produced by Bechamp by reduction of coal tar nitrobenzene with iron and acetic acid and Perkin had utilized it in the manufacture of mauve.

* Compare Roscoe and Schorlemmer, Treatise on Chemistry, III., pt. iii., 15.

† Jour. Soc. Arts. 1869. 101.

‡ Compare Hoffmann. Jour. Soc. Arts, 1863. 647.

And so the way for Perkin had been prepared. Both the industry and the science, so far as they had been able, had done their share: the industry, by efforts at the utilization of the products at hand and showing possible commercial profit; the science, in the struggle after new compounds. The spirit of the iatro-chemists still prevailed and substantial benefits flowed from it as of old. Perkin,* likewise in an effort to produce a compound valuable and scarce in the market and to effect the synthesis of quinine, produced aniline purple or mauve instead. Starting out, as he says, with the consideration of the empirical formula, he concluded that by the oxidation of allyl-toluidine he might attain his end. Describing his experiment, he says: "For this purpose I mixed the neutral sulphate allyl-toluidine with bichromate of potassium, but instead of quinine I obtained only a reddish brown precipitate. Nevertheless, being anxious to know more about this curious reaction, I proceeded to examine a more simple body under similar circumstances. For this purpose I treated the sulphate of aniline with bichromate of potassium. The mixture produced nothing but an unpromising black precipitate; but, on investigating this precipitate, I found it to be the substance which is now, I may say, a commercial necessity." Perkin treated the black precipitate with different solvents in the study of its properties and found it to yield to alcohol a colored solution. With more of the inventive and commercial spirit

* Chemical News, 1861. 347.

than prevailed with his illustrious teacher in whose laboratory he was working, he at once began experiments to determine whether this new color, so beautiful in its hues, could be fixed upon textile fibers, and succeeded in dyeing a strand of silk with it without the aid of any mordant whatsoever. He promptly submitted his discovery to Puller, of Perth, who tried the color in a larger way, proving its commercial value. The patents were secured and Perkin at once devoted himself to the industrial production of the color and, after more or less difficulty, always incident to the manufacture of a new substance, he attained commercial success. The tar color industry was launched; it was immensely profitable; it furnished incentive to further investigation and experiment in similar lines; a new field was opened up, and what a flood of results has come from it! In them both empiricism and rationalism have been represented, and the addition to the number of new substances whose properties and constitution have been essential to the establishment of new theories and new laws has been enormous and unprecedented in all the history of chemical work. The search after the production of a commercial product, yielded accidentally as it were, and almost empirically, the seed from which this great and flourishing tree has sprung.

For it must not be forgotten that, after Perkin had obtained his oxidation product of aniline and had found that some portion of it was colored and could be applied to the dyeing of fabrics, his study of its properties ended for the time being and it was not until 1863 that he was able to take up this subject and follow it to conclusion, establishing the constitution of the new compound.

The history of the coal tar color industry is full of examples of the production of new substances and new reactions by the industry of the highest importance to the advancement of knowledge in the domain of chemistry and to the development of the great theories to which, in turn, much of progress both in science and technology has been due. In this connection one may study, with profit and interest, the very able address of H. Caro* before the Berlin Chemical Society, on the subject of the 'Development of the Coal Tar Color Industry.' While very properly giving the fullest credit for the scientific or rational work done in this connection and the applications of it in the industries, he shows many examples of the important results attained by technical or empirical methods and of the highest interest and value to the science. He calls attention to the fact that C. E. Nicholson suggested to Hoffmann that pure aniline would not yield aniline red, and that it was not the true agent for the production of this compound. A gallon of aniline with a constant boiling point of 220° C. sent to Hoffmann by Nicholson gave such a result; while a sample of the ordinary aniline of commerce, and boiling at from 182° to to 220°, yielded an abundant quantity of color. From this Hoffmann concluded that the commercial aniline contained a second base which, together with aniline and homologous with it, entered into the reaction to produce the regular result. But Hoffmann† declared that, if such an admixture of bases existed, their separation by any other than operations on a large scale would be out of the question, a condition found by other investigators. Nicholson had already suggested the presence of toluidine in the mixture. Hoffman tried making the color with pure toluidine from tolu balsam sent him by Muspratt and found that this, too, gave a negative result. But upon mixing the pure aniline from Nicholson in proper

*Berichte der Deutschen Chemischen Gesellschaft, 25, 955.

† Berichte der Deutschen Chemischen Gesellschaft, 25, 976.

proportions with the pure toluidine from Muspratt, the proportions corresponding with one molecule of benzene to two molecules of toluene, the red color was promptly produced. In this connection Hoffmann said 'the industry was ahead of the science' and Caro said: "Hence the industry was not only the generator of aniline red, but furthermore it had opened up the way to the rational utilization of benzene and its homologues for all present and future uses of color manufacture."

Artificial alizarine has much the same kind of history. It was developed by Graebe and Liebermann by most rational methods and from the constitution and reactions of the body itself. Starting with a commercial body, produced by industrial methods and in most empirical ways, they endeavored to reproduce it by rational synthesis and succeeded. Their method through dibromanthraquinone was not, however, a commercial possibility, and it remained for Perkin, with his industrial experience and capacity, and his engineering skill combined with his knowledge of chemistry, to overcome the manufacturing difficulties and to attain this end by other means and reactions than had been proposed by Graebe and Liebermann. The process proposed by the latter was precluded by the high cost of bromine and Perkin replaced it by sulphuric acid, producing the anthraquinone sulphonic acids which yielded after the melt the product desired. The industrial genius of Perkin gave artificial alizarine and with it a long series of products and problems for study and solution by chemists everywhere. It taught reactions that were fertile in stimulating new research and established facts that could not be, or at least were not, discovered in the laboratory. For instance, in the course of the manufacture, Perkin found that when, as sometimes happened, sulphonation of the anthraquinone was not thoroughly effected through insufficient heating or use of too little acid, a really better product was obtained than when the process had proceeded normally. He found that in the latter case the color of the resulting product was less brilliant than when these irregular conditions prevailed; that, in the latter, the resulting paste was a mixture of colors, while with the former nearly pure alizarine was the result. Investigation confirmed the outcome of the practice and showed that from the anthraquinone monosulphonic acid only pure alizarine was produced, while from the result of higher sulphonation a mixture of products was secured. Such a discovery may have been possible only in the larger way occurring in the works and might have long been overlooked in the laboratory. At any rate it was brought out in the industrial operation of the reaction, and a new fact was added to the sum of knowledge.

This discovery brought further necessity and new invention. By the ordinary method of sulphonating then employed, the monosulphonic acid could not readily be produced and it remained for Perkin to advance both science and technology still further by the determination of a new process for attaining this end. He found* that dichloranthracene which is easily made may be as easily sulphonated and that the dichloranthracene sulphonic acid is readily converted to the anthraquinone sulphonic acid by heating with sulphuric acid, the final result depending upon the degree of heat employed in the reaction in sulphonating the dichloranthracene. He had thus not only advanced the industry in this branch of manufacture, but he had added to the list of reactions and compounds in chemistry as well.

Hoffmann received from the French color works the *queues d'aniline*, from which he was able to separate para toluidine and the

*Jour. Soc. Arts. 1879. 577.

two new bases paraniline and paramidophenol.* Other products from the same residues enabled the great investigator to arrive at a knowledge of the mode of formation and structure of rosaniline. Later another French color-maker sent Hoffmann a well crystallized by-product which he recognized as meta-toluylendiamine which he, together with Muspratt, had endeavored to make by synthesis. He found it to have been undoubtedly produced by the Bechamp method from nitrobenzene contaminated with dinitrotoluene.

In his most interesting and valuable address, from which many of these illustrations have been obtained, Caro calls attention to other instances of contributions to the advancement of science from this great industry; the use of zinc dust in strongly alkaline solution for the reduction of nitro-bodies was worked out in the factories; safranine was produced technically several years before its structure and mode of formation were made out by Nietzki. The empirical formation of nitrodracylic acid and β naphthylamine is cited as furnishing contributions to the establishment of isomerism in the classes to which they respectively belong. Aniline blue, produced empirically by heating together fuchsine and aniline, was found later by Hoffmann to be triphenylated rasanilin† and led him to the recognition that change of color could be produced by substituting an alkyl, phenyl or benzyl radical for hydrogen; and so started the theory, now developed into a law, that color of compounds is a function of structure, and that, in those compounds, having antifermentive, therapeutic or toxic action, the influence will vary in intensity with the position of the radical in the molecule. Thus it has been found that ortho-cresol is less active as an antiferment than the meta-compound, while this in turn is less intense in its action than paracresol. α Naphthol is more poisonous and more actively antiseptic than β naphthol.

* Proc. Roy. Soc. 1863. 312.

† Proc. Roy. Soc. 13. 9.

The field of chemical work, here so wonderfully opened up, has done much to bring into closer contact and communion the professional men and investigators on the one hand and the practical technologists on the other. Professional men find that such union furnishes valuable material for study and most useful suggestions for work. As Hoffmann says, "the technologist is not likely to leave long without utilization any fact of science which may be developed and made valuable from the technical side;" so we find that the benefits which flow from each to each are rapidly increasing from year to year and the distinction formerly made between science and technology is rapidly being broken down, and more cordial, and therefore more useful, relations established. Such union for progressive work was established with profit to both sides by Hoffmann and Nicholson, Graebe and Caro, O. Fischer and E. Heppe and others, and the example of these authorities has been followed by the great manufacturers in all countries by the foundation in the works, of well-equipped laboratories, intended not only for control of processes by analytical methods, but for the improvement and extension of processes by careful research methods and the discovery of new principles. Ostwald* has clearly set forth the manner in which technology and science may work together in electrical work, in the various directions.

How rapidly this practice has grown will be illustrated by the fact that the great works, successors to Meister, Lucius and Bruning at Höchst, made, in 1890, from 1700 to 1800 colors† and employ 3000 per-

* Chemische Industrie. 1895. 212. From Zeitschrift für Electrotechnik und Electrochemie. 1894. 81.

† Ost. Lehrbuch der Technischen Chemie.

sons including 70 chemists and 12 engineers.* K. Oehler & Co., in Offenbach, have 300 workmen and 45 chemists.† Other works of large capacity like the Badische Anilin und Soda Fabrik of Ludwigshafen, Bayer & Co. at Elbersfeld, Casella & Co. in Frankfurt a/m likewise employ large numbers of educated chemists and engineers. This practice now extends to most of the more important manufactures. Its value was early recognized in metallurgy and it has been adopted in other lines. As a consequence a demand has been made upon the educational institutions and an influence has been exerted upon the management leading to provision of better facilities for work both in investigation and instruction.

In connection with the working force of the German color factories, it is worthy of remark, that experience has led directors to employ educated engineers alongside the research chemists and so to recognize the fact that engineering capacity is necessary to the practical and industrial application of chemical reactions. These reactions effected in the laboratory cannot always be obtained in the works in a large way without the invention of special apparatus, and frequently the most brilliant discoveries in science prove to be nothing more than mere suggestions to the industries, doubtful stepping stones to new processes or new products. The discoveries of aniline and alizarine are examples of this principle. The ammonia soda reaction remained dormant nearly half a century until it was made practical through the genius of Solvay and by means which scarcely involved chemical reactions. The Leblanc soda process, with its beautiful reactions—partly, it is true, because of the political situation—remained dormant nearly a quarter of a century before the genius of Muspratt restored it to life. The sugar industry, the conception of Margraff and Achard, required the invention and construction of much special apparatus before it could develop into the astonishing dimensions it presents to-day. The Weldon process could be established in the industry only after a most earnest struggle extending over three years, and the final result showed that the complete reaction could be obtained only when working in the largest way.

The study of the ultimate history of any or all of these industries will show that, as they grew, they made demands upon the educated men and so both directly and indirectly contributed to the sum of useful knowledge in nearly all its branches, chemistry included.

For this reason the demand is growing for a combination of chemical and engineering knowledge in the same person. The value of this has been noticed in the lives and works of many of the leaders in chemical work, and its recognition among educators is advancing. This is illustrated in the views of Victor Meyer,* expressed as follows: "I coincide completely with Dr. Lippmann in his wish not only for an extension of his technical instruction in our own university in its present scope, but also for the further development of the same, and I would add thereto the expression of my own opinion that instruction in technical drawing ought not to be omitted in the curriculum of any university in which numerous young chemists seek their education and are likely ultimately to desire occupation in factories and works." Similar expressions have come from other high authorities in the field of education, and the wisdom of the establishment of the technical schools with provision for thorough education in all the special branches that may find useful application in the

* Grandhomme. Die Fabriken der Actien-Gesellschaft Farbwerke Meister, Lucius und Bruning.

† Dir. E. Franck. Zeitschrift für Angewandte Chemie. 1895. 444.

* Chemical News, 1894, 97.

different industries is thoroughly confirmed.

Thus far no reference has been made to the influence of the industries upon the development of analytical chemistry, and perhaps for this there is no need. It is generally accepted, or is fast growing to be, that it is an integral part of all technical work involving any kind of chemical reactions. Meyer* says: "The industry practically developed volumetric analysis. It was first used by Decroizelles and Vauquelin in an empirical way in the chemical industries with which they were connected and was finally developed rationally by Gay Lussac, who brought it to a state of perfection not greatly improved upon in many respects."

The industries of the earlier chemical history were controlled by other methods of analysis also, crude, perhaps, but serving a useful purpose and forming the foundation of the beautiful systems in use to-day.

In this particular the requirements of the industries of the present day are most exacting. Technical methods as distinguished from scientific methods have passed away, for with rapidity of operation that many of the processes call for, the utmost accuracy must likewise prevail. This is particularly true of the metallurgical industries in which many of the operations must be controlled by analysis from hour to hour. So, too, the utmost accuracy is demanded in all work controlling commercial operations, and frequently the investigation required to confirm the value of these so-called commercial methods, or the data upon which they are based, brings forth results both as to quality and quantity that are most gratifying. In at least two cases that have come to my knowledge the directors of the laboratories of great educational institutions made requests to the directors of large chemical works, asking for descriptions of the analytical methods in daily use in the works in question, and the request was of course cordially granted.

* Geschichte der Chemie, 339.

And if the analytical methods of the technical side are recognized as of value, so too are the experimental methods. In the great German chemical works, where large numbers of chemists are employed, the force is divided into 'laboratoriums Chemiker' and 'betriebs Chemiker,' each class having its appointed work;* the first class devoted to the investigation of new ideas in the smaller way in the laboratory, producing new compounds or investigating new reactions, or, still further, controlling by analysis the operations in the works; the second class experimenting in a larger way, with larger apparatus and quantities, and even with the normal factory facilities; with either new principles deduced from the results of factory work, or with processes or products worked out in the laboratory. The results of this combination are extensive and important; most of them are covered by patents, it is true, but they are nevertheless offered to the world, soon become public property and add to the store of knowledge. How much this really amounts to is illustrated by the fact that the records show that the works of Fr. Bayer & Co. patented or described in the first half of 1895 forty-five processes and products, while during the same period there were issued to the house of Meister Lucius and Brunning thirty-seven patents. The number of specifications for chemical patents† accepted in Germany from 1889 to 1893 were respectively, 4,406, 4,680, 5,900, 6,430. Of these patents Dr. Freidlander‡ says: "If one could be certain of the excellence of all these compounds, a new era in the color industry would be imminent. Manifestly, however, even the patentees themselves find it diffi-

* Caro, Berichte der Deutschen Chemischen Gesellschaft, 25, R. 967.

† Chem. Zeit. 1894, 136.

‡ Chem. Zeit. 1894, 1184.

cult to recognize instant practical value in them. The numerous naphthyldiamine, amido-naphthol and dioxynaphthaline sulphonic acids were patented, not indeed because a special technical interest was claimed for them, but only because they were new and it was scarcely possible at once to determine whether they would be applicable in one direction or another."

In no direction has the application of the methods in the larger way, either in the laboratory or in the works, given richer yields in new material than in the varied uses of the electric current in chemical work. It has led to the production of new compounds or has increased the means for production of old ones, and through it additions are constantly being made to the store of material of such composition and properties that they must inevitably lead to further new discoveries or the establishment of new principles or laws. It has added greatly to our knowledge of the reactions of oxidation and reduction and has made new applications of those phenomena possible. In this connection we may refer to the processes of Hoepfner and of Siemens and Halske for the extraction of copper from its solutions, whereby, as the metal is removed from the solution at the cathode, the reduced salts are oxidized at the anode, and the solutions thus brought to the higher state of oxidation are ready for use on new portions of ore.* Similar reactions occur in the new process of Löwenherz for the production of sodium persulphate, a compound new to chemistry and resulting from the application of electricity on a scale more extended than is usually employed for laboratory work. Sulphuric acid and sodium sulphate solutions, separated by a porous diaphragm are electrolyzed with the anode immersed in the sodium sulphate. The resulting compound is comparatively unstable, yielding up its oxygen with the production of acid sodium sulphate. And since this latter may readily be neutralized by sodium carbonate, the new compound is recommended for all uses in which oxidation may be applied.*

* Zeitschrift fur Angewandte Chemie, 1893.

With the production of hypochlorites and the chlorates we are already familiar. It grows rapidly with the cheapening of artificial power or the utilization of natural power, until eventually the world's demand for them must be covered by materials from this source. The reaction necessary to this is further utilized in the production of such compounds as chloral, iodized phenol and other similar substances.†

In the field of reductions reference may with interest be made to the late discoveries of Gattermann and the color works of Fr. Bayer & Co., that electrolysis is readily applied to the production of a large number of compounds not heretofore produced technically but for which technical uses constantly exist. Their earlier discovery of the application of electrolysis to the reduction of nitrobenzene to amido-phenol with intermediate production of phenyl-hydroxylamine finds wider application than they at first supposed and will doubtless constitute the starting point of a new line of synthesis of the carbon compounds.‡ This reaction is similar to that of zinc dust in alkaline solutions, preferably in alcohol containing calcium chloride whereby, as noticed by Wohl and Bamberger, phenyl-hydroxylamine is produced instead of the aniline produced by the reduction with acetic acid and iron.

The electrical smelting furnace has opened up a wide field of experiment and investigation as fascinating as it is new, and it is to be expected that many additions will be made to the list of new substances through its use. The increased production of chromium and the crystallization of carbon by

* Zeitschrift fur Angewandte Chemie, 1895, 349.

† Chem. Zeit., XIX.

‡ Chem. Zeit., XIX., 1111.

Moissan,* the production of carborundum by Acheson, the production of the various carbides by Moissan, Wilson, Borcher and others are of great interest from both the technical and scientific side. Whether the calcium carbide, which has been so much discussed and seems such a valuable material for the production of acetylene, will at once take and hold the high position assigned to it by its inventors is still an open question. But whether it shall find extended application in the industries or not; whether it will prove too expensive to compete with benzene as an enricher of an illuminating gas, or as a raw material for the synthesis of alcohol or other substances in a commercial way, it will serve as a convenient and sufficiently inexpensive source of acetylene for experimental purposes, and it will therefore without doubt still become the starting point for many valuable investigations. Nikodem Caro † has already applied the method of Berthelot to the syntheses of alcohol with acetylene liberated from calcium carbide and shown that the yields are so far from the theoretical amounts that immediate application in this direction is at least doubtful. But the results illustrate the possibilities of the advancement of the science through these technical or semi-technical methods.

It would be impossible in such a discussion as this to cover more than a few of the manifold ways in which the science of chemistry has been advanced by the industries, their wants and their wastes. The former have led to the establishment of the great systems of technical schools provided with the magnificent library and laboratory equipments, the state and national experiment stations, the various official boards and commissions for the study of those questions which immediately affect the general welfare, and from each and all of these

*Chemische Industrie, 1895, 231.

†Chem. Industrie, 1895, 226.

sources come reports of advances which are most gratifying. The latter,* that is, the industrial wastes, gave us new elements and new compounds and so furnished the material for the establishment of new laws. The soap-boiler's lye gave iodine, the wastes of salt gardens gave bromine, the mother liquors from the springs gave caesium and rubidium, the acid chambers selenium and thallium, and the mines and metallurgical works gave gallium and germanium.

Whether we consider this side of the subject of the advancement of our science from one direction or another, we shall find ample encouragement for combination of forces and for closer union of professional and technical workers in our general field of activity. For the benefits from one side must bring reciprocal benefits from the other.† The principle of action and reaction is as true and as applicable here as in the great domain of physics. Necessity is the most natural stimulant to effort, and honest investigation must call to her aid all knowledge whatever its source and all methods however they may be acquired, and where this is the moving spirit progress is most active. Dr. Ostwald says most justly that "the secret of German industrial chemistry is the recognition that science is the best practice." Is it not equally true that practice which leads to the development of truth is the best science?

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NEW YORK.

AMERICAN MICROSCOPICAL SOCIETY.

THE eighteenth annual meeting was held in the buildings of Cornell University, Ithaca, N. Y., August 21–23. It was characterized by a large and enthusiastic attendance and a very important program

* Roscoe and Schorlemmer, Treatise on Chemistry III. pt. III. 15.

† Garo. Ber. d. d. Chem. Gesell. 25, R. 991 Meyer, Geschichte der Chemie, 469–470.