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TABLE OF CONTENTS

INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY:

The Inaugural Meeting at Washington 707
The New York Meeting 711
The International Lectures 712
The Sectional Addresses 712
The Sectional Meetings 713
The Social Features of the Congress 713
The Closing Session 715
Factory Visits and Excursions 715
The Societies at the Congress 716

ORIGINAL PAPERS:

The Control of Dust in Portland Cement Manufacture by the Cottrell Precipitation Processes. By Walter A. Schmidt 719
Contact Sulphuric Acid from Brimstone. By G. W. Patterson and L. B. Cheney 723
Smelter Smoke Conservation. By George C. Westby. 725
Notes on a Study of the Temperature Gradients of Setting Portland Cement. By Allerton S. Cushman. 728
Cobalt Driers. By V. P. Krauss 731
The Development of Hydrosulphites in Their Relation to Modern Dyestuffs. By Philip S. Clarkson 733
The Effect of "Lime-Sulphur" Spray Manufacture on the Eyesight. By James R. Withrow 735
Phenol-Formaldehyde Condensation Products. By L. H. Baekeland 737

LABORATORY AND PLANT:

Apparatus for the Examination and Study of the Behavior of Valve and Cylinder Oils and other Petroleum Lubricating Oils in Saturated and Superheated Steam, Carbon Dioxide, Air and Other Gases. By P. H. Conradson 744
A New Calorimeter Bomb with Special Advantages as to Material of Construction and Method of Operation. By S. W. Parr 746
Some Tests on a New Calorimeter Bomb. By Richard H. Jesse, Jr. 748

ADDRESSES:

The Latest Achievements and Problems of the Chemical Industry. By Carl Duisberg 749
Synthetic Ammonia. By H. A. Bernthsen 760
Progress in Industrial Chemistry. By Rudolph Messel. 767
Oxidation of Atmospheric Nitrogen and Development of Resulting Industries in Norway. By Samuel Eyde 771

CURRENT INDUSTRIAL NEWS:

A New Wood Preservative 774
Air Compressor Lubrication 774
The Oxygraph 775
The Manufacture of Lithopone 775
The Pollution of Streams by Spent Gas Liquor 776
The Melting Points of Fire Bricks 776
"Persil" as a Bleaching Agent 776
The Disinfection of Potable Waters by Chloride of Lime 777
Ammonia Evaporation and Transformation in Soils ... 777
The Location of Underground Pipes 777
The Casting of Magnesium Alloys 777

NOTES AND CORRESPONDENCE:

Obituary—Frederick J. Mayer 777
Third International Rubber Conference 778
Municipal Water Conservation Exhibit of the City of Philadelphia 778

NEW PUBLICATIONS 779

MARKET REPORT 782

INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY

The quest of knowledge has always developed friendships among men of different countries, and the mutual interest which exists among scientists has given rise to stronger bonds of coöperation than those produced by even the languages or political policies. In the last thirty years a movement, the direct result of the progress which the nineteenth century made in science, unparalleled in the history of the world, has eventuated in the organization of various International Congresses. This movement, really an endeavor to ascertain the most practical and efficient methods of scientific procedure, has fostered a uniform mental attitude which seems to have developed rapidly throughout the civilized world, and an intellectual union has been the consequence. The natural development of these organizations constitutes in itself a guarantee of solidity and efficacy.

William H. Nichols, President.

There is to-day no German chemistry, no Russian chemistry, no Japanese chemistry, no American chemistry; there is one Universal chemistry, and in this respect our science differs from sciences in which the spirit is strictly national, as botany, seismology, etc. The psychology of the Orient and Levant may differ materially from that of the Occident, owing to the intellectual and moral differences in the peoples; but the chemistry of India and that of the United States are identical, because they are based upon uniform natural laws.

To the chemist belongs the honor of having first effected this great International movement—the convention of scientific men of varied nationalities. The initial international congress of chemistry was held at Carlsruhe in 1860; the meeting was attended by 140 chemists from all parts of Europe and lasted 3 days. At the Eighth International Congress of Applied Chemistry, 2500 chemists were present and the proceedings were of ten days' duration. The purpose of the Carlsruhe congress was the establishment of an international nomenclature. Although this congress was a success, yet more than a quarter century elapsed before the realization of the necessity of a similar convention was expressed. From 1889 on, the periods passing between the congresses of chemistry were of much shorter duration, thus, 1893, 1894, 1896, 1898, 1900, 1903, 1906, 1909, and 1912.

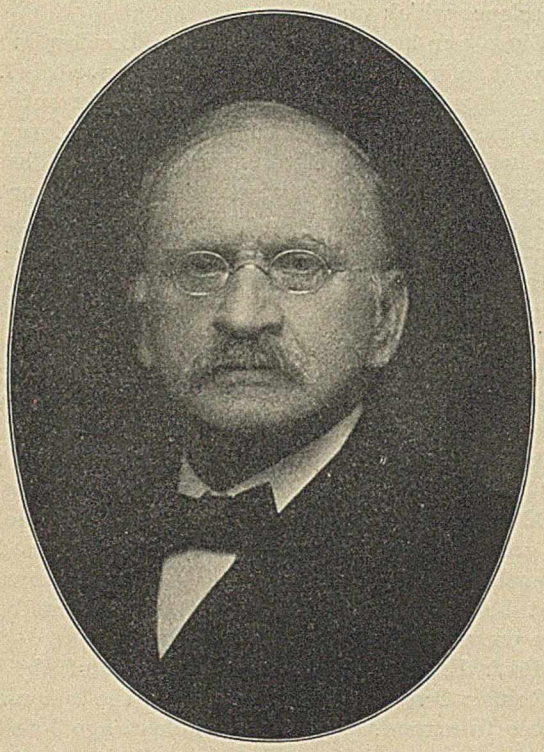
The first International Congress of Applied Chemistry was held at Brussels in 1894, and was the outcome of a suggestion of Doctor H. W. Wiley. This Congress was divided into four sections, *viz.*, sugar chemistry, agricultural chemistry, food and public hygiene, and biological chemistry. The Second International Congress of Applied Chemistry convened in Paris in 1896. Committees had been organized in various countries, and through the French Foreign Office all the principal governments were invited to send delegates; nearly 2,000 members were present, and the necessity of a close alliance between pure and applied science was shown. The Third International Congress of Applied Chemistry, held in Vienna in 1898, was divided into twelve sections; one of the principal questions before this Congress was the adoption of uniform methods of analysis for commercial products and raw materials. The Fourth Congress was held in Paris in 1900 at the time of the Grand Exposition; the work was divided into ten sections. At the Fifth Congress, in Berlin, 1903, of which there were 2,533 members representing 38 countries, about 500 papers were presented for discussion. Several German societies held their meetings in conjunction with this Congress, which was the most important and successful of all held up to that time. The Sixth International Congress of Applied Chemistry (Rome, 1906) was divided into eleven sections; the members numbered 2,375 and 658 papers were presented. The Seventh Congress (London, 1909), of which there were 4,100 members, was a worthy successor to the six preceding; 985 papers were presented in eleven sections and six subsections, and several innovations were arranged and carried out. A characteristic feature of the London Congress was the extension of the idea of the establishment of International commissions to recommend uniform standards of materials and methods of determining them.

The Eighth International Congress of Applied Chemistry, the most brilliant assemblage of men eminent in pure and applied chemistry ever brought together on this continent and a worthy successor of the preceding Congresses, officially closed its sessions on September 13, 1912, after ten days of scientific and social enjoyment—days which were replete with opportunities for affording direct interchange of views and during which Americans had the great

satisfaction of playing the part of host to those chemists who gathered from all parts of the civilized world.

This Congress, of which there were 4500 members, 2500 of whom attended the New York sectional sessions, had been an enormous undertaking and the immense amount of work which its preparation entailed devolved largely upon the President, Secretary and Executive Committee. It is to the President, Dr. W. H. Nichols, and to the Secretary, Dr. B. C. Hesse, however, that the greatest amount of credit is due for the splendid organization, elaborate arrangements and successful administration of the plans.

The Eighth Congress had been repeatedly brought to the attention of the chemical world during the past three years, and the plans of the organizers, both tentative and final, had been distributed throughout the world in a most thorough manner. The various Committees in charge of the many arrangements necessary did their work systematically, and earnest coöperation early marked the development of the many fixed rules and novel ideas introduced. It was only to be expected, therefore, that the Congress would have a number of features. One of the most important and valuable of these was that the bulk of the accepted papers was printed in advance in twenty-four carefully prepared, well-printed volumes, each devoted to a section. In this manner the greater amount of the papers presented were available for perusal and criticism prior to the sectional session openings, and



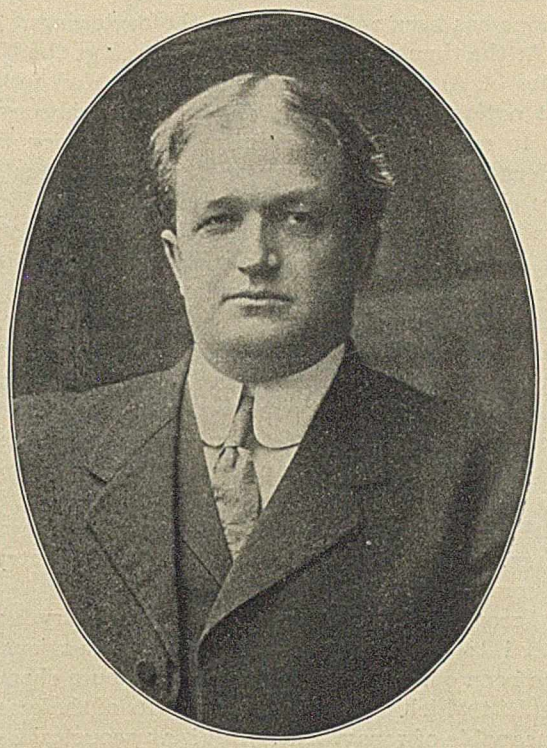
EDWARD W. MORLEY, HONORARY PRESIDENT.

this arrangement not only encouraged attendance but also provided for more thorough discussion.

It has been said that the consciousness of a duty performed gives music at midnight, and it is agreed by all that the men and women who have worked and coöperated to make this Congress a success are entitled to unbounded credit and all the peace of mind which goes with a work well done. The success of the Eighth International Congress is a crowning event in the history of Applied Chemistry in America.

THE INAUGURAL MEETING AT WASHINGTON.

The official opening of the Eighth International



BERNHARD C. HESSE, SECRETARY.

Congress of Applied Chemistry took place at Memorial Continental Hall, Washington, D. C., on September 4, 1912, at 11.00 A.M. The Patron, President W. H. Taft, was unable to open the Congress personally on account of a sprained ankle, although he had made the trip from his summer home in Beverly, Mass., for the purpose; his regrets were presented by the President of the Congress, Dr. William H. Nichols. Dr. Nichols introduced the Honorary President, Dr. E. W. Morley, who made the following address:

"The Eighth International Congress of Applied Chemistry, assembled according to the invitation of the President of the United States of America, and by the authority of the Congress of the United States, desires to express its gratitude for this invitation, and further, its especial gratitude for, and high appreciation of, the honor done us, Mr. President, by your consent to open the deliberations of this Congress.

"It is my privilege, fellow members of the Congress, to express to you the cordial welcome with which the chemists of the United States receive you to their country. This cordial welcome we gladly offer to visiting chemists from every country of the whole world. Moreover, both the representatives in this country of applied chemistry, and also the lovers and followers of pure chemistry, take a special pleasure in welcoming chemists from the four nations whose languages are the official languages of this Congress. It was among these nations that, something like a

century ago, chemistry as we now understand it had its origin. Lavoisier established an anti-phlogistic chemistry, Dalton founded the atomic theory, Liebig furnished organic chemistry with methods, and Avogadro helped us to an insight into molecular weights. During the century since these magnificent beginnings, the progress of chemistry in these four nations has been well worthy of the beginnings.

"At the time of these brilliant beginnings the United States of America were but just become an independent nation. The work of the hour on this continent was to organize the mechanism of civilization in the wilderness which then covered much of our area. Pure chemistry had to wait while roads and bridges were built and the forest was cleared. Our studies and energies had to be expended upon the difficult problems of conducting a popular government—problems which we are optimistic enough to regard as not incapable of solution. The organization of universities by private initiative and expense, and the organization of elementary schools at public expense over almost half a continent, diverted able men from research in pure science. The necessities of mine and furnace and factory led men who might have stood high as investigators, to use their energy and insight in applying chemistry to industry, and adding to the wealth of the country and the comforts of life.

"Accordingly, the chemists of this country are delighted to welcome chemists from the nations who have been our masters and teachers in pure chemistry. The debt which we owe to the chemists of these nations is incapable of repayment. But if any courtesies which we can show you, any provision for the pleasure of your visit which we can make, any solicitude for the success of your deliberations which we can feel, should suggest that such repayment would be to us a privilege and a pleasure, and a great delight, we should but feebly express the warmth of the welcome with which we receive you to the sessions of the Eighth International Congress of Applied Chemistry."

President Nichols then made his formal address of welcome, which follows in full:

"On behalf of the great army of American chemists, more than six thousand in number, and representing all branches of the profession, and in the name of the great industrial organizations depending on their services, and also of the Universities, Colleges and Technical Schools, where many are devoting their lives to instruction, it is my privilege also to extend a hearty welcome to our guests from all the corners of the earth.

"We are gathered together to compare notes and to add to what has been done before, thus contributing to the great structure of the future something of perhaps vital importance to its growth and symmetry. We realize that this is an age of coöperation rather than of destructive competition, and we therefore unite our efforts that the resultant may be worthy of us. We are here to give, that we may receive, and thus pass on to the world something more than our isolated efforts could make possible. The alchemist of the middle ages worked alone, seeking the philosopher's stone, or perhaps the elixir of life, vainly hoping to transmute baser things into gold, or indefinitely prolong the joys of youth. We work together, and much has come to pass in the transmutation not of the elements, it is true, but of useless into useful things, and much has been accomplished in the betterment of the whole span of life. It is true we cannot see the goal and cannot even imagine what it will be when discovered in the distant future, but we are trying to do our share of the onward work, so that those who succeed us will be better prepared to take their part because of what we have done.

"Coöperation such as ours becomes not only a delight but a moral quality. To this symposium we, of the new world, cordially welcome those who from other lands and other experiences come to add their assistance and sympathy.

"To this word of welcome to our guests I am sure you would have me add one of appreciation of our Chairman, President Taft, who has torn himself away from a well earned and needed rest to come here to preside at this opening meeting of our Congress—a worthy successor of the kings and princes who have similarly honored those which preceded it. While his genial nature leads him to do this freely, we none the less appreciate that the chemists of the world, whether present with us or not, are under obligations to him which they can never repay. I am sure that I speak for you all when I tender to him our united thanks for the honor he has conferred upon us and on the science which we love.

"Since our last Congress, held in London in 1909, no past officials of the congresses have died. Sir Henry Roscoe, Hon. President of the Seventh Congress, has met with great affliction in the loss of his dear wife, but with that exception death has not entered into the homes of those who have presided over former congresses. We extend to him to-day our heartfelt sympathy, added to our regret that advancing age has prevented him from being present with us to-day. I am sure he is with us in the spirit.

"The President of the Fifth or Berlin Congress, Prof. Otto N. Witt, of Charlottenburg, has also been prevented from attending. I am sure that any one who has met him, or who has known of his great works, will join me in the expression of deepest regret that one of the most brilliant lights of the chemical world cannot be with us. Those of you who had the good fortune to hear his scholarly address at the Seventh Congress will, to some extent, appreciate what he could have added to this Congress had he been present.

"Prof. Emanuele Paterno, President of the Sixth or Roman Congress, finds himself at the last moment unable to attend. Up to a few days ago I felt sure of his presence, and was therefore all the more disappointed at his change of plans. We shall miss him greatly, although there are worthy representatives of his country here.

"We are very fortunate in having with us Professor Lindet, President of the Second Congress; Sir William Ramsay, President of the Seventh Congress; and Dr.

Friedrich Strohmer, of the Vienna Congress. These, with those I have named, are the only living members of the International Commission of Congresses of Applied Chemistry, and we are happy to welcome them and to know that we are to have the benefit of their great wisdom and experience during the conduct of the affairs of this Congress.

"I am pleased to report that a very large proportion of the original communications to this Congress has already been printed and bound, twenty-four volumes in all, and will be distributed to members on registration at Columbia University on their return to New York. I think this is worthy of mention, as I believe it is a result which has never been accomplished before, and which could not have been accomplished now but for the magnificent and untiring work of our Secretary, and the coöperation with him of the officers and members of the Sectional Committees and the Committee on Papers and Publications. It is hoped that with these transactions in hand the discussions of the papers will be of great value. Thanks to the effective assistance of Mr. Edison and his staff, arrangements have been made to record these discussions on the phonograph in the official language employed, and this in itself will represent an added novelty in our Congress, and, at the same time, insure an accurate report.

"We are also fortunate in having some of the foremost chemists of Europe as lecturers on subjects of great importance; and, anticipating the public interest which these lectures will arouse, arrangements have been perfected to make them available for large numbers.

"The past fifty years have seen marvelous improvements in all branches of science. This is not the time or place to discuss details, but I feel justified in saying that the science of chemistry during the great evolutionary period has not been outstripped by any of the others. While its work has been more quiet, and has not been so obvious to the general public, it has been none the less of supreme importance. I believe it is gradually being realized that the world of the future will depend more upon the science of chemistry than upon any other, and may even have to look to it for its continued life. As its mines become more and more exhausted, and its lands more and more depleted of power to grow crops, it must turn to chemistry for instruction as to prevention of wastes and uses of power and materials, which, without its ministrations would be useless.

A CONGRESS GROUP. Photo by *Harris & Ewing.*

SIR WILLIAM RAMSAY. DR. RUDOLPH MESSEL. PRES. W. H. NICHOLS.

"With this thought in our minds we welcome with more than ordinary cordiality our foreign guests—some of them from the antipodes. We invite them to aid us in the solution of the great physical problems which confront us as a nation. We have had, and still possess, magnificent natural resources; we have perhaps done with them the best that we could, but we are becoming more and more alive to the fact that the problems are vast and complex. These natural resources must be exploited, but I conceive it to be of much more importance that they be intelligently conserved. The assistance of those who have of

necessity had these problems in conservation always before them will be doubly welcomed by us who have been so prodigal in the expenditure of our great wealth.

"The development of our country has been extremely rapid, but the thoughtful ones among us realize that the time is at hand when lavish expenditure must be succeeded by prudent conservation in order that we may not only pass down to posterity a record of wonderful evolution, but insure that we have not robbed our children's children of the materials necessary for their own progress.

"With these ideas we will proceed to our labors at New York with light hearts, believing that great good will come to our country and to the world as a result of those labors, not only in the immediate future, but more particularly in the more distant future which it is our bounden duty to carefully and religiously protect."

After President Nichols' address followed the official responses of the representatives of various countries: Prof. Dr. Rudolf Wegschneider spoke for Austria, Prof. L. Lindet for France, Prof. Dr. von Buchka for Germany, Sir William Ramsay for Great Britain, Dr. Jokichiro Lemori for Japan, Commanditore Giacomo Ciamician for Italy, Prof. Paul Walden for Russia, and Dr. Samuel Eyde for the other countries. Following these addresses, two resolutions were presented. Dr. H. W. Wiley presented a resolution of thanks to the D. A. R. for their permission to use the Continental Hall; Dr. D. T. Day moved that one copy of the official Congress badge be struck in pure gold, for presentation to the President, Dr. Nichols.

In the afternoon of September 4, there was a reception at the White House, and the delegates and their wives repaired thereto in large numbers, assembling in the East Room, where, after being introduced to the visitors, President Taft, seated in a wicker chair, said:

"Ladies and Gentlemen of the International Congress of Applied Chemistry:

"I have much pleasure in welcoming you, on behalf of the Government and people of the United States, to Washington. I sincerely hope that your stay in this Capital may be an agreeable one.

"Yours is one of those important International Congresses that mark the great progress which has been made in research and application of newly discovered principles in a most important science and art. If there be any science that goes to the heart of the matter, it is chemistry. Dealing with atoms and molecules and their association, and the manifestations of their action upon each other, chemistry seems at one time the most abstruse of sciences, and then when we see it applied in the great modern factories in the manufacture of those elements which are essential to the success of the industrial arts, we are made to know that the extent of the science from the theoretical to the practical is wider than that of any other.

"I observe that in your various divisions you discuss many different questions not peculiarly chemical. I note a consideration of the question of patents, what patents ought to include, and what kind of a patent system ought to be adopted by each Government. Patents have played a very great part in the development of the United States, and we have given to patentees a very valuable monopoly for the purpose of discovering by their industries, new methods of accomplishing useful results. Whether we have made this monopoly too great or not is now the subject of consideration by a Commission provided for by Congress. There is certainly great room for improvement in the machinery of our Patent Office, and it would be well if more value could inhere in the issuing of a patent as an evidence of real property. Now, however, until a patent has been fought through the courts, people do not seem to regard it as of a great deal of monopoly value.

"I may add that one of the great opportunities for reform, in my judgment, is in the shortening of patent litigation and the reducing of its expenditure. I know very little about chemistry, but I know a good deal about patent litigation. I know that the amount of money that has been unnecessarily wasted, and the inequality that has been produced between the rich litigant and the poor litigant, by reason of the unnecessary expense of that litigation, is one of the things that calls for remedy and immediate remedy. It is not essential that we should make a record of 10,000 printed pages at $50 a day for experts and $100 a day for patent lawyers. I have no objection to experts; I have no objection to patent lawyers: but I think we can have too much of both of them. What ought to happen is that the expert should be called into open court, should there be examined on the principal points of the case, and then dismissed, and not have that interminable system of records, which every Judge who has had any experience in respect to patent law must condemn, on the one hand, because of its uselessness, and on the other hand because of its expense. You observe that I am willing to make a diversion in the direction of which I know something. But it is not for me to discuss a subject that is only distantly related to the main purpose of your coming.

"I regret exceedingly that the weather is such as not to permit you to enjoy the beautiful grounds of the White House as fully as you could on a sunny day. I have come a long distance to meet you, in order to emphasize as much as I can the importance which the American Government and the American people attach to your deliberations and the subject matter of your consideration, and the anxiety and concern they have in promoting every International Congress which makes, as this does, for 'team-work' in the world's progress."

Upon the conclusion of this address, the party adjourned to the White House grounds, where the members were received by Mr. Taft, the introduction being made by Major Rhoads. This lawn party was a very pleasant affair and lasted from 5.00 to 6.30 P.M. The Marine Band, under the direction of Lieut. Santelmann, and assisted by Miss Agnes Hope Pillsbury at the piano, gave a most excellent musical programme. Refreshments were served in special tents, and the

terraces were crowded with friends and guests attending the Congress.

There were various private dinners in the evening, notably a "chemistry dinner" at the Raleigh by Dr. H. W. Wiley, but the principal social function was a reception by the Regents and Secretary of the Smithsonian Institution, held at the New National Museum. The latter, with its wealth of collections, including paintings, added interest to the function, which was in every respect a brilliant success. The Marine Band furnished a musical programme to which Mrs. Bertha Lincoln Heustis contributed a number of vocal selections. Dancing followed, in which the younger element participated.

work being greatly facilitated by having everything on one floor and in one room. Appropriate booths, properly numbered and named, were provided for registration, for general information in the four official languages, for United States branch post office, telegraph and telephone offices, railroad information bureaus, treasurer's office, factory inspection bureau, facilities for distributing printed proceedings, checkroom, express office, stenographers, etc. Official marshals were on hand to act as interpreters and assist the foreign members in registering and arranging their residence while at the Congress. The Columbia University Dormitory facilities were placed at the disposal of the visiting members by the Trustees, and

ENTRANCE TO COLUMBIA UNIVERSITY GROUNDS.

The following day many of the visitors went on a sight-seeing tour of Washington, and visits were paid to the various Government buildings and bureaus. In the evening of September 5, the Washington visitors left for New York to continue the formal work of the Congress.

THE NEW YORK MEETING.

The formal opening of the Congress in Washington was followed by the final registration and organization in New York City on September 6th. The work was centralized in the buildings at Columbia University on Morningside Heights, and at the College of the City of New York on Washington Heights. The Gymnasium in University Hall, the central building in the Columbia group, was converted into a series of offices for the administration of the Congress business, the

the students dining room in University Hall was opened up to accommodate the visitors. Each section of the Congress was assigned a commodious meeting room in some of the buildings of the University group; the International public lectures, organ recitals and general meetings were held in the Great Hall at the College of the City of New York.

A daily Journal was published and distributed by the Congress and every detail of the administrative feature was carefully worked out for the comfort and convenience of the visiting members. The hospitality of the two great educational centers in New York—Columbia University and the College of the City of New York—contributed in a great measure to the success of this undertaking.

THE INTERNATIONAL LECTURES.

The important lectures which followed the sectional meetings on September 6, 9, 10, and 11, and which were open to the public, were delivered in the Great Hall of the College of the City of New York, by eminent members of the chemical profession from each nation represented in the four official languages, French, German, Italian, and English.

M. GABRIEL BERTRAND, *Professor of Biological Chemistry at the Sorbonne and the Pasteur Institute, Paris, France*: "THE PART PLAYED BY INFINITELY SMALL QUANTITIES OF CHEMICALS IN BIOLOGICAL CHEMISTRY." This lecture was delivered on September 6th in French, and embodied a scholarly summary of the results of years of study and experimental research conducted by the speaker.

GEHEIMER REGIERUNGSRAT PROF. DR. C. DUISBERG, *Managing Director of the Farbenfabriken of Elberfeld, Germany:* "THE LATEST ACHIEVEMENTS AND PROBLEMS OF THE CHEMICAL INDUSTRY." This lecture, delivered in German, was illustrated by lantern slides and extensive exhibits; it dealt most impressively and eloquently with the enormous strides which Germany has taken in the development of certain chemical industries, and was highly enjoyed by an audience of about 1500 persons. A full translation of Prof. Duisberg's lecture appears in this issue of THIS JOURNAL.

PROFESSOR WILLIAM HENRY PERKIN, *of Manchester, England:* "THE PERMANENT FIREPROOFING OF COTTON GOODS." Professor Perkin, who spoke, of course, in English, illustrated very forcibly the research chemist's services to the cause of humanity; his lecture which will be published in the next issue of THIS JOURNAL pertained to his discovery of a process for the permanent fireproofing of all kinds of cotton goods, and included a practical demonstration of its success.

PROFESSOR GIACOMO CIAMICIAN, *of Bologna, Italy:* "THE PHOTOCHEMISTRY OF THE FUTURE." This lecture, delivered in Italian, was of great practical importance on account of the suggestions it contained in regard to the better utilization of radiant energy.

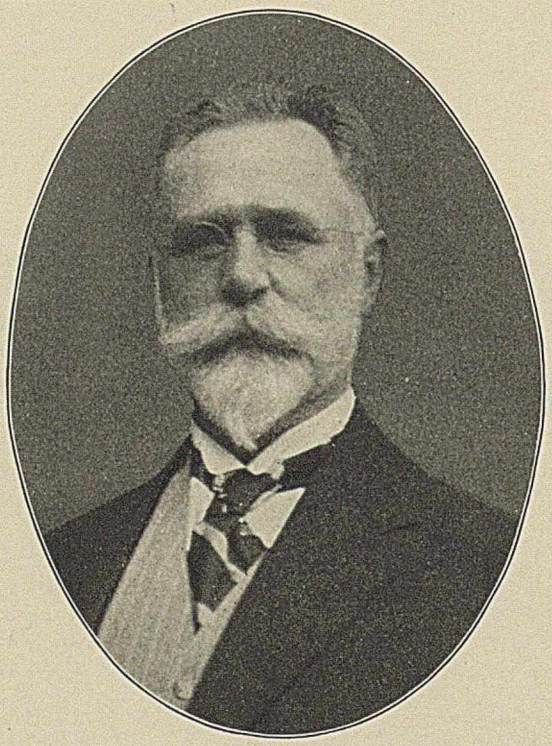
All of the above general lectures, which were comprehensive and of great interest, were preceded by organ recitals and every facility had been provided by The Honorable Board of Trustees, President J. G. Finley, Professor Charles Baskerville, and Dr. W. L. Estabrooke of the College of the City of New York for the convenience of the lecturers and the reception of the audience. Each of the lectures was followed by a tea served on the College campus.

THE SECTIONAL ADDRESSES.

One of the interesting features of the Eighth Congress was the holding of joint sessions of various sections; at several of these joint meetings symposiums were held, while at three, important addresses were delivered by distinguished chemists.

DOCTOR SAMUEL EYDE, the eminent chemical engineer of Kristiania, Norway, addressed the joint meeting of the Sections on Inorganic Chemistry, Physical Chemistry, Electrochemistry, and Agricultural Chemistry, on September 7th in the Auditorium of the American Museum of Natural History. His subject was "THE OXIDATION OF ATMOSPHERIC NITROGEN AND DEVELOPMENT OF RESULTING INDUSTRIES IN NORWAY." This meeting was attended by the most prominent chemists at the Congress, as well as by many manufacturers and engineers, and will always be remembered by those present. An extended abstract of the address by Dr. Eyde appears in this issue.

HERR HOFRAT PROF. DR. HEINRICH AUGUST BERNTHSEN, *Managing Director of the Badische Anilin und Soda-Fabrik, Ludwigshafen*, delivered an address before the joint meeting of the Sections on Inorganic Chemistry, Physical Chemistry, Electrochemistry, and Agricultural Chemistry, at the Horace Mann Auditorium on September 11th, on



Courtesy of *American Druggist*.

HEINRICH AUGUST BERNTHSEN, PRES. BUNSEN GESELLSCHAFT.

"SYNTHETIC AMMONIA." This lecture was one of the most novel delivered before the Congress, and included a demonstration of the Haber process. The thanks of the meeting were voted to Professor Bernthsen for his brilliant lecture, the motion being made by Dr. Eyde and seconded by Professor Duisberg. Professor Bernthsen's lecture is reprinted in full in this number of THIS JOURNAL.

PROFESSOR WILLIAM HENRY PERKIN delivered a lecture on "THE POLYMERIZATION OF BUTADINE AND ISOPRENE," before the Sections on Organic Chemistry and India Rubber, on September 11. A large audience was present.

Prof. Perkin outlined the method of making synthetic rubber, which he recently described in a paper before the Society of Chemical Industry and then described a new method which he said looked very

promising. Since this new method has not yet been described we give its outline here:

Take ethyl alcohol, which may be easily oxidized to acetaldehyde. This is condensed by means of potassium carbonate to aldol and the aldol can be quantitatively converted into butylidine glycol. All the yields of these reactions are practically quantitative. The butylidine glycol is then converted into a chloride and passed over soda lime when practically the same product is produced as the isoprene from the isoamyl chloride and when treated with sodium gives even better rubber than isoprene.

Prof. Perkin exhibited samples of what he called the first synthetic rubber ever made (the product of Tilden).

THE SECTIONAL MEETINGS.

The scientific work of the Congress was organized in twenty-four sections. Each section was administered by a complete organization consisting of President, Vice-president, Secretary and Sectional Committee.

All papers offered to the Congress, after being passed upon by the proper Sectional officers, were submitted for final action to the Committee on Papers and Publications.

The greater portion of the Proceedings of the Eighth International Congress was printed in advance of the meeting, and issued to members on and after the morning of September 3rd. The Proceedings contained all accepted papers presented by June 30, 1912, and consisted of twenty-four volumes, including over 600 papers and over 5000 pages with illustrations.

The many additional papers read at the Sectional meetings but not submitted before June 30th, will be included with discussions of all papers in the Supplement to the Proceedings, to be issued before December 31, 1912.

Each volume of the Proceedings was devoted to a section. Thus authors were able to present their papers in abstract before the section and bring out a most complete and full discussion.

SECTIONAL DIVISIONS AND THEIR PRESIDENTS.

Analytical Chemistry: W. F. Hillebrand, Ph.D., Bureau of Standards, Washington, D. C.

Inorganic Chemistry: Charles L. Parsons, B.S., Technical Expert of Bureau of Mines, Washington, D. C.

Metallurgy and Mining: Joseph W. Richards, Ph.D., Lehigh University, South Bethlehem, Pa.

Explosives: Charles E. Munroe, Ph.D., George Washington University, Washington, D. C.

Silicate Industries: Allerton S. Cushman, Ph.D., The Institute of Industrial Research, Washington, D. C.

Organic Chemistry: Marston T. Bogert, LL.D., Columbia University, New York.

Coal Tar Colors and Dyestuffs: Herman A. Metz, 122 Hudson Street, New York.

Industry and Chemistry of Sugar: W. D. Horne, Ph.D., National Sugar Refining Co., Yonkers, New York.

India Rubber and Other Plastics: L. H. Baekeland, Sc.D., Yonkers, New York.

Fuels and Asphalt: David T. Day, Ph.D., United States Geological Survey, Washington, D. C.

Fats, Fatty Oils and Soaps: David Wesson, B.S., 24 Broad Street, New York.

Paints, Drying Oils and Varnishes: Maximilian Toch, 320 Fifth Avenue, New York.

Starch, Cellulose and Paper: Arthur D. Little, 93 Broad Street, Boston, Mass.

Fermentation: Francis Wyatt, Ph.D., 402 West 23rd Street, New York.

Agricultural Chemistry: Frank K. Cameron, Ph.D., Department of Agriculture, Washington.

Hygiene: W. P. Mason, M.D., LL.D., Rensselaer Polytechnic Institute, Troy, New York.

Pharmaceutical Chemistry: Joseph P. Remington, Ph.M., 1832 Pine Street, Philadelphia, Pa.

Bromatology: W. D. Bigelow, Ph.D., Department of Agriculture, Washington.

Physiological Chemistry and Pharmacology: John J. Abel, M.D., Johns Hopkins University, Baltimore.

Photochemistry: W. D. Bancroft, 7 East Avenue, Ithaca, New York.

Electrochemistry: William H. Walker, Ph.D., Massachusetts Institute of Technology, Boston.

Physical Chemistry: W. R. Whitney, Ph.D., General Electric Co., Schenectady, New York.

Law and Legislation Affecting Chemical Industry: The Honorable Edward D. White, Chief Justice of the Supreme Court of the United States, Washington.

Political Economy and Conservation of Natural Resources: J. A. Holmes, Bureau of Mines, Washington.

A prominent feature of the Congress was a number of joint sessions held for the purpose of a more general interchange of ideas and views on interrelated subjects. These joint sessions also gave excellent opportunities for the presentation of some of the most interesting and valuable lectures delivered during the Congress, notably those on "Oxidation of Atmospheric Nitrogen and Development of Resulting Industries in Norway," by Samuel Eyde; "Synthetic Ammonia," by Prof. Bernthsen; "Synthetic Rubber," by Prof. Perkin.

A list of the articles published in the proceedings and of especial interest to our readers can be found in the New Publications column of this issue. Many of the papers of industrial and engineering importance will appear in the current or subsequent issues of THIS JOURNAL.

THE SOCIAL FEATURES OF THE CONGRESS.[1]

One of the great advantages of an international congress is the opportunity offered for social intercourse; accordingly, the encouragement of frequent association among the members was carefully carried out by the Officers and Committees of the Eighth International Congress of Applied Chemistry,[2] and the entertainment of the visiting members was fully provided for. In fact, the social features of the Congress were almost equal in importance to the sectional meetings, for they gave every chance for *intimate* exchange of ideas and views.

[1] Exclusive of the entertainments and functions attending the Opening of the Congress in Washington, reported elsewhere.

[2] The Marshals, it may be mentioned here, did much to promote cordial acquaintances among the foreign guests and the home members.

The reception of the American Chemical Society to the members of the Congress at the Metropolitan Museum of Art, from 8.00 P.M. to 10.00 P.M. on the evening of Saturday, September 7, was a largely attended, highly enjoyed function. The Receiving Line, composed of twenty-eight Past Presidents and Officers of the Society and Officers of the Metropolitan Museum of Art, with their wives, and under the chairmanship of Dr. Arthur D. Little, formed at 8.30 P.M. in the Grand Foyer of the Museum, and from 9.00 to 10.00 P.M. a collation was served in the Trustees Room on the second floor. Members of the International Association for Testing Materials were also welcome with their guests. Through the courtesy of the Museum, a special illustrated program advising as to how best to see the collections and where they were located was distributed at the entrance. The Reception Committee, also under the chairmanship of Dr. Little, was made up of one hundred prominent American chemists; the Ladies' Reception Committee was constituted of sixty-five ladies; and the Executive Committee on Arrangements, of which Dr. George F. Kunz was chairman and Dr. E. F. Roeber secretary, was made up of seventeen ladies and gentlemen.

GREAT HALL OF THE COLLEGE OF THE CITY OF NEW YORK.

Those members of the Congress holding entertainment coupons enjoyed a Boat Excursion up the Hudson River on Sunday, September 8; an Entertainment at the New York Hippodrome on September 11; a Baseball Game at the New York Polo Grounds on September 13. The Boat Excursion was attended by a large number of members and lady guests, the party leaving 41st Street and North River at 9.30 A.M. and returning late in the afternoon; the boat proceeded as far as Newburgh and during the trip refreshments were provided. The members who attended the production at the Hippodrome in the evening of September 11, which, like the baseball game on the 13th, attracted in particular many foreign visitors, were enjoyably entertained.

Among other social functions and entertainments, all of which were free to the members of the Congress, were the following: The inspection of the American Museum of Natural History on Saturday afternoon, September 7; the reception and entertainment by the Chemists' Club on the evening of September 10; the the Afternoon Tea and Exhibition of Photographs at the Camera Club after the joint meeting of the Section on Coal Tar Colors and Dyestuffs with the Sections on Paints, Drying Oils and Varnishes, and on Photochemistry; the Organ Recitals by Mr. Mark Andrews, of Montclair, N. J., on September 6 and 9, and the organ recitals by Professor Samuel A Baldwin on September 10 and 11, all in the Great Hall of the College of the City of New York; the Informal Teas at the College of the City of New York on September 6, 9, 10 and 11; and the Afternoon Tea on the lawn at Columbia University on September 12. There were in addition certain other functions taking place in connection with other organizations; on the evening of September 6, a number of receptions to foreign members in attendance and sectional smokers occurred. Throughout the Congress the Chemists' Club was the center of social activities; here many informal meetings and social gatherings took place. The reception and entertainment by the Officers and Trustees of this club to the members of the Congress, on September 10, was largely attended and highly successful. Dr. and Mrs. Morris Loeb gave a reception at the Chemists' Club for the Latin-speaking visitors, and, on the afternoon of September 11, the Italian delegation and their friends were entertained by the Italian Chamber of Commerce.

Among the private functions were the delightful lawn parties of Dr. and Mrs. Morris Loeb on September 8 and Mr. and Mrs. William James Evans on September 12. The charming garden-party of Mr. and Mrs. Evans was at Yattonhurst, Dobbs Ferry; the invited guests were conveyed to and from the reception in a special train. During the New York sessions a number of private dinners were given in honor of visiting chemists, the most notable of these being the ones of Dr. Hugo Schweitzer in honor of the Official Delegates of the English, German, French, Austrian and Italian Governments, at his residence on September 6; Professor Charles Baskerville, in honor of Sir William Ramsay, at the Century Association on September 6; and the several dinners of President W. H. Nichols, especially those on September 8 and 9.

The Grand Banquet of the Congress occurred on the evening of Thursday, September 12, at the Hotel Waldorf-Astoria. This dinner was attended by more than 1,000 members and ladies, and the Mayor of New York City, Hon. W. J. Gaynor, was the guest of honor

and principal speaker; addresses were also delivered by various American chemists, in which a welcome was bestowed upon the guests, and by English, French, German and Italian chemists, who referred appreciatively to the United States and Americans.

Mayor Gaynor, referred to by the toastmaster, President Nichols, as "the man who has the hardest job in all the world," regretted that he could not do justice to all the languages represented, hence his address was delivered in English. His remarks were partly on the public press, in the course of which he said that the newspapers had, during the Congressional week, given more space to stories of crime than to the proceedings of the world's great chemists. He also referred to socialism and requested the foreign representatives in his audience to take some of his statements on this subject over the seas with them for reflection.

Dr. John Huston Finley, President of the College of the City of New York, delivered an address on behalf of Governor Dix, of New York, in which he spoke in chemical metaphors. Dr. Finley's remarks were very entertaining and amused the audience immensely.

An unusual innovation for such an occasion was a speech by a lady. Mrs. L. H. Baekeland, Chairman of the Women's Committee of the Congress, spoke in a delightfully entertaining manner and was warmly applauded.

The list of speakers included: W. P. Wilkinson, representing Australia; Dr. Rudolph Wegscheider of Austria; B. Setlik of Bohemia; Paul Hagamans, Consul General of Belgium at Philadelphia; Dr. Anthony McGill of Canada; Prof. Belisario Diaz-Ossa of Chili; Mr. Yung Kwai of China; Dr. Don Guillermo Wills of Colombia; Dr. Einar Billman of Denmark; Prof. Leon Lindet of France; Prof. Dr. von Buchka of Germany; Rudolph Hofmann of Prussia; Prof. Gilbert T. Morgan of Ireland; Prof. G. Bruni of Italy; Prof. Adolfo P. Castanares of Mexico; Dr. Alfred Sinding-Larson of Norway; Mirza Ali Kuli Kahn of Persia; Dr. Paul Walden of Russia; Prof. Dr. Knut Wilhelm Palmaer of Sweden; Dr. F. P. Treadwell of Switzerland; Dr. James Moir of the Union of South Africa; and Sir William Ramsay of England.

The bearers of tickets for ladies accompanying members were welcome at all social functions, and the receptions, teas, organ recitals, general lectures, etc., were graced by the presence of many lady guests. A number of New York Ladies' Committees and Sub-Committees had been organized for the reception of the lady guests of the Congress, an enjoyable program had been prepared for the entertainment of these, and the Ladies' Committees did everything for the comfort and pleasure of the visiting ladies.

On Friday, Sept. 6, the General Meeting of all the Ladies' Committees (except the Reception Committee) took place at 10.00 A.M. at Columbia University; this was followed, in the morning, by an informal reception and welcome to the guests at Columbia University, and, in the afternoon, by a lecture on "Communal Work of Woman in America" in Rumford Hall, Chemists' Club. On Monday, Sept. 9, the lady guests enjoyed automobile trips in the morning, a luncheon at the "Claremont" at 1.00 P.M., and the informal tea at the College of the City of New York at 5.00 P.M. The following day, Sept. 10, the visiting ladies had, in the morning, the choice of one of the following two automobile trips, starting from the Chemists' Club: (1) Public Library, Tiffany's and the Metropolitan Tower; (2) Aquarium, Down-town Section, and the Stock Exchange. At noon the ladies and their gentlemen escorts visited Gimbel's Department Store; after this inspection a luncheon was served by Gimbel's in their Tea Room. Later in the afternoon a number of the ladies repaired to the College of the City of New York to attend the informal tea. On September 11, there were automobile trips in the morning and a concert in Rumford Hall, Chemists' Club, and an informal tea in the afternoon; the next morning an enjoyable boat excursion about New York Harbor, starting from 42nd St. and the North River.

THE CLOSING SESSION.

The Eighth International Congress of Applied Chemistry which had been in session in Washington and New York since September 4, officially closed with a business meeting at noon, September 13 in the Great Hall at City College. Dr. Nichols, the President, presided and a number of important business matters were considered.

A resolution to adopt Esperanto as the official language for the Congress was referred to the Ninth Congress for consideration and decision. The resolution to fix the periods for the meetings of the Congress five years apart instead of three was defeated and the meeting of the Ninth Congress was definitely fixed for 1915. The plan to standardize atomic weights for periods of five years instead of the present annual revision was changed to three years.

St. Petersburg was selected as the meeting place for the Ninth Congress and Professor Dr. Paul Walden, Professor of Chemistry, Polytechnical School of Riga, was elected President, and Professor Dr. Demetrius P. Konovaroff, Emeritus Professor of Chemistry in the University of St. Petersburg, and now Assistant Minister of the Department of Commerce and Industry in Russia, was elected Honorary President.

The gavel was formally passed by President Nichols to the newly elected President, Professor Walden, and the Eighth International Congress of Applied Chemistry, which was the most successful ever held, was officially closed.

FACTORY VISITS AND EXCURSIONS.

Great interest was shown by the visitors to the Congress in the facilities offered to inspect manufacturing plants. There was little time available for factory excursions during the meetings, but a number of very interesting trips were arranged for Saturday, September 14.

About one hundred and fifty members visited the Consolidated Gas Works at Astoria, L. I. This excursion was under the personal direction of Dr. Arthur

H. Elliott, the company's consulting chemical engineer; he was able to show the largest gas works in the world, producing both coal gas and water gas, in full operation. The Consolidated Gas Company furnished a special boat which transferred the visitors from the East 21st Street pier to Astoria and return.

The Corn Products Refining Company took a party of one hundred members under the guidance of their Chief Chemist, Dr. H. C. Humphreys, to their plant at Edgewater, N. J.

Dr. W. H. Nichols extended an invitation to about one hundred and fifty foreign guests to join a special boat trip to visit the works of the Nichols Copper Company at Laurel Hill, L. I. After inspecting the plant which has a daily output of 1,000,000 lbs. of refined copper, the party was entertained at lunch on board the boat during a short trip up Long Island Sound.

The Standard Oil Company conveyed a party of about two hundred visitors by special boat to their Queens County Works in Brooklyn. This excursion was under the direction of Mr. Gail Mersereau, formerly chemist for the Standard Oil Company, and Dr. Otto Kress, of Columbia University. The guests spent several hours in the plant and were keenly interested in the work.

One of the most interesting excursions in and about New York was the visit of a large party to the plant of the Bush Terminal Company in Brooklyn. This unique enterprise which constitutes probably the largest group of buildings in the world, planned for and devoted exclusively to various lines of manufacture, is located on the water front and is provided with every facility for the in and out transportation of goods.

On Monday, September 16, the excursions through the west left New York, *via* Pennsylvania Railroad. These excursions were organized by the Inland Transportation Committee under two heads to meet the convenience of the guests.

The Short Trip visits Philadelphia, Pittsburgh, Niagara Falls, Detroit, Chicago, Cleveland and Boston.

The Long Trip will extend to the Pacific Coast and will visit Philadelphia, Pittsburgh, Niagara Falls, Detroit, Chicago, Omaha, Denver, Glenwood Springs, Salt Lake City, Bakersfield, San Francisco, Los Angeles, Grand Canyon of the Colorado, Shreveport, New Orleans, Birmingham, Atlanta, Ducktown and various other points of interest in the south, returning to New York on October 22.

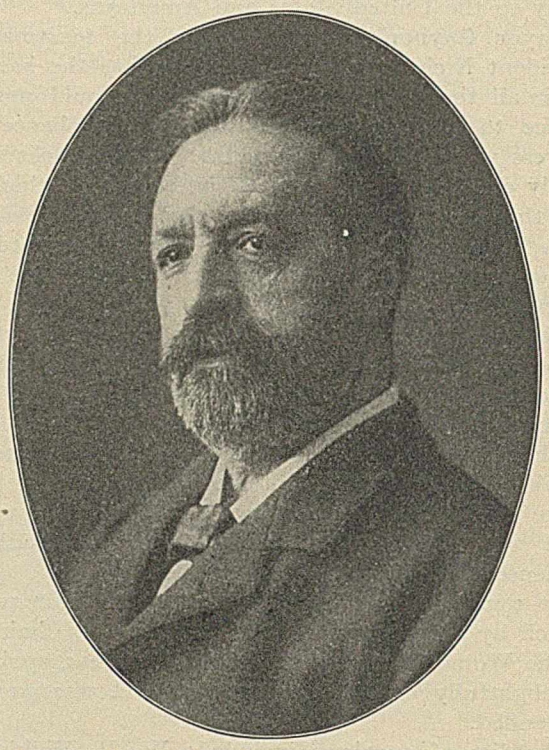
The Congress has organized along the entire route of these excursions, local committees for the entertainments of the guests, and much of the time will be devoted to the inspection of the principal industries of the localities visited. The two excursions are under the management of Dr. Geo. D. Rosengarten and Dr. David T. Day, both of whom will accompany the party throughout the trips.

THE SOCIETIES AT THE CONGRESS.

SOCIETY OF CHEMICAL INDUSTRY.

An informal reception was given at the Chemists' Club on Saturday, August 31, by the New York Section of the Society of Chemical Industry to visiting guests. This reception was very well attended. Refreshments and music helped to make the event enjoyable.

The Annual General Meeting of the Society was



RUDOLPH MESSEL, PRES. SOCIETY OF CHEMICAL INDUSTRY.

held on September 3, at 10 A.M., at the Chemists' Club. The address by the Retiring President, Dr. Rudolph Messel, is printed elsewhere in this issue.

The following are interesting abstracts from the Report of the Council:

"The number of members of the Society is now 4273 as compared with 4300 at the last Annual Meeting. During the year 225 new members have been elected as compared with 245 last year; and the losses have been 253 as compared with 244 last year.

"The Journal in 1911 numbered 1478 pages of text besides supplement and advertisements, as against 1482 pages in 1910. On the recommendation of the Publication Committee, the list of British patent applications has been placed in the Supplement in such a way that it can be bound with the Journal if desired.

"The Council has appointed the President, Dr. Messel, F.R.S., to represent the Society on the Governing Body of the Imperial College of Science and Technology in the place of the late Dr. Divers, F.R.S. The Council will be glad to receive suggestions in connection with the establishment of an efficient system of education in Chemical Technology.

"Mr. Thos. Tyrer has been elected a representative of the Society on the Board of the National Physical Laboratory. A special Committee of the Laboratory has just commenced an investigation into the properties of glass for optical and other scientific purposes.

"The Society is taking part with other institutions in several inquiries of common interest; with the Textile Institute as to the dyeing of textiles with indigo,

with the Chemical Society into the possibility of so preparing abstracts as to avoid duplication, and with the Institute of Metals in considering the nomenclature of non-ferrous alloys. It has also taken part in a recent conference on the International Interchange of Students.

"The Royal Commissioners for the Exhibition of 1851, who have recently established a system of Industrial Bursaries, and are subsidizing young graduates in science who propose to take up industrial positions, have invited the Society to express its opinion thereon. Great diversity of opinion on the subject was expressed by the Sections, and the Council sent to the Commissioners a synopsis of the various views expressed. The Royal Commissioners have expressed their indebtedness to the Society for its assistance.

"The Society's medal, founded in 1896, and awarded once in every two years for conspicuous service rendered to Applied Chemistry by research, discovery, invention or improvements in processes, has this year been awarded to Sir William Crookes, O.M., F.R.S., for his epoch-making discoveries in physical chemistry and the rare metals.

"At the celebration of the 250th Anniversary of the foundation of the Royal Society, the Council was represented by the President of the Society who presented an address. A copy of this address appeared in the Journal for July 31.

"An International Exhibition will be held in San Francisco in 1915 to mark the opening of the Panama Canal, and the Board of Trade has expressed the opinion that Great Britain should take part in it. The Council of the Society is of the same opinion and trusts that the Exhibition will be supported by the Chemical Industry."

The President-elect of the Society is Marston Taylor Bogert, LL.D., Professor of Organic Chemistry in Columbia University.

The next annual meeting of the Society will be held in Liverpool, England.

The Annual Banquet of the Society of Chemical Industry, the most important social event of the annual meeting, took place on September 13th, at the Waldorf-Astoria Hotel. This banquet was attended by about two hundred and fifty persons, including many distinguished foreign guests.

The President, Rudolph Messel, Ph.D., F.R.S., occupied the chair, and the President-elect, Marston Taylor Bogert, acted as Toastmaster. The Toasts of the evening were:

"*The President of the United States,*"

"*The King of Great Britain and Ireland,*"

"*The Society of Chemical Industry,*" by Rudolph Messel, Ph.D., F.R.S.

"*New York,*" by Chas. F. Chandler, D.Sc., M.D., Ph.D., LL.D.

"*The Eighth International Congress of Applied Chemistry,*" by William H. Nichols, M.S., LL.D., D.Sc.

"*Our Guests,*" by J. Joyce Broderick, Esq., Acting British Consul.

"*The Ladies,*" by Mr. Lewis Sayre Burchard.

"*Science,*" by Sir William Ramsay, K.C.B., D.Sc., F.R.S.

VEREIN DEUTSCHER CHEMIKER.

After sight-seeing trips to Coney Island on Saturday, and in New York City on Sunday afternoon, the Verein met in Havemeyer Hall, Columbia University, on Monday, September 2, for a business meeting and lectures. The President, Geheimrat Prof. Dr. Carl Duisberg, occupied the Chair and made the opening speech, sketching the progress of the Verein from its foundation in Frankfort in 1887 by twelve German chemists, to the present growing membership of five

CARL DUISBERG, PRES. VEREIN DEUTSCHER CHEMIKER.

thousand. This meeting was a continuation of the 25th anniversary of the Verein held in Freiburg last Spring, and was largely attended, about three hundred and fifty people being present.

The Mayor of New York, represented by Mr. Speer, President of the Borough of Brooklyn, welcomed the Verein to New York.

Dr. Charles F. Chandler made the address of welcome (in German) for the American chemists. The Austrian chemists were represented by Prof. Dr. Rudolph Wegscheider, of Vienna. Official telegrams of welcome were sent to President Taft and the German Emperor.

Two lectures followed:

First: "*The Scientific and Technical Importance of Tar-phenols:*" Dr. F. Raschig, Ludwigshafen am Rhein.

Second: "*Thirty-two Years in the United States as Chemist and Manufacturer:*" Dr. F. W. Frerichs, of St. Louis.

The Verein took dinner at 1 P.M. at the Claremont Inn.

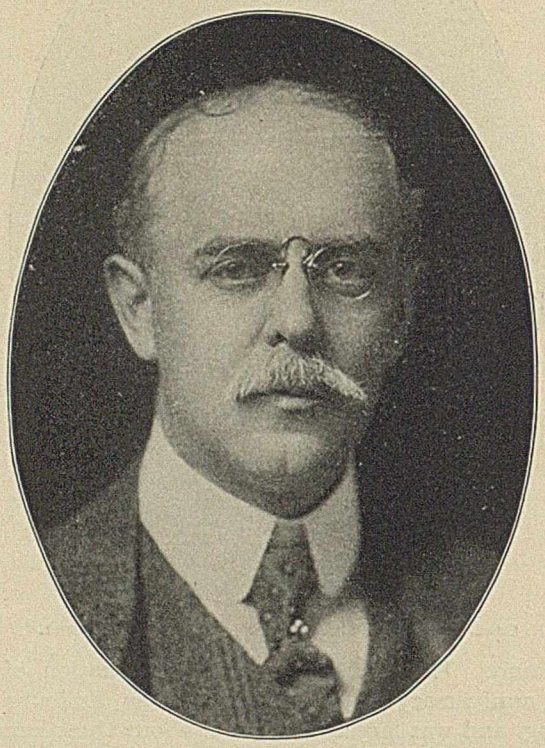
The ladies of the party spent the evening at the Knickerbocker Theatre, going to the Ritz-Carlton

Hotel for a collation after the performance.

The gentlemen attended a Kommers held by the Verein at Arion Hall. Dr. Hugo Schweitzer presided. The many addresses were well received. There were many salamanders and a "Bierspiel" full of typical German fun. The whole affair was one of considerable vivacity; the hall was crowded and the Kommers will remain in the memories of those present as a successful and enjoyable event.

AMERICAN CHEMICAL SOCIETY.

The Annual Meeting of the Council of the Society, presided over by President Arthur D. Little, took up the question of changing the dates of the annual meetings from July and December to the Spring and Fall months; this was discussed and is to be referred to a mail vote of the Society. Important changes



ARTHUR D. LITTLE, PRES. AMERICAN CHEMICAL SOCIETY.

in the Constitution were passed and recommended for adoption by the membership. A number of other business matters were disposed of and will be duly reported in the Proceedings of the Society.

The Regular Annual Meeting was held at the College of the City of New York, and took up only routine business. All of the scientific and social features which usually accompany the annual meeting were incorporated in the various functions of the International Congress.

The Society officially entertained the International Congress by a very successful reception at the Metropolitan Museum of Art.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.

The annual business meeting of the Institute was held in Rumford Hall, Chemists' Club, Thursday, September 5, with Dr. L. H. Baekeland presiding. The greater portion of the time was given over to a discussion of the report of the Committee on Ethics, Mr. G. W. Thompson, Chairman. After a few minor amendments, the report was adopted by the council and will now be submitted to the membership for approval, after which it will be published.

LEO. H. BAEKELAND, PRES. AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.

The Institute banquet, which was very well attended by members and guests, was held in the dining-room of the Chemists' Club following the meeting. Dr. C. F. McKenna presided as toastmaster and responses were given by Dr. L. H. Baekeland, Mr. G. W. Thompson, Prof. Wm. P. Mason, Prof. C. F. Chandler, and Dr. Samuel Rideal of London.

Members of the Institute contributed a number of important papers at the sectional meetings and participated in all of the social events of the Congress.

CHEMISTS' CLUB.

The members of the Club constituted the reception wing of the Congress. They met the steamers, pro-

MORRIS LOEB, PRES. CHEMISTS' CLUB.

vided for the clearing and transportation of baggage, arranged hotel accommodations, and rendered invalua-

ble services in attending to the comforts of the visitors. The Club was a center of activity both in and out of season and its popularity as a meeting place and social center must have been a source of great pride to its officers and founders.

A number of brilliant receptions and entertainments were given at the Club, notably the reception to the visiting members of the Society of Chemical Industry on August 31, the luncheon to the members of the Society of Chemical Industry on September 3, the reception by Dr. and Mrs. Loeb to the Latin-speaking visitors to the Congress on September 2 and the Club reception to Congress visitors on September 10.

AMERICAN ELECTROCHEMICAL SOCIETY.

The twenty-second general meeting of the Society was held in joint session with the "Electrochemistry" section of the Eighth International Congress. In addition to the scheduled papers belonging jointly to the Society and the Congress, the following special papers were presented:

"*On the Electrolytic Refining of Silver-Bismuth Alloys*," by William N. Lacey.

"*The Electrical Resistivity of Fire-bricks at High Temperatures*," by A. Stansfield, D. L. McLeod and J. W. McMahon.

"*Fixation of Nitrogen by Alumina and Carbon*," by S. A. Tucker and Henry L. Read.

To avoid confliction with the special arrangements made by the different Committees of the Congress, no excursions or other special forms of entertainment were planned by this Society. The excursions of the Congress, however, were open to those members who were also members of the Congress.

W. LASH MILLER, PRES. AMERICAN ELECTROCHEMICAL SOCIETY.

ORIGINAL PAPERS

CONTROL OF DUST IN PORTLAND CEMENT MANUFACTURE BY THE COTTRELL PRECIPITATION PROCESSES.[1]

By WALTER A. SCHMIDT.

The control of the dust arising from the rotary kilns in the manufacture of Portland cement is continually becoming a more serious problem. This is partly the result of the enormous growth of the Portland cement industry which now demands factories of such magnitude that the large volumes of gases leaving the stacks carry enormous quantities of dust into the atmosphere, but is probably more directly attributable to the present trend of public opinion, which continually demands a more thorough control of fumes and smokes.

The question of the proper relationships which should exist between the factory and the surrounding inhabitants has become a very important social problem. At the present time a large amount of hardship is being caused by improper action on one side or the other, often substantiated by our courts on the ground of mere technicalities. This is a problem which should receive the closest and most thorough study by a competent body in an endeavor to establish such laws as will draw a line of equity between the different parties coming into contact through the development of our modern industries.

Should every smelter, refinery and like industry emit poisonous and noxious fumes from its stacks and all other factories permit smokes and dusts to escape in unrestricted quantities, life in any large industrial center would be unbearable. On the other hand, however, most industrial furnace processes cannot be conducted without the production of large volumes of gases which usually carry from the furnaces volatilized materials and solid particles, these solids being swept along by the heavy rush of the gases. As the factories grow in size and number the damage and "nuisance" caused by the fumes and dusts usually assume most aggravating magnitudes and, after a certain mark is reached, control of the annoying material in the stack gases becomes a necessity. At the outset we are, therefore, confronted with two conflicting factors, *first*, the one from within the factory, which in many instances makes it utterly impossible to prevent the formation of dusts, fumes and smokes in the manufacturing processes; and, *second*, the one from without, which makes it equally impossible to permit these materials to escape into the air, due to the damage to the surrounding country. A further complexity arises from the fact that the surrounding country very often demands the maintenance of the factory for its own continued prosperity.

It is readily seen, that to permit a problem of such conflicting interests to take its course without thorough

[1] Paper presented at the Eighth International Congress of Applied Chemistry, New York, September, 1912.

study and guidance, is bound to work hardship upon one party or the other, and, of necessity, will result in such unjust proceedings as have at times closed some of our most important industrial establishments or permitted other factories to continue causing damage to the territory surrounding them. A vital question confronts the people to-day in this regard,

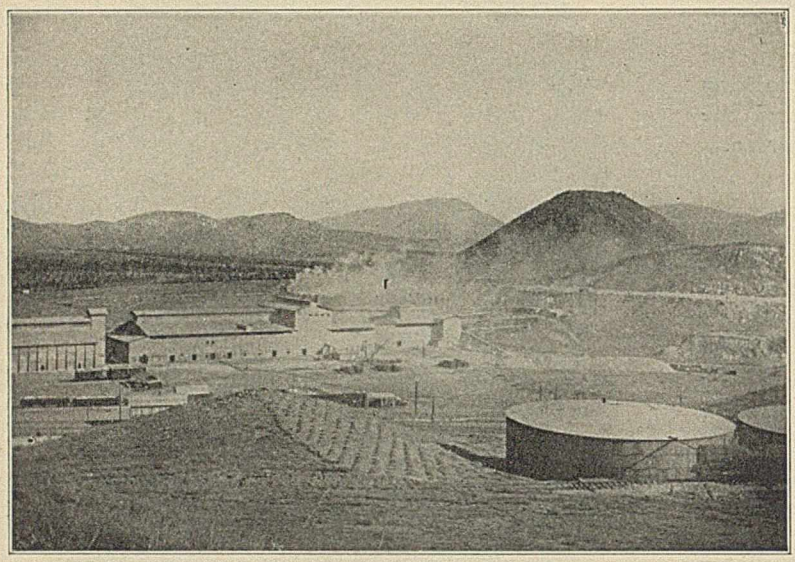


FIG. 1.

in the establishment of a rational relationship between the different parties, taking into consideration the various questions entering into the rapid changes of our present-day industrial development.

The problem of relationships between factory and farmer has become extremely critical in Southern California with the cement industry, where the dust arising from the two large factories, the Riverside Portland Cement Company at Riverside, California, and the California Portland Cement Company at Colton, California, settled upon the orange and lemon groves in the vicinity, causing some damage. It would be out of place in this paper to comment upon the actual damage done, as all of the court testimony presented has so far thrown little light upon actual results. Whether the dust really does cause any injury to the trees is a question of minor importance in this particular locality, as the dust makes the groves unsightly and the farmers are convinced that actual damage has been done.

The Riverside Portland Cement Company experimented with numerous methods in an endeavor to control the dust arising from their factory, with little encouraging results, and two years ago the writer undertook the work of applying the Cottrell electrical precipitation processes to this new problem.

The Cottrell processes were invented and developed by Dr. F. G. Cottrell, now of the United States Bureau of Mines, but until recently of the Chemistry Department of the University of California. These processes were first developed in connection with the problems arising in the manufacture of sulphuric acid by the contact process. After the successful control of these acid mists, the processes were applied to smelter fumes, aiming directly at the control of the sulphuric acid in these gases. The first plant has now been in steady operation for over five years, operating upon the parting flue in the refinery of the Selby Smelter on San Francisco Bay. The processes were later applied to the larger problem of general smelter fume control. No attempt will here be made to go into detail regarding the work with these processes in this field, as the early history of the processes was quite thoroughly discussed in an article published a year ago in THIS JOURNAL[1] and has since been extensively abstracted in other journals.[2] Further, Mr. Linn Bradley is presenting a paper to the Metallurgical Section of the Congress upon the recent work done in this field of application.

In undertaking the application of the Cottrell processes to the problem of collecting the dust in cement mills, a large number of new factors had to be dealt with, as all work done previously had been conducted upon cool moist gases either containing large quantities of water vapor, acid fumes or similar materials, all of which gave distinct electrical characteristics to the gases. The primary factors in cement work are dry non-conducting gases, non-conducting dust particles, intense temperatures, large volumes of gases and large quantities of solid material carried by the gases. It is a fair estimate to assume as an average figure that a rotary kiln 100 feet long and 7 feet in diameter, oil-fired as on the Pacific Coast, has a volume of stack gases of 50,000 cubic feet per minute; the gases above the combustion zone in the stack have a temperature of about 450° C. and carry dust aggregating between

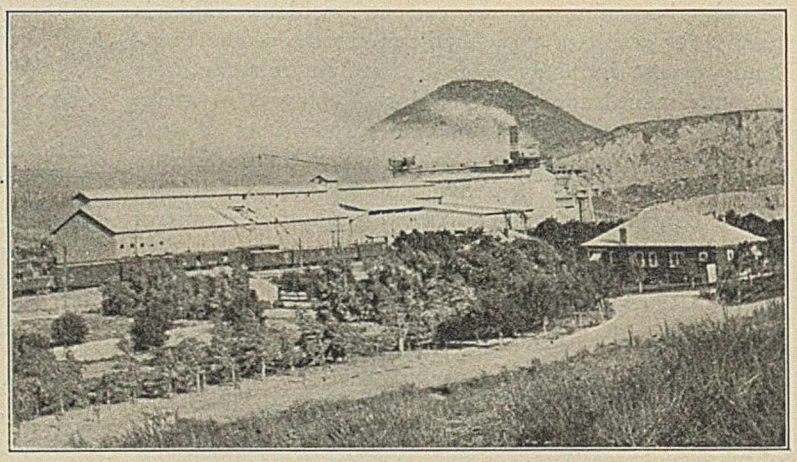


FIG. 2.

four and five tons per day of twenty-four hours.

[1] "The Electrical Precipitation of Suspended Particles," THIS JOURNAL, Aug., 1911.

[2] *Mining and Scientific Press*, Aug. 26, 1911; *Scientific American Supplement*, Sept. 30, 1911; *Engineering and Mining Journal*, Oct. 14, 1911; *Engineering News*, Oct. 26, 1911; *Metallurgical and Chemical Engineering*, March, 1912; *Cement and Engineering News*, April, 1912; Rauch and Staub, April, 1912.

The plan which was first suggested for handling these gases was to turn all gases from the entire factory into one general flue and conduct them to such a point as would bring the temperature within the region of our past experiences. It was soon found, however, in our first tests, that the dry gases presented entirely different electrical characteristics than were encountered in treating the gases from smelter stacks, and it was later found that the high temperature facilitated the uniformity of the electrical discharge. The plan adopted therefore was to treat the gases at as high a temperature as was permitted by the properties of the structural material used in the treating apparatus. By using ordinary steel, it is quite possible to work at the average temperature of the stack gases, namely 450° C., provided however that the abnormal temporary rises in the temperature in these gases are prevented. The question necessarily arose regarding the possibility of maintaining satisfactory factory operation if we attempted to regulate the stack temperature too closely; extensive tests were undertaken in pyrometric control of the same. Work done during the past year has shown that by installing recording pyrometers in the proper place in the stacks and placing the instruments so that the "burners" can keep close watch upon them, it is an easy matter to regulate the fires in such a way as to give practically a uniform temperature in the stacks.

It was the first plan at the Riverside Portland Cement Company to connect all ten stacks by a common flue which should conduct the gases into a general treating apparatus, but the factory engineers decided that it would be preferable to maintain individual control of the kilns. As the factory design was such as to prevent installing this form of apparatus upon the ground, it was decided to allow the entire stack structure to remain intact and treat the gases after they left the existing stacks. These stacks are eighty feet high

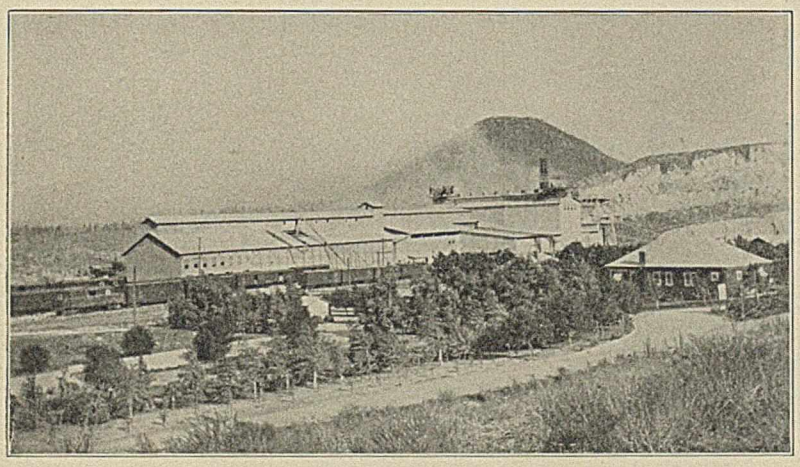


Fig. 3.

and at this level has been constructed a platform upon which the entire apparatus has been placed. In order to test out what effect the apparatus has upon the kiln conditions, we passed the gases through the treater and directly into the air alternately without having the "burners" know the direction of flow of the gases. Sensitive recording radiation pyrometers failed to indicate any effect, either in the temperature of the stack gases or of the burning zone in the kiln.

It might be well here to say a few words regarding

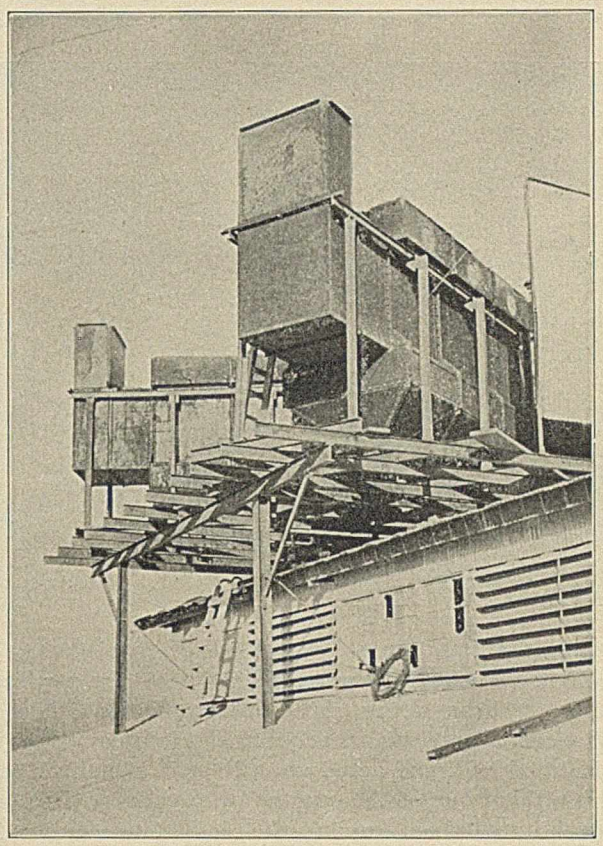


Fig. 4.

the underlying principle of the Cottrell electrical precipitation processes, for those who are not acquainted with them or who have not the time to read the references cited. The principle consists of bringing the dust-laden gases under the influence of a series of electrodes, some of which maintain a "silent" or "glow" discharge. By virtue of the discharge, the space between the electrodes becomes filled with gaseous ions and the dust particles passing through this space become charged by having these ions impinge upon them, imparting their ionic charges to the particles. The charged particles are then passed through an intense electric field which causes them to migrate in the direction of the field, which in the commercial apparatus is arranged transverse to the direction of the flow of the gases. The dust particles are by this action drawn out of the gases and deposited upon the electrodes, the gases being permitted to go their way unaffected and emerge from the treating apparatus freed from the solid particles which had been held in suspension.

The distinct advantage which this process has over mechanical processes arises from the fact that the

gases themselves play no part in the action in the treater, except as carriers of electricity. In all mechanical processes the entire volume of gas must be acted upon in such a way as to take advantage of the differences in specific gravity between the suspended particles and the gases themselves, or some similar action. In electrical processes the gases are permitted to pass through the apparatus unaffected while the particles themselves are taken hold of individually by the electrical field and acted upon in such a manner as to draw them out of the current of advancing gases and precipitate them upon the collecting electrodes. In order to maintain a definite direction of migration of the dust particles, the electrodes must be given a unidirectional electrostatic charge which, in the commercial apparatus, is generated by rectifying a high tension alternating current. In the commercial apparatus the potential varies under different conditions from 20,000 to 40,000 volts.

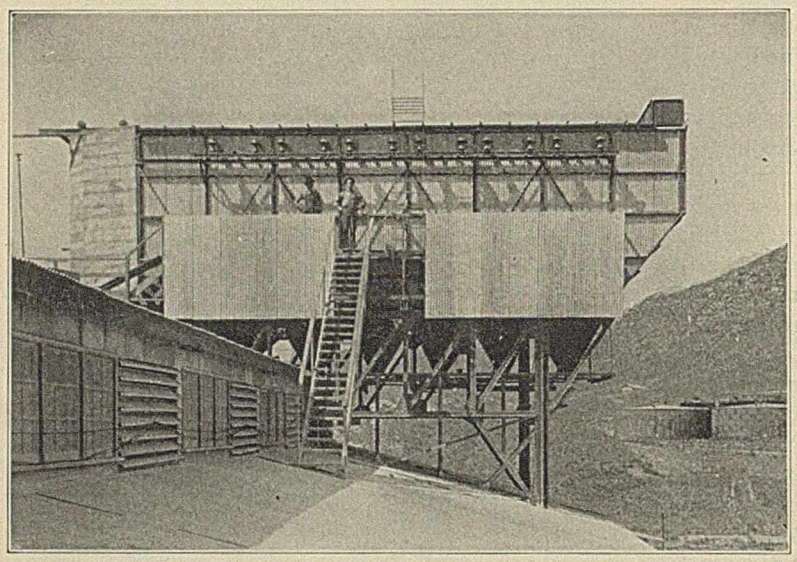


Fig. 5.

The electrode system consists of two forms of electrodes: *first*, the discharge electrodes, which are made in various forms, depending upon conditions, but are always of a light construction and are so chosen as to maintain a heavy electrical discharge from them; *second*, the collecting electrodes upon which the solids are precipitated. These are usually of a heavy construction and the form and arrangement are so chosen that no discharge takes place from their surface. The two forms of electrodes are alternated across the apparatus with an electrode spacing of from two to six inches, this distance varying with the conditions to be met. A series of these rows of electrodes is placed in the treater so that the dust particles are brought under the successive action of this series of electrodes. The length of the treater is so chosen as to affect the desired cleaning of the gases. The cross section of the apparatus is made such as to bring a balance between the two forces acting upon the suspended particles, namely, the frictional force tending to carry the solid particles along with the gases and the electrical force tending to draw the suspended particles out of the advancing current of gases.

In the installation at the Riverside Portland Cement Company the treater has a cross section of 12 × 16 feet, and an over-all length of 20 feet. As stated above, the apparatus is placed upon a platform constructed at a height corresponding to the top of the original stacks, namely, 80 feet above ground. Upon this platform is placed a short stack extension which extends through the roof of the building structure and is supplied with a damper of special design. Upon either side of the stack is placed a complete electrical treater separated from the stack extension by a large louvre damper. By means of these three dampers, the gases can either be conducted through one or the other or both treating chambers or emitted directly into the atmosphere as occasion may warrant. Each stack is equipped with two treaters so as to have an auxiliary apparatus for each kiln. In case one treater should be shut down for repairs, cleaning or the like, the other treater will be able to take care of the gases with moderate efficiency. Under normal conditions the gases are passed through both treaters, insuring a thorough cleaning of the gases. The electrode spacing is here chosen at 6 inches and there are twenty rows of discharge electrodes in series. The dust is precipitated upon the collecting electrodes which are cleaned once every three or four hours by being given a mechanical rapping, this action being made automatic to the extent that the operator merely puts an electric motor into operation. The dust falls into hopper bottoms from which it is again conducted into the bins feeding the rotary kilns. Each treater is

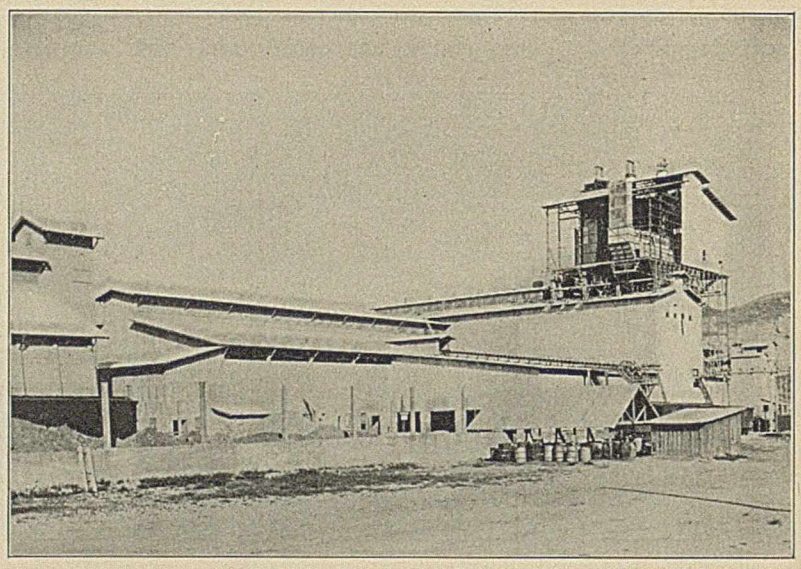


Fig. 6.

supplied with a small outlet stack 20 feet high which is sufficient to compensate for the resistance offered to the gases by the treater. As stated above, sensitive pyrometers do not indicate any change of temperature in the kilns or stacks when the gases are permitted to escape directly into the atmosphere or are passed through the treater.

The operating costs of the apparatus are low. A complete treater of the size described consumes approximately $7^1/_2$ kilowatt hours. This includes electrical energy for all motors. A 5,000 barrel mill will, therefore, consume approximately 75 kilowatt hours in an entire installation. The manual labor required consists of one man per shift, of the character of men ordinarily employed to run electrical mill machinery. It is, however, usually advisable to have an extra man on duty. There is no deterioration in the apparatus under steady running and the machinery is subject to exactly the same wear as any other piece of electrical machinery.

In the series of photographs shown, Fig. 1 shows the factory as it appeared in 1910 with the experimental flue No. 1 and laboratory on the ground in front of the building. Fig. 2 gives a closer view and shows the initial experimental installation of two small precipitating units on the roof of the kiln room and just above the middle of the picture. The first full sized treater is at the right or opposite end of the row of stacks; Figs. 2 and 3 represent pictures taken 1 minute apart and show very plainly the effect of turning on the electrical current in the treater. In Fig. 3 the solid particles are all retained in the treater; the smoke from the other nine kilns is, of course, unaffected. Figs. 4 and 5 are views of experimental treaters built on the top of the stack. Fig. 6 is the first part of the permanent installation.

One important question which has grown out of the present work at the Riverside Portland Cement Company lies in the possible utilization of the collected material as a source of potash for fertilizer purposes. This factory does not use clay in its raw mix but a decomposing feldspar which has a considerable potash content. In the burning of the cement the potash is volatilized and condenses again in passing up the stack. The greater part is caught in the electrical treater along with the dust which gives a dust containing considerable potash value. Experiments have been conducted for some little time in the endeavor of utilizing this material either directly as a fertilizer "filler" or extracting the potash from the material with the aim of obtaining a concentrated potash salt. This work is not sufficiently far advanced to permit publishing definite figures.

Dr. F. G. Cottrell, inventor of the process, is presenting a paper to this Congress before the Section of Conservation and Political Economy upon what he has termed "An Experiment in Public Administration of Patent Rights." This deals with the recently organized "Research Corporation" to which Dr. Cottrell and his associates have given the Patent Rights to the processes for all of the United States except the six western states and the application of the processes to the Portland cement industry. These latter rights, along with the foreign holdings, are retained by the parent companies, the Western Precipitation Company and the International Precipitation Company, with offices at Los Angeles, California.

LOS ANGELES, CALIFORNIA.

CONTACT SULPHURIC ACID FROM BRIMSTONE.[1]

By G. W. PATTERSON AND L. B. CHENEY.

The plant we purpose to describe was erected in 1907 at the U. S. Naval Proving Ground, Indian Head, Md., for the manufacture of acid used in making smokeless powder. It was designed by the New Jersey Zinc Co., which controls the Schroeder patents in this country.

With a rated capacity of six tons, it was operated successfully for three years, burning pyrites from New York and Virginia in O'Brien burners. During the last two years, Louisiana brimstone has been used entirely. The reason for changing raw materials was primarily to increase capacity without enlarging the plant, and it was hoped incidentally to reduce costs, notwithstanding the large increase in price per unit of sulphur. Our expectations have been fully realized in both respects.

The installation will be described under four heads: burner and gas cooling system, gas purifiers, conversion system, and absorbing system. The burner is housed in a detached frame building, 19 ft. × 32 ft., with sulphur store sheds adjacent. A frame building, 52 ft. × 60 ft., contains the conversion and absorbing systems. The gas cooling and purifying systems are in the open at the rear of the two buildings, in part protected by an open shed.

The burner is known as the Tromblee and Paull burner and has been most satisfactory. It consists of a horizontal cylindrical iron shell 8 feet long and 3 feet in diameter with conical ends, revolving on its axis once in two minutes. At one end is a hopper and worm feed with sliding dampers. The other end connects with a rectangular cast iron box of 37 cu. ft. capacity, provided with sliding damper and vertical cast iron uptake pipe. This pipe leads to a brick dust catcher such as is ordinarily used with pyrites burners. The dust catcher merely cools the gas, as no appreciable amount of sulphur is carried beyond the combustion box.

The burner is rated at 5500 lbs. per day, but there has been no difficulty in burning 6000 lbs. per day. Before feeding to the hopper, the sulphur needs no other preparation than breaking up large lumps with a shovel. When forced along by the worm, the sulphur melts just before it drops into the body of the burner, and a sufficient amount of melted sulphur is always present to form a complete liquid coating on the inside of the shell as it revolves. The combustion box and vertical uptake complete perfectly the combustion of any sulphur which is volatilized from the cylinder.

The special advantages of this burner are ease in controlling composition of gas, low cost of upkeep and

[1] Paper presented at the Eighth International Congress of Applied Chemistry, New York, September, 1912.

freedom from losses. Once in about two months it is necessary to clean out the dross which collects in the cylinder. To do this, or to prepare for a shut-down for repairs in any other part of the plant, the sulphur charge is allowed to burn out completely. Any residue in the cylinder is then easily removed by a hoe. Starting the burner after cleaning, or even when it is cold, is a simple operation and no losses occur.

At the exit from the dust catcher the gas has cooled to a temperature of about 230° C. At this point it enters the purifying system, consisting first of 250 linear feet of horizontal lead pipe arranged in tiers in a wooden rack. All gas passes through this total length of pipe. This pipe is cooled by a water spray, and here is deposited a small quantity of weak sulphuric acid formed in burning the sulphur. The acid deposited is, however, slight in comparison with the amount collected at the same point when pyrites was burned. The lead pipe connects with a large lead-lined box containing coke and here a further deposit of weak acid is obtained. Up to this point also is formed a slight deposit of carbonaceous matter from the asphaltic material which Louisiana brimstone always carries in small quantities.

From the coke box the gas passes to two wet scrubbers in tandem. Each scrubber outfit consists of a vertical lead cylinder with conical top, about 4 ft. high, a lead pot provided with lead cooling coils for water, and an air lift for circulating constantly a stream of sulphuric acid from the pot to the scrubber. The scrubber is divided horizontally by perforated diaphragms. The acid washes and dries the gas thoroughly and flows out through trapped pipes in a weakened condition to the pot. A pot holds 2500 lbs. of acid and is constantly strengthened to a gravity of 1.75 by the addition of strong acid. The excess acid formed at this point is collected in an egg and can be forced by air pressure to the weak acid supply used in the absorbing system. The air lift was designed by one of us (Patterson) to replace the ordinary bubbler formerly used. Only 5 lbs. air pressure is used, raising 80 lbs. of acid per minute, and the top of the lift is gas-tight, the air being piped to the gas system preventing any loss of SO_2 at this point.

From the scrubbers the gas passes to a second lead-lined coke box exactly like the first one and thence to a pair of dry filters in parallel. Each dry filter consists of three superimposed lead-lined iron trays luted together. Each tray contains a mat of dry asbestos fiber supporting a quantity of slag wool. A reserve set of these filters is kept ready for use as they require to be renewed about once in four weeks. The entire charge for two filters is 30 lbs. of asbestos and 400 lbs. of slag wool. The dry filters complete the purification process and the gas is then carried into the main building. Throughout the purification process the gas comes in contact with no other metal than lead, but beyond this point either cast iron or wrought iron is used entirely.

Within the house, the gas first passes through a positive pressure blower, by regulating the speed of which the composition of the entrance gas is controlled, and the movement of gas through the whole system is completed. Manometers on either side of this blower show a suction of 1.5″ of mercury and a pressure of 0.75″ of mercury. Just forward of the blower is the sampling pipe where the composition of entrance gas is tested by the usual iodine solution.

The next step in the process is the conversion system which includes a preheater and converter. The preheater is a series of vertical iron U pipes and headers housed in a furnace heated by soft coal to give to the gas an initial temperature of 380°C., this being required for proper catalytic action by the contact mass.

The converter is placed close to the preheater and is a vertical cast iron cylinder 6 ft. in diameter and $8^1/_2$ ft. high, composed of 5 horizontal sections. Each section contains a wire mesh tray for supporting the contact mass and a baffle to properly spread the gas. The contact mass is anhydrous magnesium sulphate carrying two-tenths of one per cent. metallic platinum in finely divided condition. A total quantity of 5900 lbs. of mass which is in coarse granules is spread on the trays to a depth of 14–16 inches, leaving a space of about 6 inches between mass sections. The gas enters the bottom of the converter and leaves at the top, pyrometer tubes being provided to read the gas temperature before entrance and in each section. From the converter the gas passes through 180 feet of iron pipe to the absorber. This pipe is air-cooled in order that the temperature of the gas may be sufficiently low for good absorption.

The absorbing system consists of a tower absorber, an acid-cooling pipe, a weak acid mixer and reservoir, a head tank for strong acid, an acid pump, and collecting tank. The tower is a vertical cast iron cylinder $15^1/_2$ ft. high resting on a cast iron base, the top being covered by a perforated plate from the center of which rises the exit pipe for waste gases. The tower is lined with acid tile and packed with quartz rock. The gas enters on one side near the bottom. A constant stream of acid is supplied by the pump to the top plate, percolates through the mass of quartz and passes out at the bottom of the tower to the cooling pipe. This is a horizontal water-cooled U pipe, one leg of which carries an overflow pipe connecting with the pump and the collector. The acid supplied to the top of the tower is kept at a temperature of 70° C. and has a strength of 99.5 per cent. H_2SO_4. The strength of the acid leaving the bottom of the tower is reduced by the constant addition of a small stream of 75 per cent. H_2SO_4 just before it enters the cooler.

The reservoir of this weak acid, the mixer and strong acid head tank are mounted on a platform in the center of the building at a sufficient elevation for the acid to flow by gravity. The reservoir is an open lead-lined box holding 1000 gallons. The mixer is a lead pot provided with lead coils for cooling water and a special mixing pipe designed by one of us (Cheney) in which water and strong acid are brought in contact. The mixing pipe consists of two heavy $^3/_4$″ lead pipes set at an angle of 30° and held together by a heavy lead sheath burned onto a short length of $1^1/_2$″ lead pipe. One of the $^3/_4$″ pipes carries strong acid from

the head tank, and the other ordinary cold water from the mains. The $1^1/_2''$ pipe serves to carry the hot mixture to the pot without spatter. This type has the advantage of minimum repair and mixes about 5000 lbs. of 75 per cent. acid per hour. The head tank has a capacity of 18,000 lbs. of strong acid.

The product of the plant passes through a scale tank and is delivered to the nitric acid plant where in winter weather it is mixed with 2 per cent. of nitric acid to prevent freezing. The entire product can be delivered as 99.5 per cent. H_2SO_4, but for use in making nitric acid a portion of it is reduced to 94 per cent. H_2SO_4.

This being a government plant the hours of labor for any one shift of men can not exceed eight. The plant is run continuously with three shifts and in addition to the men directly employed in the operation of the plant there is a superintendent who devotes about half of his time to it.

The successful operation of a contact plant, of course, depends largely upon the efficiency of the contact mass. This efficiency is easily influenced by arsenic in the raw materials. Should arseniuretted hydrogen be present in the gas entering the converter, arsenic is deposited on the platinum and is said to "poison" it. The result of "poisoning" is immediately noticeable in the temperature produced by the catalytic action and in the quantity of SO_2 unconverted. Fortunately, this effect may in part be counteracted by raising the temperature of the gases entering the converter, and for this reason hardly any two plants burning pyrites will be found using the same initial temperature. In different plants we have noted temperatures of entrance gas varying from 420° C. to 480° C. The catalytic properties of "poisoned" mass may be improved by sprinkling it with aqua regia and expelling the arsenic by the heat of the converter, or they may be entirely restored by heating the mass in a furnace after sprinkling with aqua regia.

Another factor in conversion is the quantity of SO_2 contained in the gas entering the converter. With pyrites it is customary to use an entrance gas containing not over 5.5 per cent. SO_2 with mass in good condition. When "poisoning" has occurred, this percentage must be reduced to obtain good conversion.

In this plant, using Louisiana brimstone for eighteen months, we have had no indications of "poisoning" and have not opened the converter. The temperature of gas entering the converter is kept constantly at 380° C. and conversions are regularly 95–95.5 per cent. This low temperature means a decided saving in coal, and wear and tear on the preheater. During six months the average consumption of coal has been 21.8 lbs. per 100 lbs. of SO_3 made. We believe this to be a figure decidedly less than in any Schroeder plant burning pyrites. An entrance gas of 6.5–7 per cent. SO_2 is regularly used. During six months under the above conditions, the average make has been a little more than 6 tons of acid a day, and the average yield on sulphur fed to the burner 93.36 per cent. The plant can make a maximum quantity of 8 tons with a yield of 90 per cent. Comparison of cost sheets shows that by changing raw materials from pyrites to brimstone, we have reduced cost of manufacture nearly two dollars per ton of 98 per cent. acid; that this reduction is due in part to minimizing losses from shut-downs for repairs, in part to increased yields and in part to saving in coal and cost of upkeep.

U. S. Naval Proving Ground,
Indian Head, Md.

SMELTER SMOKE CONSERVATION.

By George C. Westby.

Received August 21, 1912.

The question of smelter smoke treatment is one of commercial metallurgy, and the application of a panacea a question of dollars and cents.

There have been many plans devised for quieting the complaints of injured agriculturists and others to whom smelter smoke seems all that is evil, but too often the proposed plan has been merely mitigatory, or has neglected provision for a material return on the investment in the plant. In other cases the process is rendered inapplicable on account of limited demand for the output whose production and sale is the vital commercial feature.

Of the methods projected for treating smelter smoke in an economic way, this article is limited to consideration of methods with which the writer has experimented.

The first of these was developed during 1902–1903 and consisted of a process for producing liquid SO_2 from the smoke, utilizing the heat of the smoke by means of economizers and air heaters. The SO_2 was to be liquefied by an ice or refrigerating machine, with the crystallohydrate of SO_2 as an intermediary product.

Aside from the mechanical difficulties incident to the arrangements for removing the flue dust, the crucial objection advanced against the process was the lack of a market for the liquid gas as produced at the rate of thousands of tons per day. The suggestion that it could be used as a refrigerant in place of ice in freight cars, and in the small ice boxes of private homes, seemed inadequate in face of the fact, that the market was both problematical and undeveloped while awaiting the expenditure of some millions of dollars in providing the necessary equipment.[1]

During the course of further work in connection with the smoke problem, the idea suggested itself that the sulphurous gases of the smoke might be bound with the bases of slag and thus reduced to a more controllable form. Experiment demonstrated that the idea might be practically applied, and also suggested the general method of smoke treatment which consists in the neutralization of acid fumes on slag, and ensuing precipitation of the toxic oxides in ponds or other limited areas on the earth, chiefly as harmless and insoluble compounds with iron and other bases of the slag. As developed, the process also involved the recovery of values carried by slag and flue dust.

[1] This phase of smoke eradication method was independently educed by Dr. Carpenter, of Denver.

The fact that chilled, finely divided slag very rapidly dissolves in hot dilute solutions of HCl or H_2SO_4, is generally known to metallurgists and chemists, and they are also acquainted with the fact that the silicic acid is retained in apparent solution. Experiment proved that hot solutions of SO_2 are also capable of effecting the dissolution of the slag in the same way; this discovery became the basis of our attack on the smoke difficulty.

In carrying out the process we have at command a hot acid smoke, laden with flue dust, vapors of sulphur and possibly arsenious or other volatilized compounds. We have also at hand granulated and chilled slag.

The acid smoke is an immediately available and intensely active chemical agent, but the granulated slag while susceptible to the vigorous attack of the sulphurous reagent, is preferably finely ground in order to accelerate its solution and incidentally reduce the size of apparatus required in its treatment. In conjunction with the smoke and slag, water or circulating ferruginous smoke liquor is necessarily used as a medium of chemical translation, in maintaining suspension of the slag pulp and in carrying the compounds formed. The slag and smoke are brought together by means of an apparatus which is introduced as a part of the flue systems. The province of the appliance is the retention of a vast surface of wetted slag in the direct path of the smoke current, in such a way that the smoke, slag dust, steam and water become as nearly as possible a hot homogeneous mist or spume.

Chemical action under such circumstances is essentially rapid, and ensures the absorption of the sulphurous gases without recourse to unwieldly apparatus or large chambers.

The result of the combination of the constituents of the mixture is the production of ferrous and ferric sulphite, ferrous sulphate, various thionates of iron and in a smaller degree sulphur salts of other bases.

The copper is mainly present in the matte particles contained in the slag, and when ground slag is used in the apparatus, remains for the most part undissolved. That portion of the copper taken in solution may be reprecipitated in the absorber by the action of polythionates developed in the smoke liquor through the interaction of the SO_2, sulphites and free sulphur of the smoke.

In many of our experiments copper was obtained principally in an oxidized form by blowing molten slag into slag wool. In these cases the copper was maintained in solution and after discharge from the absorber was precipitated in a wooden tank by heating the solution with steam to about 80° C.

The development of thionates, on which the precipitation of part of the copper depends, requires no attention under the usual circumstances attending the roasting of ore. Their formation is encouraged in the presence of the sublimed sulphur of the smoke, and by the sulphites and the excess SO_2 of the smoke liquors. During the course of their production, there may be a constant representation of all those compounds designated as polythionates, but the dominance of any particular form depends on the chemical and physical characteristics of the smoke, the liquor and the material treated. The thionates produced are ephemeral and finally break up into sulphates, sulphur dioxide and free sulphur as indicated in the following equation:

$$MS_nO_6 = MSO_4 + SO_2 + (n - 2)S.$$

To illustrate a possible set of conditions occurring in the absorber during treatment of the smoke, we may take the following successive reactions:

$$4FeSO_3 + 2SO_2 + O_2 = 2Fe_2(SO_3)_3.$$
$$Fe_2(SO_3)_3 = FeS_2O_6 + FeSO_3.$$
$$2FeS_2O_6 + S_2 = 2FeS_3O_6.$$
$$2FeS_3O_6 = FeS_2O_6 + FeS_4O_6.$$
$$2FeS_4O_6 = 2FeS_2O_6 + 2S_2.$$
$$6FeS_4O_6 + 4CuSO_4 = 2Cu_2S + 14SO_2 + 3S_2 + 6FeSO_4.$$

When sodium and potassium are present in the slag they are dissolved with the other constituents and later appear as sulphates in the discharged smoke liquors, and may be recovered if desired from the residues of the evaporated liquor. Zinc if present is similarly dissolved and may be separated from other residues by volatilization or any practicable means. Lead, silver and gold are retained undissolved with the precipitated copper. In some cases green vitriol would be an important and valuable by-product.

The liquor produced in the absorption chamber may be again used or it may be continuously discharged on waste land, over which it spreads in a thin sheet that will rapidly evaporate under the influence of wind and sun. In the latter case, oxidation and hydrolysis form an insoluble basic sulphate, by translation of the green vitriol in general accordance with the equation

$$4FeSO_4 + O_2 + 2H_2O = 4FeSO_4(OH),$$
$$\text{or } 6FeSO_4 + 3O + 3H_2O = 2Fe_3(SO_4)_3(OH)_3.$$

At the same time deposition occurs of the silicic acid and of sulphur arising from the decomposition of thionates.

Generally the liquor issuing from the absorber contains only very limited quantities of free acid. If, however, any objectionable amount of acid is present, it may be neutralized by passing the liquor over slag or through calcareous or soluble ferruginous material. In some cases the percolation of the liquor into calcareous soil would not be objectionable, as the comparatively small quantity of acid would be effectually neutralized in the formation of insoluble calcium sulphate, and thus the liquor could not seriously affect the ground water.

The flue dust carried by the smoke is effectually caught by the somewhat glutinous slag particles, and remains with the residues of the reaction chamber.

In carrying out the experiments it was recognized that the development of a simple apparatus was of the first importance; accordingly much time was spent on different tentative designs, but the aim in each case was the form of apparatus which would require the minimum of attention, repairs and adjustment.

The arrangements tried were of two general forms:

a tower or vertical chamber and a horizontal rotary apparatus.

The vertical arrangement consisted generally of a wooden tower, provided with a large number of narrow staggered shelves. These pieces were set three or four inches apart, from one end of the tower to the other. A hopper was introduced at the top of the tower for the reception of the slag and water used in the treatment. The bottom of the tower was arranged to permit the formation of a hydraulic seal at the discharge. At each end of the tower pipes were inserted; one of these was connected directly with the flue of a furnace and the other with a fan.

In operation the wet slag was charged into the hopper and was discharged from the hopper by gravity to the shelves. From the top shelves the material spread over the cross section of the tower and by the action of the series of staggered shelves, fell in splashing cascades to the bottom of the tower, coming in contact throughout its course with the hot current of acid smoke drawn through the apparatus by means of the fan.

The liquor derived by the action of the smoke on the wet slag discharged through the hydraulic seal to a large wooden tank in which the copper was precipitated by means of steam. Wooden launders conveyed the residual liquor to a pond.

The horizontal rotary apparatus was cylindrical in form. Shelves or projections were set at intervals along the interior surface, so as to lift the mixture of slag and liquor and drop it in sheets through the smoke current in the apparatus. The shelves were set at different angles so that the material would be distributed along the different planes during rotation of the cylinder. The splashing on the sides and bottom of the apparatus caused by the falling material, aided in filling the whole of the cylinder with a constant spray of absorbent mixture.

The cylinder rotated about short pipes of comparatively large diameter; these were set at the smoke entry and exit ends of the cylinder and were connected respectively with the flue of the furnace and the intake of an induction fan. The treated smoke was discharged through the fan.

Means were provided for continuously feeding the absorbent material into the cylinder, and a pump with a syphon attachment was used in removing the exhausted liquor.

The first general test was made with a rotating cylinder. The cylinder was about 10 feet in length and 30 inches in diameter.

The results of one of the experiments with the apparatus are given below:

Time.	10.15.	10.45.	11.00.	11.15.
Temp. gas inlet ° F.	215°	220°	210°	242°
Temp. gas outlet ° F.	82°	84°	74°	74°
Temp. water inlet ° F.	64°	65°	65°	65°
Temp. liquor outlet ° F.	90°	100°	78°	86°
Cu. ft. gas per min. measured at intake	34.2	32.4	33.0	44.4
Per cent. SO_2 inlet	4.9%	4.7	5.4	4.7
Per cent. SO_2 outlet	1.9	1.0	0.85	2.7
Absorption in 10 feet	61.2%	78.8%	84.2%	42.5%

NOTE: 140 lbs of slag charged at beginning of test; none charged during interval between 10.45–11.15. The test gives results better than average, consequent on treatment of smaller volume of smoke per sec. than ordinary.

The test illustrates a set of experiments where the slag was not fed continuously, but was charged in one mass. The absorption in this case steadily increased for a short period after charging, then fell off rather rapidly. In the experiment given above the drop is accentuated by the increase of gas current.

In the experimental results given below the slag was practically continuously charged, although not in sufficient quantity to bring about complete absorption.

The tests were made with the tower apparatus of which the general principles have been described. Two towers were used connected at their tops. The total length of the apparatus was 77 feet. The cross section was 4 square feet.

	Temperature in Degrees Fahrenheit of				Cu. ft. gas per min.	Per cent. absorption SO_2 by volume.
Time.	ingoing gas.	outgoing gas.	ingoing water.	outgoing liquor.		
10.00 A.M.	320	90	96	110	68.4	81.1
10.20	355	90	..	...	84.6	79.6
10.30	355	90	..	...	84.6	82.0
11.00	355	..	..	...	84.6	82.0
1.00 P.M.	350	..	96	109	112.2	74.8
1.20	340	..	..	...	85.8	79.1
1.35	345	..	..	...	85.2	81.1
1.4	350	..	..	...	91.8	81.6
1.50	360	..	..	...	99.0	83.0
2.00	380	..	..	...	132.0	80.3
2.10	380	..	..	...	98.4	84.4
3.30	390	90	96	111	99.2	79.0

The analysis of the solutions of the set of experiments, of which the above is an example, varied with the relative quantities of slag and water charged, the rate of smoke supply, and to a large extent depended also on the temperature of the gases.

The constituents of the solutions varied between the following figures:

	Minimum.	Maximum.
Fe	0.54%	3.0%
S	0.49%	2.9%
Cu	0.00%	0.8%
SiO_2	..	3.2%

The average temperature of the incoming smoke was 393° F. and that of the discharged gases 92° F. Throughout the series the volume of smoke treated varied between 90 and 235 cu. ft. per minute.

On the whole these tests were the most satisfactory as no trouble was experienced with the apparatus or in the introduction and application of different conditions.

Succeeding the experiments described, tests were instituted for the treatment of 5000 cubic feet per minute of smoke assaying 4.5 per cent. SO_2, a volume representing the total gases discharged per minute from a 35–40 ton McDougal roaster.

The apparatus used consisted of a rotating cylinder 36 feet long and 12 feet in diameter, arranged as previously described. On account of an underestimate of the charge to be carried, the foundations, running equipment and apparatus generally were designed to sustain only a fraction of the slag and water charge necessary to absorb all of the SO_2 in the smoke;

our absorptions were therefore seldom greater than 45–55 per cent. of the SO_2 in the smoke volume. For brief periods in one case we secured absorptions of 92 per cent. and 100 per cent. We never approached a satisfactory degree of elimination of the SO_2 from the smoke, except at the expense of a breakdown with this particular apparatus. The results obtained, however, were valuable as the basis for a successful design for a cylindrical apparatus.

A study of the set of results given below will show the trend of the experiments and also make clear the limitations of the apparatus used, when it is understood that the entry "Period of run—minutes" implies "Period of anxiety before smash-up—minutes."

The entry "Slag required—theoretical" is a factor derived from the analysis of the solution, in consideration of the ratio iron dissolved to sulphur absorbed. The weight of iron dissolved is multiplied by 2.7, a constant derived from the fact that the weight of slag was approximately equivalent to 2.7 times the weight of iron contained in the slag treated.

"Slag required" represents the quantity of slag which would be required per minute, to exactly neutralize the weight of SO_2 driven from the furnace per minute. It is obvious that in practice the mere presence of this figured amount would be altogether inadequate to actually neutralize the SO_2 given off minute by minute from the furnace, since the whole of the mass is not instantaneously acted on. Depending on the degree of subdivision, the constitution of the slag and other physical and mechanical factors, a slag excess of 3,000 per cent. to 10,000 per cent. is requisite to effect a complete elimination of the SO_2 from the smoke.

	1.	2.	3.	4.	5.	
Period of run—minutes....	70	57	200	280	110	
Temp. of gas, entering....	250	425	400	387	250	° F.
Temp. of gas discharge....	77	80	80	94	100	° F.
Temp. of liquor discharge	100	118	..	130	130	
Water supplied per min., lbs.	620	396	359	138	270	
Total Fe in soln., lbs.....	479	208	604	732	652	
Total S in soln., lbs.....	309	307	656	594	548	
Rate of adding slag per min.	30.0	35.3	22.3	14.2	50.0	
Slag required—theoretical per min.....	44.3	19.4	30.8	37.8	37.0	
Total available slag charged, lbs.....	2120	2015	4470	3998	5512	
Per cent. SO_2 absorbed of total passing through apparatus.....	38.2	46.8	39.0	19.8	43.3	
Analysis:						
Milligrams Fe per 100 cc. solution.....	1008	924	1053	1897	2194	
Milligrams S per 100 cc. solution.....	710	1360	1143	1540	1837	
Milligrams Cu per 100 cc. solution.....	21.4	10.5	15.0	15.0	9.1	

By comparison of the above data it is seen that the absorption of SO_2 tends to rise as the rate of charging slag is increased. Consideration of (2) and (5) would suggest also that the absorption rises with the temperature; this indication is confirmed in other experiments not given here. In (1) the temperature is low and the absorption high; this is probably due to the high rate of water supply combined with the comparatively high rate at which the slag wool is charged.

In order to determine the practical effect of maintaining the slag excess, which had been deduced as the necessary amount to ensure complete absorption of all the SO_2 discharged from the furnace, during any period, we commenced a cylinder experiment by introducing before starting operation, 1500 lbs. of slag wool. The results were as follows:

Period of run, 10 minutes. 300 lbs. of slag added during run.	
Rate of adding slag per min., lbs.....	180 (comparative)
Water supplied per minute, lbs.....	1195
Per cent. SO_2 absorbed.....	100%
Milligrams Fe in 100 cc. solution	1260
Milligrams S in 100 cc. solution.....	1050

After ten minutes the apparatus was stopped, measurements made and samples taken. Five minutes later the apparatus was again started and operated 15 minutes, a stop being necessary at the end of that time on account of the great weight accumulated in the apparatus—principally liquor in excess of the pump capacity.

The result at the end of the second period was:

Period of run, 15 minutes.	
Rate of adding wool per min., lbs.....	100
Rate of adding water per min., lbs.....	1001
Per cent. SO_2 absorbed.....	90.2%
Milligrams Fe per 100 cc.....	908
Milligrams S per 100 cc.....	1036

The experiments stopped short of a commercial realization of the process, due to circumstances not affecting the question of smoke elimination. However, the net results of the work sufficiently established the following facts:

(1) The acid gases of smelter smoke can be effectively neutralized by means of chilled slag, with the complete elimination of flue dust from the discharge.

(2) The toxic action of the smelter vapors and gases can be controlled by converting them into constituents of harmless compounds and causing their deposit in an insoluble form on waste land.

(3) In bringing about the control of the gases in the manner stated, it is both feasible and desirable to recover copper, lead and other values contained in the slag and in the smoke.

(4) The conservation of by-products such as green vitriol, potash and soda salts, and silicic acid is possible where markets for the material are not too far removed from the smelting plant.

(5) The indirect use of sulphurous smoke in the treatment of wastes from the concentrator in the shape of slimes and tailings, is sometimes feasible. The reaction given below will suggest the general procedure:

$$Fe_2(SO_4)_3 + SO_2 + 2H_2O = 2H_2SO_4 + 2FeSO_4.$$

$$nH_2SO_4 + Cu_2S + 2Fe_2(SO_4)_3 = 2CuSO_4 + 4FeSO_4 + S + nH_2SO_4.$$

Ely, Nevada.

NOTES ON A STUDY OF THE TEMPERATURE GRADIENTS OF SETTING PORTLAND CEMENT.[1]

By Allerton S. Cushman.

The reactions that take place when hydraulic cements are tempered with water and while the mixture is hardening are not as yet understood. It is true that many theories have been advanced in regard to the hardening process or processes but more data are

[1] Paper presented at the Eighth International Congress of Applied Chemistry, New York, September, 1912.

required before much that now seems inexplicable can be understood.

Since all chemical reactions are accompanied by definite and measurable thermal changes, complete temperature records of hardening cements should yield interesting and valuable data.

It is well known that if a Portland cement clinker is ground without the addition of from 2 to 3 per cent. of calcic sulphate or gypsum to act as a restrainer it will be "flashy." By "flashy" is meant the tendency to harden very quickly, so quickly in fact that in many cases it is impossible to mold the wetted cement into a plastic mass. While this sudden hardening is going on, a considerable amount of heat is generated so that the mass feels hot to the hand. The temperature rises about 10° to 15° C., but the heat reaction lasts only a short time and after cooling no further heat reaction takes place. When, however, a Portland cement has been properly restrained by grinding with it 2 or 3 per cent. of gypsum (plaster) the conditions of thermal activity are changed in a quite extraordinary manner. On mixing a normal Portland cement with sufficient water to form a normally plastic mass, a certain amount of heat is immediately disengaged although not so much as in the case of an unplastered cement. The plastic mass soon cools down to the air temperature and generally falls somewhat below the surrounding temperature, showing that a decided cooling effect is taking place. If now the plastic mass is allowed to stand quiescent in a constant temperature chamber, nothing of moment happens for a period of from four to eight hours, if the cement be a normal standard brand. At a given time however for every mixture, a secondary heat rise begins and increases more or less rapidly to a definite maximum. After this rise is completed the cement has attained its final set and a gradual cooling takes place to the temperature of the surrounding air and nothing further happens. If an imperfect, damaged or lumpy cement is under observation the temperature gradient for the rise may show aberrations. That is to say, a sudden rise may be followed by a temporary cooling only to be followed by another rise.

The wonderful effect of a small percentage of gypsum plaster in thus controlling and regulating the temperature gradients or reactions of setting cement is little understood and indeed presents certain anomalous occurrences for our consideration, as will be shown later on.

The first successful attempt to record the temperature gradient of setting cement as far as the writer has been able to ascertain was made by Gary who used a photographic recording device which has been fully described by Burcartz.[1] The method consisted of placing the bulb of an ordinary glass thermometer in the cement paste. The whole arrangement was enclosed in a box through which a beam of light was made to impinge through a slot upon the graduated stem of the thermometer and then upon a traveling photographic film. As the mercury rose or fell the beam of light was cut by its shadow and thus a continuous temperature gradient was obtained.

The only criticism of this method that can be made is that it calls for an expensive and delicately adjusted piece of apparatus which few laboratories would care to install and in which the temperature changes cannot be watched while they are taking place. The apparatus used by the writer is simple, comparatively inexpensive and can be installed and used in any laboratory for making daily records. The apparatus is shown in Fig. 1.

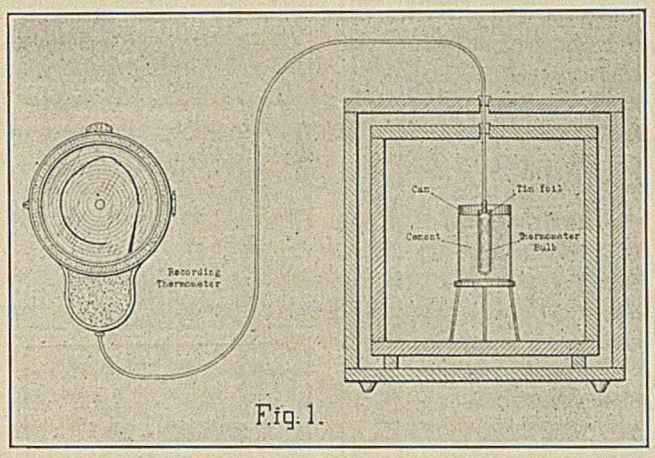
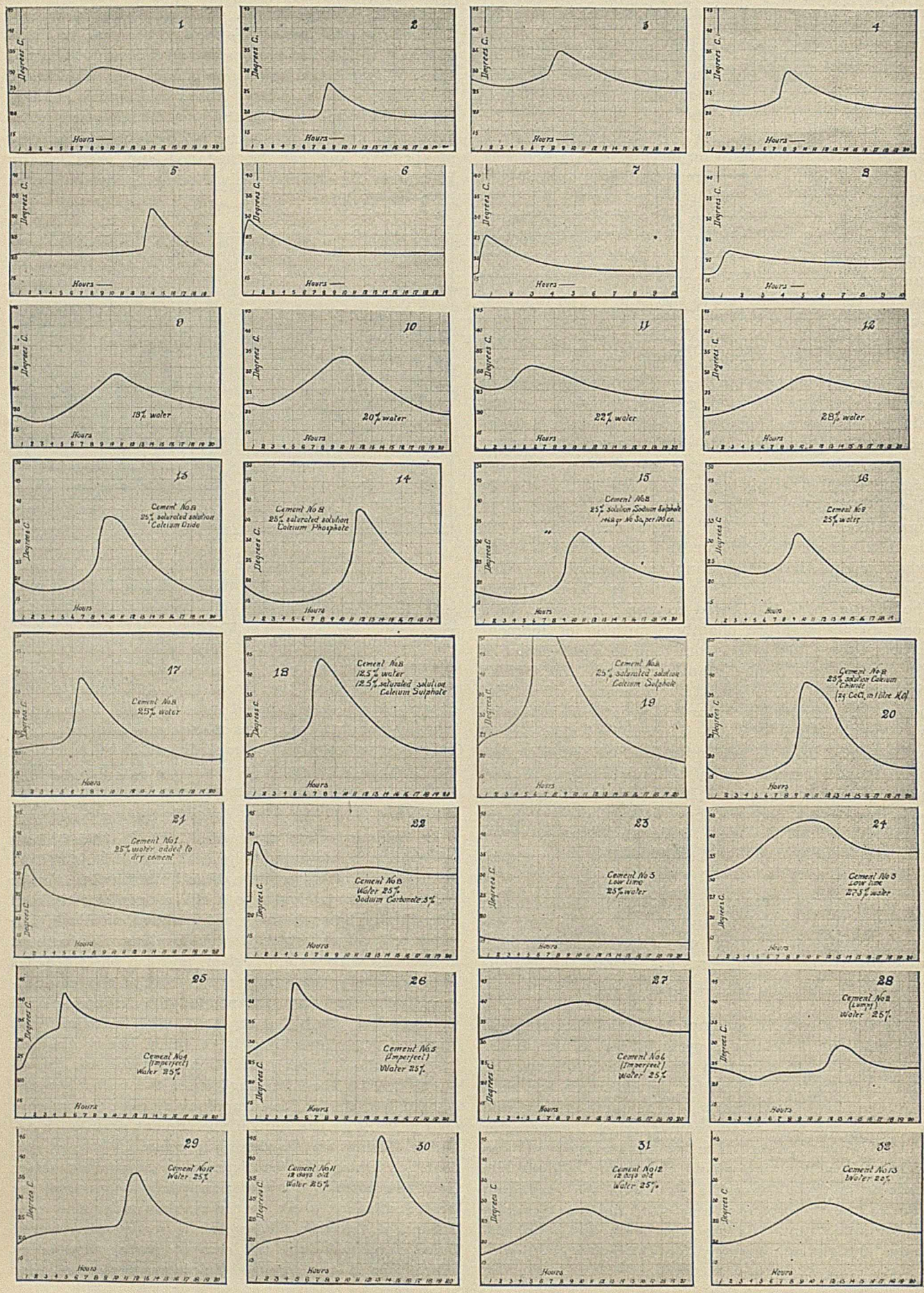


Fig. 1.

A double walled wooden box as shown in Fig. 1 is used simply to avoid any sudden changes which may take place in the laboratory temperature during a test run. An ordinary so-called "fireless cooker" such as can be bought at any kitchen supply store answers very well for this purpose. The recording thermometer is of the Tycos type and consists of a copper-plated steel tapered mercury filled bulb 9 cm. long by about 2 cm. in its maximum diameter. The bulb is connected to the recording dial by a flexible steel capillary tube. The recording dial has a range from 10° to 120° F. The recorder is fairly accurate for the middle range and is easily calibrated and adjustable.

In ordinary tests as carried out in the writer's laboratory, 1 kilogram of the neat cement is tempered with 250 cc. of water to make a homogeneous plastic paste which is packed into a No. 2 open top tin can. The thermometer bulb is not inserted until the primary heat effect (which always develops when cement is kneaded with water) is over, and the paste reaches approximately the same temperature as the calorimeter box. In the meantime the copper-plated thermometer bulb is smeared with vaseline and wrapped with several folds of fairly heavy tin foil. The object of these precautions is two-fold: (1) to guard against the "freezing" in of the bulb when the cement hardens; (2) to overcome any possible pressure on the walls of the bulb if the cement shrinks or expands during the hardening process. With 25 per cent. of water the consistency is somewhat softer than the normal, but experience has shown that the wetter mixture gives better results under the conditions of the test. When all is ready the covered bulb is pushed into the cement paste, care being taken that it is not pushed below the surface so that

[1] *Eng. Record*, Dec. 11, 1909.


1
2
3
4
5
6
7
8
9
18% water
10
20% water
11
22% water
12
28% water
13
Cement No 8
25% saturated solution
Calcium Oxide
14
Cement No 8
25% saturated solution
Calcium Phosphate
15
Cement No 8
25% solution Sodium Sulphate
16
Cement No 8
25% water
17
Cement No 8
25% water
18
Cement No 8
12.5% water
12.5% saturated solution
Calcium Sulphate
19
Cement No 8
25% saturated solution
Calcium Sulphate
20
Cement No 8
25% solution Calcium
Chloride
21
Cement No 1
25% water added to
dry cement
22
Cement No 8
Water 25%
Sodium Carbonate 5%
23
Cement No 3
Low time
25% water
24
Cement No 3
Low time
22.5% water
25
Cement No 4
(Imperfect)
Water 25%
26
Cement No 5
(Imperfect)
Water 25%
27
Cement No 6
(Imperfect)
water 25%
28
Cement No 2
(Lumpy)
water 25%
29
Cement No 12
Water 25%
30
Cement No 11
12 days old
Water 25%
31
Cement No 12
12 days old
Water 25%
32
Cement No 13
Water 20%
Degrees C.
Hours

the cement can close over the shoulder of the bulb and so imprison it when hardening takes place. When these precautions are taken the apparatus gives no trouble and the bulb is easily withdrawn from the hard cement at the end of the test. The temperature gradients are usually taken for a twenty-four hour period, although this is not necessary unless the full cooling curve is desired.

In presenting these notes on the temperature gradients of setting cements, it is not the intention of the writer to draw any conclusions at this time in regard to the mechanism of the hardening reactions.

The curves obtained on the revolving scale are transferred to centigrade degrees and plotted in rectangular coördinates as is shown in curves 1–32. An inspection of the curves will show that in some cases the temperature gradients are much steeper and more sudden than in others. Curves 6, 7, 8 and 21 represent cases in which the water was simply poured on to the dry cement without previously kneading the mass to a paste. In no case of this kind is a rise in temperature noted following the final set or hardening, at about seven to eight hours.

In the cases of some brands of cement, as is shown in curves 9, 10, 11 and 12, the rise in temperature is constant and gradual to a maximum which usually occurs at about ten to eleven hours. In other cases, notably in curves 17 and 29, the rise is sharp and sudden. As both types of cement pass muster in the standard tests, it is not possible at the present time to state what the ideal temperature gradient curve for a cement should be.

That the maxima and shape of the curves is modified by the addition of various salts to the tempering water is shown in curves 13, 14, 15, 16, 17, 18, 19, 20 and 22.

Perhaps the most extraordinary curve is number 19 which shows the heating effect produced by saturating the water with calcium sulphate. In this case the temperature rose above the scale of the recording device and the test piece became uncomfortably hot to the hand. Since calcic sulphate is used as a restrainer when ground with a cement, this extraordinary effect of calcic sulphate solution is difficult to explain.

Curves 25, 26, 27 and 28 were from cements which did not stand test and had been rejected. The abnormality of these curves is at once apparent to the eye and furnishes the best argument as to the value of a study of the temperature gradient as an additional method of control in cement testing.

In conclusion, the author wishes to point out that these notes on the study of temperature gradients are offered not as data on which to establish theories but to stimulate other workers to include similar investigations in their studies of the hardening of hydraulic cements.

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COBALT DRIERS.[1]

By V. P. KRAUSS.

The cobalt compounds which are generally offered on the market to-day may be divided into two classes: In the first are cobaltous oxide, acetate, sulphate, chloride, nitrate, hydroxide, and basic carbonate. In the second class are various grades and qualities of resinates (sometimes called sylvinates), both fused and precipitated, oleates or linoleates, oleo-resinates, tungates and resino-tungates, besides some other liquid preparations composed in whole or part of the foregoing.

From the varnish manufacturer's standpoint the substances in the first division are crude materials which are utilized in the production of the compounds in the second class, and also in the preparation of some varnishes, liquid driers, drying oils, and the so-called paint oils. The materials enumerated under the second class are the result of a varnish maker's labor, and when properly made and used in mixtures to which they are adapted give very good results.

The inorganic salts of cobalt do not directly come under the scope of this paper, and thus will not be directly considered except inasmuch as their use as crude material affects the driers into whose composition they enter.

It is only within the past year that the cobalt driers have been offered to the American paint and varnish manufactureres. Up to the present time their use is not general, first, because of the very high price, and second because their use is not thoroughly understood and many experimenters have had unsatisfactory results and therefore refused to further consider the introduction of the new material. Furthermore, not all of the cobalt driers, whether liquid, paste, or solid, now offered for sale, are properly made and truly adapted to the purposes for which they are recommended. This situation in addition to unsatisfactory results obtained by some of those experimenting, would naturally have a retarding effect on the introduction of a new type of material.

The salts of cobalt which are at our disposal in commercial quantities, are all of the cobaltous or divalent type. It has been found that although they can be readily used in the manufacture of driers and worked like the various compounds of manganese, lead, zinc, calcium, aluminum, etc., the organic compounds formed, which are the basis and active principles of the so-called driers, are not efficient while in the cobaltous state. The cobaltic combinations, however, are very active driers, and it is for the formation of trivalent cobalt compounds that we strive in the making of driers. This transformation can be effected in several ways. By blowing cold, heated, or ozonized air through the hot cobaltous drier stock, or by the introduction of liquid or solid oxidizing agents. The use of cold or even heated air is a very long and tedious operation if carried out to the extent to which it is necessary in order to get the maximum strength in the drier, and greatly adds to the cost of an already expensive material. The use of the liquid or solid oxidizers can be carried out successfully and in a comparatively short time, although even when great care is exercised the batch of material is in danger of catching fire.

[1] Paper presented at the Eighth International Congress of Applied Chemistry, New York, September, 1912.

Since driers are used in a number of industries in which drying oils form part of the material produced, and since the operating methods of the various manufacturers are widely divergent, the siccatives or driers adapted to each will in many instances show widely different characteristics, not merely in form but also in composition.

Since the paint manufacturer and also the practical painter who mixes his own paints from paste colors and raw or treated oil, are the principal consumers of what are generally known as driers, the materials adapted for their use may be first considered. The driers will, in practically all instances, be in the liquid state, either very fluid, of heavy consistency or of a semi-paste nature. In composition, they will mostly consist of resinates, tungates, oleates, or linoleates, or combinations of the three. For the drying of linseed oil, when the proper driers are selected, little or nothing can be asked in addition to those known at present. When the general lead, manganese and other prevalent metallic driers are well chosen, raw linseed oil can without any difficulty be made to dry by the addition of from 5 to 10 per cent. or even less, the time of drying under average weather conditions being from 10 to 24 hours. By the use of cobalt driers, the same drying effect can be obtained when only from 1 to 3 per cent. of a liquid drier is used. I am not yet prepared to say positively what the ultimate effect of cobalt driers is upon paint films, but from my experiments I am led to believe that cobalt has not the harmful progressive oxidizing action that some of the usual manganese lead compounds have. It has also been noticed that although a cobalt drier may be fairly dark in color, it will not have as darkening an effect as one of the usual driers of like color would have upon a white paint. The cobalt driers likewise show the same phenomena as some of the others when used in excessive amount; that is, although the paint film will set up well in the usual time, the drying action apparently reverses and the film remains tacky.

The terms applied to liquid driers are often uncertain and apt to be misleading. There are no general standards for strength or consistency, and, it must be admitted, many of the materials found on the market contain more volatile thinners than is conducive to obtaining a maximum drying effect with a minimum quantity of drier.

The value of the cobalt specialties depends not on their power to dry linseed oil, but on their ability to make the lower priced semi-drying oils act like it.

Soya, fish, and even corn and cottonseed oil are adaptable for use in paint, and when correctly treated increase its durability. Dr. Maximilian Toch has published the results of his extensive research and experimental work with both fish and soya oils, and there describes the types of driers suitable for them.

In the making of waterproof fabrics, insulating coatings, etc., both liquid and solid driers are used. In the linoleum, oilcloth, patent leather, artificial leather and similar industries, the semi-liquid, paste, and solid driers are in demand since for these products the manufacturers cook the oils and varnishes in their own factories.

The paste and solid driers must essentially be considered under the caption of crude materials because they must be churned or cooked in the oils or varnishes in which they are used.

The methods of making both solid and liquid driers are in general similar in the first stage of the process, and thus may be described under the same headings.

RESINATE OF COBALT, PRECIPITATED AND FUSED.

This is correctly made by saponifying rosin or colophony with caustic soda or sodium carbonate, care being taken to avoid an excess of the reagent, and then precipitating with a solution of some salt of cobalt. The chloride or sulphate serve best for this purpose. The precipitated resinate, or as it is sometimes called, rosinate or sylvinate, must then be thoroughly washed and then pressed and dried. This will yield a pinkish, fairly fluffy powder when ground, which will readily dissolve in oil at a low temperature. The fused variety is made by melting the dried resinate in a kettle and then pouring into cooling pans. The operation is performed more rapidly by taking the cakes from the presses and driving off the water and fusing in one operation.

COBALT OLEATES OR LINOLEATES.

The basis of this class is generally linseed oil, although walnut, perilla, soya, and some other oils may be used. The oil is thoroughly saponified with caustic soda and, like the resinate, precipitated with a salt of cobalt. The material is then carefully washed and pressed. It may be melted to form a dark viscous heavy fluid.

Several samples of cobalt linoleate which I examined consisted of bodied linseed in which small amounts of inorganic cobalt salts had been dissolved. Another was of the same order with the addition of volatile solvents.

True linoleate of cobalt, when fused with varnish gums and dissolved in volatile oils, yields an excellent drier.

OLEO-RESINATES.

This type of drier is made by melting together the precipitated resinate and linoleate, sometimes with the further addition of fused fossil gum-resins.

TUNGATE OF COBALT.

Like the linoleates, the tungate of cobalt is made by saponifying pure China wood oil (tung oil) with caustic soda, care being taken to avoid excess of caustic, and then precipitating with a salt of cobalt. The tungate is then washed thoroughly, pressed and generally dried and fused. Great care is necessary in the preparation of a tungate since it oxidizes very rapidly, and the oxidized material is useless.

Like the linoleate of cobalt, the tungate may be fused with the resinate to form what may be called a resino-tungate.

In general, the foregoing substances are incorporated in oils by means of heat, the combining temperature being between 300° and 500° F. The amount necessary will vary from about $^1/_2$ per cent. to 5 per

cent. In order to make *liquid driers*, the paste or solid driers can be melted alone or in combination with gum-resins, bodied linseed oil, or both, and then thinned to liquid consistency with volatile oils.

Among other cobalt salts, some of the chemical manufacturers offer the acetate, with directions for its use as a drier. All agree that between two- and four-tenths of one per cent. are necessary to dry linseed oil. The oil should be at a temperature between 300° and 400° F., and be carefully stirred until all the salt is dissolved. Soya and China wood oil may be similarly manipulated.

It is still a little too soon to make a positive statement as to how oils thus treated with the acetate withstand wear and exposure.

Cobalt oxide, like the acetate, can be directly added to oil during boiling. It however dissolves slowly and necessitates heating to high temperature; the resulting product is also very dark, and mostly consists only of bodied oil. Rosin also will directly combine with cobalt compounds on heating together in a suitable kettle or container. The product possesses a number of objectionable features. It still is mostly unchanged rosin, has become much darker and lost considerably in weight due to volatilization. I have tried the effect on oils of quite a number of cobalt compounds, but found none equal in efficiency to those described in the foregoing.

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THE DEVELOPMENT OF HYDROSULPHITES IN THEIR RELATION TO MODERN DYESTUFFS.[1]

By PHILIP S. CLARKSON.

In 1869 when Schuetzenberger first made sodium hydrosulphite and in 1872 when he, together with Lalande, applied it to the preparation of indigo-white and introduced a vat for indigo dyeing based on its use, a basic foundation was laid for the practical application to the fibre of the latest and the most desirable group of synthetic dyestuffs. These are now known technically as "vat colors" but some better term should be applied to them than one derived from the large vats or dye vessels necessary on account of the quantity of sediment in the old style method of indigo dyeing. As is well known, these products are insoluble in water and require reduction, generally in an alkaline solution, to render them soluble and suitable for use in the dye kettle. The old methods of fermentation, etc., used with indigo are not applicable here and the hydrosulphites are found to be the most satisfactory agents, being most energetic in reducing action, and in the form of their sodium salts giving no insoluble combinations with the dyestuffs.

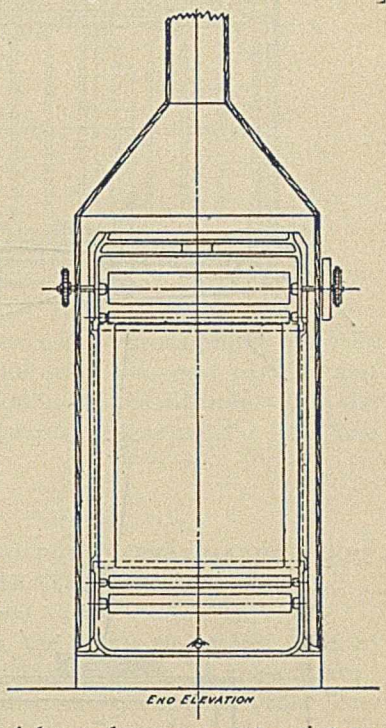
Before the discovery and invention of the now large group of vat dyestuffs, the use of hydrosulphite in dyeing was small, and the improvement in manufacture of hydrosulphites not marked, but coincident with the discovery of new coloring matters suitable for use in vat dyeing came new interest in the use of hydrosulphites as discharging agents in calico printing.

[1] Paper presented at the Eighth International Congress of Applied Chemistry, New York, September, 1912.

This led to the discovery of the formation of stable compounds with formaldehyde for which the first American patent appeared in 1904[1] followed by that for the production of pure sodium hydrosulphite powder in 1905,[2] that for sodium formaldehyde sulphoxylate in the same year and finally the two zinc salts in the year 1911.

These may be said to represent the products now in commercial use, the pure sodium hydrosulphite powder ($Na_2S_2O_4$) representing the products used for dyeing, the formaldehyde compounds those used for printing and for discharging. These are as follows:

Sodium-formaldehyde-sulphoxylate, $NaSO_2.CH_2O + 2H_2O$, which is commercially known as hydrosulphite N F conc., Rongalite C and hyraldite C extra, according to the maker. This is the compound of especial interest to the calico printers.



Di-zinc-formaldehyde sulphoxylate,[3] $ZnSO_2CH_2O$, is known to the trade as hydrosulphite A Z, decrolin or hyraldite Z. This is used only for stripping or removing dyestuffs from dyed materials.

Mono-zinc-formaldehyde sulphoxylate,[4] $Zn(HSO_2CH_2O)_2$, which is hydrosulphite A Z soluble conc. This is used for the same purpose as the di-zinc salt, but is more effective and is soluble in water.

The other commercial marks represent mixtures with various substances for special purposes.

Practical Applications.—These comprise dyeing, printing, discharge-printing on dyed materials, and stripping or the removal of dyestuffs and coloring matters from previously dyed material. The dyestuffs which require the use of hydrosulphites are as commonly classed: indigo and substituted indigoes, usually halogen substitution for hydrogen; indigoids, those having the molecular construction of indigo but having other replacements; and anthracene compounds.

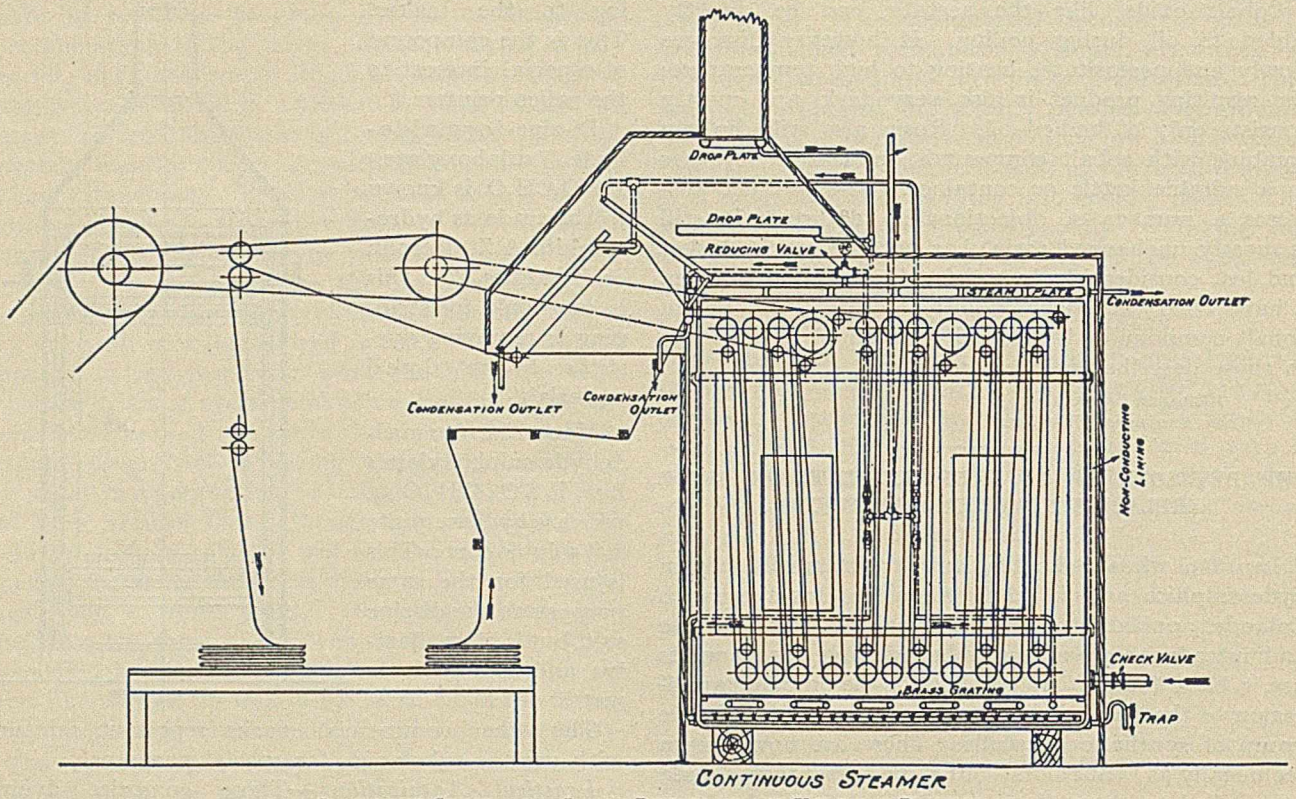
Dyeing.—The method of application for all these classes of dyestuffs is practically the same; the dyestuff is reduced with $1^1/_2$ times to twice the amount of sodium hydrosulphite in the presence of alkali to dissolve the leuco compound formed. This reduced dyestuff is then applied to the fibre in the well known manner and the color finally developed by oxidation. Various assistants are added to secure technically

[1] U. S. Patent No. 769,593, Des Camp.
[2] U. S. Patent No. 793,559, Bazlen and Wohlfart.
[3] *Ber. d. chem. Ges.*, **1909**, p. 4657.
[4] B. Fran., 435,260.

perfect results. The shades obtained are generally speaking much in advance of any previously known in regard to fastness to all injurious influences combined with brilliancy of shade.

Printing.—It is in this branch of the art of coloring that the most marked change has taken place. Previous to the development of the application of vat colors in this industry, the dyer was far ahead of the printer in the production of shades of extreme fastness. Especially the manufacturing and finishing process depends on the production of insoluble color lakes in the process of coloring. The hydrosulphite-vat color process of printing provides this nearly in perfection. The required installation of machinery is not extensive, the success or failure of the operation depending mainly on the proper construction and condition of the steamer, preferably a Mather-Platt. This must be arranged so that all access of air is excluded and suitable steam plates provided for heating so that the interior is at all times at a temperature of 102°–104° C. (see figure). With proper conditions here and the usual care in making up the print colors failure is not to be anticipated. The present application of the vat colors in the printing process depends on the use of sodium-formaldehyde-sulphoxylate. This is stable at ordinary temperatures and enables the pastes to be made up without difficulty, and the prints from the machine are uniform throughout the length. On steaming, the sulphoxylate is liberated and at once reduces the dyestuff to its soluble condition in which it combines with the fiber. After steaming, the material is treated with either soap or oxidizing agents which fully develop the color in an insoluble condition. By the proper selection of dyestuffs the printer can furnish shades which can be guaranteed as fast to light, washing, wearing and other injurious influences, in fact almost that the color will last longer than the fibre. This condition has undoubtedly been brought about by the discovery and perfection of the hydrosulphite-formaldehyde compounds. This is the present state of the direct printing industry; now the printer is ahead of the dyer for he can work more economically and the results are in every way satisfactory to the consumer. One of the very apparent results is "laundry-proof shirts for one dollar."

The method of discharging azo colors by the use of these salts has been used for sometime and cannot be said to have been very recently developed—only improved by the use of sodium-formaldehyde-sulphoxylate in place of the zinc-dust-bisulphite mixtures of the original formulas.



Continuous Steamer for Indigo Discharges and Vat-color Prints.

But the use of formaldehyde-sulphoxylate for discharging white patterns on material dyed with indigo is the most recent and the most notable advance in the printing industry brought about by the use of hydrosulphites. It has long been known, and use has been made of the fact that oxidizing agents would destroy indigo blue and render it colorless and all the discharge printing on indigo has been based on this. The great disadvantage has been, however, that these agents also acted on the cotton fiber and the formation of oxycellulose with material loss of strength has occurred. By the use of reducing agents this could be avoided but the difficulty was to remove the indigo-white produced in the pattern before it became re-oxidized.

In 1907 one of the foreign manufacturers of indigo suggested the use of anthraquinones in the printing

paste with sodium formaldehyde sulphoxylate. This rendered the discharge more energetic and also hindered the reoxidation, but it was necessary to handle the material very quickly to avoid tarnishing the whites. The usual conditions of the printing rooms rendered the production of uniform results almost impossible and little practical use was made of the process in this country.

However, in the last two years a notable advance has been made owing to the discovery that certain bases of the substituted ammonium type would combine with indigo white to form stable compounds which do not oxidize in the air. Further experiments proved that this property was characteristic of compounds of certain tertiary bases with benzyl chloride, its homologues and analogous bodies and their substitution products. In the presence of zinc oxide desirable reddish to yellow shades can be obtained by this method.

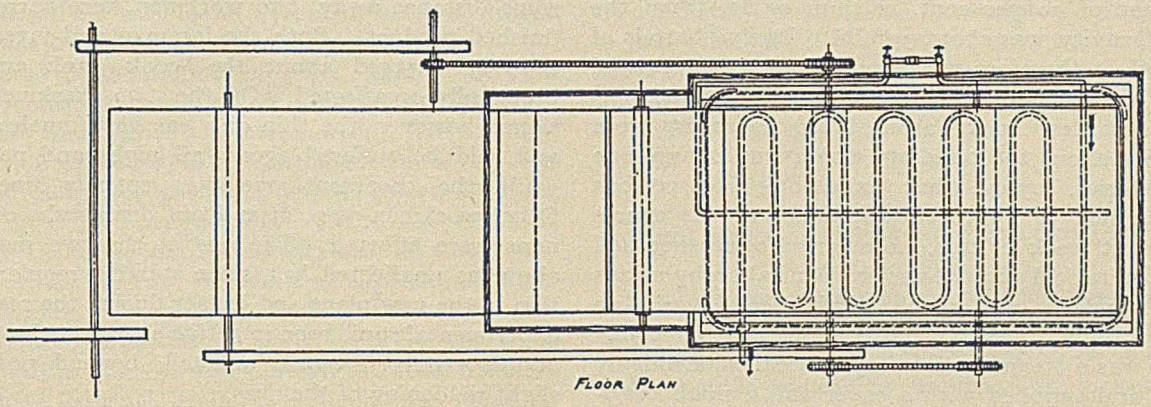
But in order to obtain white discharges the compounds obtained in the discharge process had to be made readily soluble. It was found that this could be done by the substitution of a sulphonic group in the benzyl nucleus. The yellow compound obtained by using a substance of this nature in the formaldehyde sulphoxylate discharge paste is readily soluble in alkalies and being easily removed from the material leaves the patterns clear.

Thus the problem of satisfactory indigo discharges was solved. For certain considerations the discharge material is not sold as such but in combination with sodium formaldehyde sulphoxylate as hydrosulphite C L or rongalite C L, according to the maker.

The practical method of handling is simple. The discharge pastes are made up with 20 per cent. of the sulphoxylate discharge compound, 8 per cent. zinc oxide, 4 per cent. anthraquinone, 30 per cent. paste, with suitable thickening. The material is printed, dried, steamed in the before described steamer for 3–5 minutes at 100°–103° C., washed in hot water, then passed through an alkaline bath, washed and dried. In this process, the pastes are perfectly stable and after printing and steaming the material can be left indefinitely before clearing. The writer kept a piece for two months before clearing and the resulting whites were perfect.

The process has been adopted by the largest indigo printers in this country. In spite of the fact of the higher cost the commercial product now represents the standard of indigo prints. The gain to consumers is in the same proportion: for the strength of the material is not affected and after the garments are washed three times the whites are no longer holes but remain the original material.

The zinc-formaldehyde-hydrosulphites are used solely for removing the dyestuff and colors from previously dyed material and have little interest for the phase of the subject under consideration. Their great advantage lies in the fact that the strength of the fiber is not affected.



The increase in the use of hydrosulphites and the formaldehyde compounds has been most marked and the probable consumption in the textile industry in the United States for the year 1911 was not far from one million pounds.

NEW YORK CITY.

THE EFFECT OF "LIME-SULPHUR" SPRAY MANUFACTURE ON THE EYESIGHT.[1]

By JAMES R. WITHROW.

About two years ago, the writer was called upon to take charge of the installing of a "Lime-sulphur" department for a manufacturer engaged in other lines of chemical manufacturing. Preliminary to starting industrial experimentation, a very thorough laboratory study had been carried out by the manufacturer's regular chemist. This work reviewed in a most capable manner about all the recommendations of recent chemical and experiment station literature concerning "lime-sulphur" preparation. As a result of this work a formula was evolved, which was used as a basis for manufacturing experiments. The laboratory experiments themselves were never made in larger than five-gallon apparatus. The writer witnessed, from time to time, these experiments or portions of them and at no time noticed anything causing discomfort. The laboratory assistant, who did most of the experimental work for the company's chemist and was constantly in contact with the material and its fumes, never noticed any effect or discomfort at any stage of the laboratory work, which extended through several months. To be sure, there was the ever present odor of hydrogen sulphide or at least a similar odor. This was never offensively strong. At no time was it

[1] Paper presented at the Eighth International Congress of Applied Chemistry, New York, September, 1912.

so noticeable as to compel enforced ventilation.

The writer's business was to accept the work as completed in the laboratory and transfer it to factory operation. The first factory experimental runs were made on about a 12-barrel scale. These experimental cooks were made to get factory scale data for construction work and also to uncover any unforeseen operation difficulties. The product had varying specific gravity from 45° to 32° Bé., depending on the purpose of the experiment. The final solution of calcium polysulphide or so-called "lime-sulphur" contained about 25 per cent. sulphur and about the equivalent of 10 per cent. calcium oxide, when the specific gravity was about 33° Bé. Twelve barrels of this product therefore would contain 1625 pounds of sulphur and the equivalent of 650 pounds of lime.

The first few cooks aroused no comment from employees about the building, which was a large one of four stories, beyond what would come from persons unaccustomed to hydrogen sulphide. In the course of the next week or two, however, the weather had become quite cold and the normal ventilation by means of the windows was much diminished. Again no particular effect was noticed at first. The "cook" digester was a steam jacketed cylindrical tank roughly 5′ × 5′ and supplied with a cover and a small ventilating pipe. This pipe was inadequate for proper ventilation of tank and would have been useless anyway, for the top of the "cook" tank was usually open during the experimental runs for observation purposes. The man in charge of the cooks usually stationed himself at the opening to become familiar with boiling conditions within the tank during the various runs under different conditions.

Within a cook or two, after the windows were closed to diminish the cold conditions, the man in charge of the cook became aware of a smarting sensation in and around the eyes. The eyelids became red. The writer was constantly about the tank, but was only occasionally at the tank opening and felt little or no discomfort, though there was a slight burning feeling about the eyes. The room became partially filled with condensed steam at times and finally about 8.00 P.M., during a slightly prolonged run, the writer noticed that the amount of vapor in the room was greater than usual and that the incandescent electric lights had a halo of some eighteen inches in diameter when viewed through the fog: the halo tended to have rainbow colors. An hour or two afterwards, the writer found the same conditions as to fog and halo to exist in his room in his hotel and concluded that his eyesight was affected. Cold water was applied liberally and he turned into bed and went to sleep at once. In the morning the blurred eyesight was about as bad as the evening before. The foreman, who stood at the opening of the cook tank, had gone home at the end of the run at the time the writer did. He was unable to report for work next day. His eyes were much inflamed and were too sensitive to light to open them. He said they pained and felt gritty under the eyelids. He was back at work again in a couple of days. In the case of the writer, with the liberal use of saturated boric acid solution, the blurred vision gradually returned to normal during the course of a week's absence from the manufacturing operation. There was a recurrence of the blurred effect at another time, which rendered vision almost impossible, but it rapidly wore off and at no time was there any pain. The foreman never again had an attack after his initial experience. None of the workmen were affected after proper precautions were taken.

At one time however, when a batch was being concentrated by boiling down, the cover was thrown open to expedite evaporation. In the same room some distance away, two workmen were barreling off finished product. Both the foreman and myself were actively engaged about the cook tank and were practically unaffected. Of the two workmen mentioned however, the thin one was very much affected and said he suffered agony all night and next day, while the corpulent one was entirely unaffected. Other workmen were in and out during the cook but none were affected. The one of the two mentioned above as unaffected has, since starting regular operation in the new plant and in fact during the rest of the experimental runs, been in active charge of the "cooks" and has never become affected, beyond possibly a slight reddening of the eyes.

No one at all has been affected in anyway since the new plant was installed with its ample facilities for ventilation. Inquiry directed to other manufacturers disclosed similar experiences. One manufacturer's experience was so bad that he at once knocked one side out of his cooking room. This is undoubtedly effective, but from the writer's experience unnecessary. All that is required is a hood over the cook tank, which will carry all vapors out doors, and a "cook" room which is high ceilinged and reasonably well ventilated. Providentially the copious evolution of steam has caused most plants to provide hood-covered tanks, thus avoiding the unexpected trouble we are discussing.

A search of the literature of "lime-sulfur" available to the writer found no mention of the effect of the eyes. The suggested reactions to explain the action of sulfur on calcium hydroxide and water, varied as they were, gave no clue to what might have been the body which gave rise to the trouble. During a subsequent study of polysulfide literature in general, however, it was found that Bloch and his pupils[1] had prepared polysulfides of hydrogen of the formulas H_2S_3 and H_2S_2. The latter is formed by heating the former and is easily volatile. The fumes of these polysulfides are said to have a penetrating disagreeable odor and their vapors attack the mucous membranes. Thorpe says their vapors attack the eyes.[2] They are decomposed by alkalies and therefore would not exist very long in the lime-sulfur cook, but if they were being given off in mere traces, continuous exposure to such fumes would naturally cause discomfort.

Hydrogen sulfide itself, however, may have been the cause of the trouble. It has been shown to be a

[1] *Ber. d. chem. Ges.*, **41**, 1961; *Am. Chem. J.*, **41**, 155.
[2] *Dict. Applied Chem.*, **3**, 699 (1893).

product of the evaporation of a solution of calcium polysulfides.[1] Hydrogen sulfide could not likely have been the cause, unless the symptoms of H_2S poisoning recorded are the effects of only sudden or brief exposure to large amounts of the gas and that prolonged exposure to dilute H_2S would cause a different series of violent symptoms. This latter assumption does not appear probable for in such cases where H_2S was permitted in the atmosphere of laboratories in small amounts, the *usual* symptoms, only not so pronounced, were the result. The only recorded symptom of hydrogen sulfide poisoning observed in the cases under discussion was the occasional occurrence of headache. This was to be expected, since hydrogen sulfide was itself being evolved to some extent.

It should be mentioned, however, that K. B. Lehmann[2] mentions cases where "intense irritation of eyes, nose and throat" occurred within five to eight minutes of exposure to a concentration of 0.3 per thousand of hydrogen sulfide, but no affection of the sight is mentioned even in this extreme case. In long exposure to lower concentrations, such as would correspond with the case of hours of exposure in lime-sulfur cooking, the action recorded is on the respiratory tract. These symptons appeared entirely absent in the lime-sulfur cases as also were all the other common symptoms (except headache), such as muscular weakness, etc. A tendency to conjunctivitis, a symptom of chronic hydrogen sulfide poisoning, may have been present in the case of the man in charge of the cooks. He was the man, however, whose eyesight itself was never affected. The writer has suffered at other times in the last six years, most of the symptoms of slow hydrogen-sulfide poisoning, due to inadequately ventilated, over-crowded and poorly arranged university laboratories, but the symptoms in the lime-sulfur experience were quite different. In fact the usual muscular weakness and general depression as caused by hydrogen sulfide were not experienced at all in the lime-sulfur manufacture. It should be mentioned also, that the writer has been informed that attendants at "sulphur" baths have had their eyesight temporarily affected in a similar fashion. Volatile polysulphides may be present in this case also, although they have not been proven to the writer's knowledge to be present in either case. This would be an interesting point for some favorably situated person to develop.

It seemed possible therefore that these hydrogen polysulphides might have been the cause of the action on the eyesight of the vapors from the boiling of a mixture of sulphur, lime and water.

It may be stated at this point that this indication of the presence of hydrogen polysulphide in the vapors of the lime-sulphur cooks might have an influence upon the solution of the problem of the actual reactions involved in lime-sulphur preparations, a mooted question at the present time. The trouble with the eyesight always came when a batch was being concentrated by evaporation before filtration and not during ordinary cooks.

[1] Divers, *J. Chem. Soc.*, **1884**, p. 284.

[2] Arch. F. Hygiene, Bd. XIV, 1892, 135; Blyth, "Poisons, Their Effects and Detection," 3rd. Ed., C. Griffin and Co., London, p. 73.

It seemed worth while to record these facts as a warning, at least, as to the serious dangers of lime-sulphur manufacture in the absence of adequate ventilation. This is all the more necessary since it is probable that attention has not already been frequently called to the matter, because ordinary ventilation precautions only, are necessary to avoid all trouble, and therefore the average manufacturer has not had the experience or it has appeared so seldom that the isolated affections of a workman now and again may have been attributed to something else. It is worth noting also because the mere occurrence of a cold spell of weather gave the opportunity of experiencing this difficulty possible in lime-sulphur manufacture, so that otherwise it might never have occurred at this plant or only in such isolated cases as to destroy any connection between cause and effect.

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PHENOL-FORMALDEHYDE CONDENSATION PRODUCTS.[1]

By L. H. Baekeland.

The resinous or amorphous products resulting from the action of phenolic bodies upon formaldehyde have lately attracted considerable attention on account of their rapidly increasing applications for industrial purposes.[2]

It is questionable whether this general designation of "condensation products of phenols and formaldehyde" should be maintained much longer. Indeed, it is well known that these products can be obtained without the use of so-called formaldehyde. In fact, the first condensation products thus described were produced without the use of formaldehyde,[3] and it is generally accepted that other methylene compounds, for instance, methylal, trioxymethylen, hexamethylentetramin, etc., can replace formaldehyde in this reaction. The fact that hexamethylentetramin can suitably replace formaldehyde in the formation of the infusible phenolic condensation products was published as far back as December 31, 1907, by Lebach.[4]

Lately, I have succeeded in producing fusible resinous condensation products identical with those described by Blumer, DeLaire, etc.,[5] by introducing a mixture of salicylic acid and an inorganic acid in the cathode compartment of an electrolytic cell in which sodium chloride is electrolyzed, a mercury cathode being used. According to the well known reaction of Kolbe, the carboxyl group of salicylic acid is introduced by reacting with CO_2 on phenolate of sodium, so that we have here an example of the possibility of introducing indirectly the methylene group as CO_2, then reducing the carboxyl group by means of nascent hydrogen. A similar observation

[1] Paper presented at the Eighth International Congress of Applied Chemistry, New York, September, 1912.

[2] Baekeland, This Journal, **1**, No. 3, 149 (1909); No. 8, 545 (1909); **3**, No. 12, 932 (1911).

[3] *Ber.*, **5**, 1905; **19**, 2009, 3004; **25**, 3477; **27**, 2411.

[4] Knoll patent, Belgium, No. 204,811, December 31, 1907. Ditto. Wetter (Knoll) British patent, No. 28,009, 1907, owned by the Bakelite Gesellschaft of Berlin.

[5] Baekeland, This Journal, **1**, 545 (1909).

has already been recorded by Velden,[1] who expected to get oxybenzyl-alcohol by reducing salicylic acid but obtained the corresponding saliretin-body resulting from the dehydration of phenol alcohol.

However, the designation "phenol-formaldehyde condensation products" has been so generally used, that for a while at least, we shall have to submit to it as a matter of routine.

In the same way, we are erroneously designating as "formaldehyde" a commercial aqueous solution containing some real formaldehyde or methylen-oxide, CH_2O with much methylen-glycol, methylal, trioxymethylens, hydrates of trioxymethylens, other polyoxymethylens, etc., all compounds of methylen of which the technical value is equivalent in this reaction to that of true formaldehyde.[2]

The direct relationship of the resinous condensation products to phenol alcohols or their anhydrides seems now pretty well established. The so-called fusible soluble resinous condensation products are merely varieties of the saliretins,[3] and all these products differ from each other only by greater or lesser fusibility, solubility, or hardness, and each of these properties can be modified at will. Furthermore, we have the means at hand of producing all these bodies directly from phenol alcohols.[4]

The formation of ortho- and para-oxybenzyl-alcohol, or their homologs, by Manasse and Lederer, is sufficiently well known;[5] this process consists in the direct action of one molecule of phenol on one molecule of formaldehyde in presence of one molecule of NaOH under special conditions.

Then DeLaire[6] showed that these same phenol-alcohols can be transformed industrially, by dehydration, into fusible resins or saliretin products suitable for commercial purposes in place of shellac, copal, or other natural resins. In that process, it is not necessary to first produce the phenol alcohol in pure form, and the two reactions can be carried out practically at the same time, so that the phenol alcohol is dehydrated to saliretin resins as soon as it forms.

This is accomplished more directly by reacting with phenol on formaldehyde in presence of an acid,[7] provided the reaction be carried out under suitable conditions. One of the required conditions is that the phenol should be in excess so as to avoid the formation of variable amounts of infusible and insoluble products. A fusible soluble saliretin can thus easily be prepared which has all the appearances of a resin; it melts if heated and solidifies by cooling; it is soluble in alcohol and acetone; it can be maintained in fusible condition for very long periods without becoming infusible or insoluble, provided heating be carried on below certain temperatures, and provided the excess of phenol be not removed. This fusible resin and its preparation has been described by Blumer, and DeLaire as a "shellac substitute," or "resin substitute;"[1] by Baekeland, who calls it "Novolak;"[2] and lately again by Aylsworth, who calls it "phenol resin,"[3] In whatever way it be obtained, whether by using a phenol alcohol (DeLaire, Baekeland), whether by starting from phenol and formaldehyde in the presence of oxy-acids (Blumer), or in the presence of mineral acids (DeLaire, Thurlow, Bayer), or by the action of phenol on formaldehyde without adding condensing agents (Story)[4] or (Aylsworth)[1] the product is absolutely the same in its chemical and physical properties. Its melting point or fusibility may be modified at will by varying the amount of free phenolic body. This free phenol exists in solid solution in the mass and can be eliminated by merely physical methods; by the partial elimination of this free phenol, the fusibility and the solubility of the resin are decreased. The last traces of free phenol cling tenaciously to these saliretin resins; so much, indeed, that at one time, I was inclined to believe that this small amount of phenol was chemically combined. Indeed, the last traces of phenol cannot be expelled by heating at the lower melting temperatures of the product. There is nothing strange in this, if we take into consideration that phenol itself has a relatively high boiling point, and we know of numerous examples where colloids retain, physically, small amounts of other bodies which form therewith colloidal solid solutions. As long as there is some excess of phenol present in the saliretin, it is possible to maintain the mass in fusion for a practically indefinite time, provided the temperature be not raised too high. Pure saliretin, containing no excess of phenol, may be kept in fusion for some time, but after a while it polymerizes and becomes less fusible until finally it changes into some infusible product. However, it should be noted right here that this latter product, although it is infusible, does not possess the maximum mechanical strength nor hardness, nor general chemical and physical resistivity, of those other polymerized infusible products, of which I will speak later on, and which are obtained by reacting with a sufficiently larger amount of formaldehyde, or equivalent methylen compounds, and which have been designated as Bakelite C.

It is possible to expel the slight excess of phenol which lends special fusibility to the so-called fusible resins; this can be accomplished whether these resins be called "shellac substitutes," "Novolak," or "phenol resins," or whether they be made directly from phenol alcohols, or from phenol and formaldehyde with or

[1] Velden, *J. prakt Chemie*, [2] **15**, 164; *Jahresbericht*, **1877**, 337.

[2] Raikov, *Chem. Ztg.*, **26**, 135; **12**, 11 (1901). Kekulé, *Ber.*, **25**, 2435. Harries, *Ber.*, **34**, 635; *Compt. rend.*, **124**, 1454; *Bull. soc. chim.*, **17**, 849. F. Auerback, also Auerbach and Barschall, *Arb. kais. Gesundh.* Band, 22, Heft 3 and Band 27, Heft 1. Verlag Julius Springer, Berlin.

[3] Beilstein, *Organ. Chemie*, **2**, 1109 (1896). R. Piria, *Ann. Chem.*, **48**, 75; **56**, 37; **81**, 245; **96**, 357. Moitessier, *Jahresbericht*, **1886**, 676. K. Kraut, *Ann. Chem.*, **156**, 123. Gerhardt, *Ann. Chim. Phys.*, [3] **7**, 215. F. Beilstein and F. Seelheim, *Ann. Chem.*, **117**, 83. C. Schotten, *Ber.*, **1878**, 784.

[4] Baekeland, **1**, No. 8, 545 (1909).

[5] *J. prakt. Chem.*, [2] **50**, 224. *Ber.*, **1894**, 2409–2411. D. R. P. Bayer, 85,588; U. S. P. Manasse, 526,786, 1894.

[6] DeLaire, British Patent 15,517, 1905; D. R. P. 189,262.

[7] Blumer, British Pat. 6,823, 1903; 12,880, 1902. DeLaire, French Patent 361,539. Wetter (Knoll), British Patent, 28,009, 1907. Knoll, French Patent 395, 657; Bayer, D. R. P. 237,786; D. R. P. 201,261; British Patent, 26,317, 1907, etc.

[1] *Loc. cit.*

[2] THIS JOURNAL, **1909**, 545.

[3] U. S. Patent 1,029,737.

[4] Austrian Patent 30,844, page 2, lines 17–20.

without acid condensing agents. Indeed, plain heating at 300° C to 350° C. or better, heating *in vacuo*, or in a current of an inert gas, like nitrogen, easily expels the free phenol, and produces infusibility. The same result is readily obtained by entraining the free phenol by blowing superheated steam through the molten resinous mass.

These facts are corroborating proofs to others which establish clearly the saliretin-nature of these fusible products, and demonstrate their relationship to the phenol alcohols from which they are derived. If these fusible resins are prepared directly from phenol and formaldehyde, the preliminary formation of phenol alcohol may escape our notice, because by the action of heat on the mixture, especially in presence of acid bodies, the phenol alcohols are rapidly dehydrated to saliretin products. But it is quite possible to demonstrate their presence, and my assistant, Dr. A. H. Gotthelf, while preparing fusible resinous condensation products, by boiling a mixture of phenol and formaldehyde, acidulated by means of HCl, has been able to extract from this mixture well defined crystals of oxybenzyl-alcohol before the heat had accomplished its resinifying action.

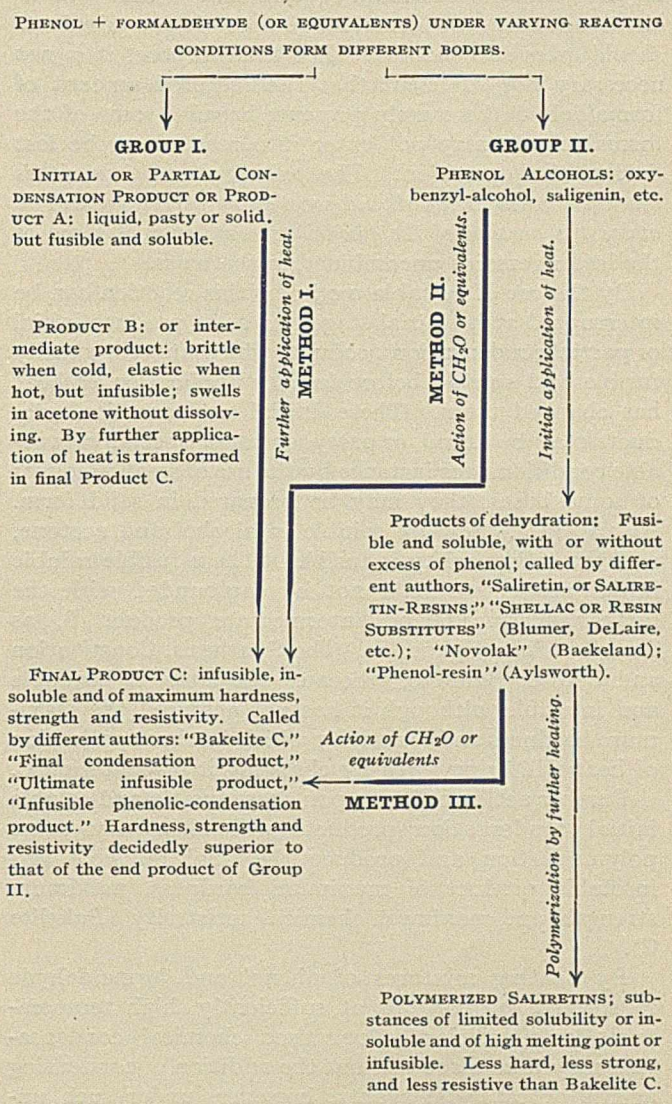
It is self-evident that as soon as high temperatures are applied to such mixtures, the formed phenol alcohol will quickly undergo resinification, because the phenol alcohol will be dehydrated to a saliretin product as soon as it is formed.

If there is an excess of phenol present, or if the formaldehyde reacts in insufficient proportions, which amounts to the same thing, a fusible saliretin will be the result.

In the absence of an excess of phenol, but using however, a restricted amount of formaldehyde or other methylen compound, a polymerized infusible saliretin will be produced.

But whenever we succeed *in bringing into reaction a sufficient amount of formaldehyde* or its equivalent, then a much harder, much stronger and more resistive infusible body than an infusible saliretin, will be formed, and this body of maximum strength and resistivity is identical with Bakelite C.

If we first produce the pure crystalline phenol alcohol, containing no excess of phenol, for instance crystalline saligenin or oxybenzyl-alcohol, and if we heat it gently, it will simply dehydrate and be transformed into a fusible mass which on cooling solidifies to a resinous product—a fusible saliretin resin. The latter submitted to the further action of heat polymerizes and becomes an infusible, insoluble saliretin. This polymerization is facilitated by the presence of small amounts of catalyzers, for instance, hydrochloric acid. The presence of an excess of phenol retards polymerization, hence the infusibility induced by polymerization will be retarded, and this until in some way or another the excess of phenol has been expelled. The infusible polymerized saliretin obtained by heating phenol alcohols containing no free phenol, or by heating fusible saliretin containing no free phenol, is insoluble in alcohol, but swells in acetone; it softens decidedly on heating, although it is no longer fusible. Longer heating does not harden it further, nor make it more resistive. It is harder, stronger, and more resistant to physical and chemical agents than the fusible saliretin from which it is derived; in this respect, it surpasses even more the soluble fusible resins described by Blumer,[1] DeLaire,[1] Baekeland,[1] and called "phenol resin" by Aylsworth.[1] But even after polymerization or hardening has been carried as far as possible, it is considerably less hard, less strong and less resistant to physical and chemical agents than the polymerization products resulting from the reaction of phenol on a sufficiently larger proportion of formaldehyde or equivalent substances.



In order to obtain the latter polymerization products of maximum strength, hardness, and maximum resistivity, an adequately larger amount of methylen group must be introduced before or during the act of polymerization. The introduction of this methylen group may be accomplished by at least three distinct methods:

First: Reacting directly with a sufficient amount of formaldehyde (or its equivalents) upon phenol.

[1] *Loc. cit.*

Second: Reacting with formaldehyde (or its equivalent) on phenol alcohol.

Third: Producing a fusible dehydration product of phenol alcohols or saliretin products, then reacting thereon with formaldehyde or its equivalents.

The preceding diagram describes very well all these relations:

FIRST OR DIRECT METHOD.

Direct Action of Phenol on Formaldehyde.—Phenol can be made to react on formaldehyde or its equivalents at sufficiently high temperature to produce directly an infusible, insoluble polymerization product of maximum strength and hardness (Bakelite C). In this reaction, the main requirement is that a sufficient amount of formaldehyde or its equivalents *should enter into reaction.* For this purpose, it is not necessary nor sufficient that the required amount of formaldehyde be merely present; because some of the formaldehyde may not enter into reaction or be lost during the operation. *The principal requirement is that the formaldehyde should react in sufficient amount on at least a portion of the phenol present,* even if some of the latter remains uncombined in the mass.

By the use of suitable methods, this reaction can be interrupted at its initial stages so as to produce initial or partial condensation products which are temporarily fusible and soluble before further application of heat has changed them. These initial condensation products may be liquid, or pasty, or under specially favorable conditions, for instance by the use of small amounts of some bases, they may be prepared in solid form. At any rate, they are soluble in alcohol and acetone, and the solid variety is fusible. These fusible soluble initial products should not be confounded with the further advanced and intermediate product B, as described in my paper on "The Synthesis, Constitution and Uses of Bakelite,"[1] because the latter is insoluble and infusible, although it has not acquired the maximum hardness and resistivity which further application of heat will bring forth by changing it to condition C.

Further action of heat upon these fusible and soluble initial condensation products will ultimately cause polymerization and produce the final infusible and insoluble product of maximum hardness, maximum strength, and maximum chemical resistivity (Bakelite C).

By heating mixtures of phenol and formaldehyde in suitable proportions at sufficiently high temperatures for a sufficiently long time, chemical condensation may take place without the addition of condensing agents or catalytic agents; however, under such unfavorable condition, the action is too slow and too difficult to control for technical purposes.

By the addition of acids or acid salts, the reaction may be hastened to the point of becoming violent. But the presence of acid bodies tends to develop disturbing side-products which lessen the technical value of the final product. Furthermore, in presence of an acid-reacting mixture, whenever there is a sufficient excess of phenol, we do not obtain the infusible, final product, but resins of the fusible saliretin or "shellac substitute" type. Things go quite differently if small amounts of bases are present during the reaction.[1] Small quantities of bases prevent radically the formation of fusible soluble saliretin products (shellac substitutes, Novolak, phenol-resin, etc.) and insure the formation of infusible, insoluble final products, even in presence of a decided excess of phenol. If the phenol be used in excess, it will be found in the final product as a solid solution. In fact, the excess of phenol may be exaggerated to the point that the final product becomes very flexible or assumes a gelatinous appearance, and swells considerably in certain solvents, like phenol, or alcohol, or acetone, without, however, entering into complete solution. In any case, this free-phenol-containing substance is infusible; in other words, the application of heat can no longer liquefy it, although higher temperatures may char or destroy it.

This behavior of the bases constitutes a radical difference from that of acids or other acid-reacting bodies. Whenever acid-reacting bodies are used in conjunction with an excess of phenol, or an insufficient amount of reacting formaldehyde, which amounts to the same thing, they tend to produce fusible soluble resins, while under exactly the same conditions and with the same proportions of phenol and formaldehyde, small amounts of bases develop *surely* infusible polymerized bodies as ultimate products.

In this method, the bases should be used in relatively moderate amounts; not in molecular proportions, as Manasse and Lederer[2] utilize them for making phenol alcohols, nor as DeLaire[2] employs them to produce the fusible resinous dehydration products of these phenol alcohols. Neither should they be used in such large quantities nor under such conditions as Hentschke[3] recommended for the manufacture of certain antiseptic compounds.

If the amount of base be properly restricted, the reaction proceeds very regularly and remains under easy control. The base acts as an excellent accelerator, both in the condensation and in the polymerization. The use of bases under the above mentioned conditions enables one to carry out the reaction with the utmost uniformity and certainty of results.

At first sight the importance of these seemingly modest facts is not very apparent; no more than the value of the observation that sufficient counterpressure permits quick polymerization at high temperatures without risk of porosity; no more indeed than the realization of the fact that the final product with its great hardness, its strength and other splendid qualities is unelastic and wofully deficient for most industrial purposes where great resistance to shock or vibration is required, and that the incorporation of suitable fibrous materials improves all this by modifying the shattering wave induced by impact. Yet these three main factors have enabled us to harness into technical service an elusive laboratory reaction and have rendered possible the creation of a new industry which is gaining daily in importance.

[1] This Journal, 1, No. 3, 149 (1909).

[1] See Baekeland, U. S. Patent 942,809.

[2] *Loc. cit.*

[3] Hentschke, D. R. Patent 157,553.

It has been shown[1] that small amounts of ammonia or amines may be used to good advantage for this purpose. It is a well known fact[2] that ammonia or ammonium salts in presence of formaldehyde produce instantly a corresponding amount of hexamethylentetramin. In the same way, if any ammonia be added to a mixture of phenol and formaldehyde, a corresponding amount of hexamethylentetramin is produced which can easily be extracted from the mixture. This fact was confirmed by Lebach, and can easily be ascertained by direct experiment.[3] It is self-evident that instead of a mixture of phenol and formaldehyde and ammonia, an equivalent amount of hexamethylentetramin or hexamethylentetramin-triphenol[4] may be used.

So that in the preparation of these bodies, formaldehyde can be replaced by hexamethylentetramin; this was already published by Lebach in the patent literature as far back as the end of 1907.[5] Whether the phenol mixture be prepared with ammonia or with hexamethylentetramin, its properties are practically the same, and on heating, both mixtures engender the same product, with the final evolution of ammonia gas.

Whatever be the methods employed, this reaction is strongly exothermic, and heat is set free in the two phases of the reaction: *First*, in the condensation stage, by which the initial product is formed, and water is separated. *Second*, in the final hardening when the product becomes infusible by polymerization, a considerable disengagement of heat takes place anew. If the substance be heated in thin layers, this self-heating may be unobservable on account of the heat losses; under such conditions, if, however, the mass is thicker or bulkier, and more especially if it be contained in a mold, this self-heating becomes very disturbing and liberates gaseous or volatile products which cannot escape before the mass sets to infusibility; this causes the mass to swell and raise and to become porous, and makes it practically worthless for almost all technical purposes. This was the stumbling block which former investigators tried to avoid by conducting the hardening at very low temperatures, or by the use of suitable solvents which tend to moderate the reaction. This tendency towards foaming exists also if acid-condensing agents are used, or even if no catalytic agents are added at all. The liberated gaseous products may vary according to conditions; in some cases, they may consist largely of formaldehyde gas which tends to escape before the reaction is accomplished; if ammonia be used, and more so if hexamethylentetramin be employed, varying amounts of ammonia gas will be set free.

Especially when hexamethylentetramin is used, the evolution of ammonia is very abundant, and this naturally increases the tendency to foam and to give a porous final product. This tendency to foam becomes pronounced only at temperatures above 50° or 100° C., because at these increasing temperatures the exothermic reaction sets in. It should be noted that temperatures considerably higher than 100° C. are those which are employed in almost all commercial applications of these products, because they allow quick hardening and quick molding. At such high temperatures, polymerization proceeds very rapidly, but the exothermic reaction superinduces a further spontaneous increase of the temperature of the mass, and in this way, the defect of foaming is considerably more pronounced.

This tendency to foam makes it of the utmost technical importance whenever high temperatures are employed, for quick commercial work, that the liberation of gaseous or volatile products during the polymerization or hardening process, should be opposed by a suitable counter-pressure. The latter may be applied in various ways; for instance, by heating in closed molds or in closed vessels, so that the imprisoned gases develop a suitable counter-pressure; or by heating in a chamber in which air or other gases have first been pumped to a suitable pressure; or by heating in a hydraulic press. In the latter case, the first function of the pressure is to counteract the development of gaseous products, while at the same time the mass is given the desired shape in the mold.[1]

For other applications, like varnishes or lacquer, where the material is applied in thin layers, the use of counter-pressure is not indispensable.

As stated above, the use of ammonia or hexamethylentetramin increases the tendency to foam. On the other hand, small amounts of fixed alkalies, like caustic soda, act as more powerful accelerators than ammonia or hexamethylentetramin, without causing the evolution of disturbing ammonia gas or other gases. In this and other respects, the fixed alkalies have decided advantages over ammonia or hexamethylentetramin, as well as over acid-condensing agents. For instance, they permit rapid hardening at the relatively low temperatures of 70° to 95° C.; furthermore, as soon as the initial solidification has set in, the temperature can be raised quickly to 110°, 120° and 160° C. At these higher temperatures, the hardening proceeds with great intensity and without fear that the gas bubbles should cause porosity. If the heating be carried to the hardening temperature before all the water has been first expelled, then the only necessary precaution will be to keep the temperature sufficiently below 100° C. so that there can be no evolution of steam which might cause blisters; but as soon as the mass has been heated long enough at these lower temperatures, so that it has solidified sufficiently, the temperature can be raised with impunity above the boiling point of water. As soon as these higher temperatures become available, the polymerization to final hardening advances very rapidly.

For many purposes, it is simpler to drive off the water at temperatures below the polymerization temperature, either by drying *in vacuo*, or by drying in a

[1] Baekeland, U. S. Patent 942,809.

[2] Wohl, *Ber.*, **19**, 1892; Tollens, *Ibid.*, **17**, 653; Carl Goldschmidt, page 29, Bonn, Verlag von Friedrich Cohn, 1903; Cambier, Borchet, *Compt. rend.*, **120**, 557.

[3] Lebach, *Zeit. angew. chem.*, **1909**, 1600.

[4] "The Addition Product of Phenol and Hexamethylenetetramin," see Beilstein, *Handb. der Organ. Chem.*, [3] **2**, 651.

[5] Knoll, Belgian Patent, *loc. cit.*, and Wetter (Knoll), British patent, *loc. cit.*

[1] Baekeland, U. S. Patent 942,699.

stove at ordinary pressures at moderate temperatures, for instance 50° C. or below. Such dried material can now be submitted directly to relatively high temperatures without risk of blistering or foaming. This gives us the very best means for rapid hardening, as required by commercial processes. The use of these fixed alkalies has enabled us to carry on hardening and molding at a faster rate than is possible with ammonia or hexamethylentetramin, or other means, and at the same time to produce molded articles of better heat-resisting qualities, of highest resistivity to solvents, chemicals, and of excellent dielectric properties. For many electrical purposes, the fact that no free ammonia exists in the mass is a further advantage; indeed, this free ammonia is slowly liberated by heat from molded articles and sometimes may play rather disturbing pranks. It has a tendency to corrode brass articles.

SECOND METHOD.

Action of Formaldehyde or its Equivalents on Phenol Alcohols.—I have described this process in 1908.[1] It has been shown that the best results are obtained if the amount of formaldehyde is at least one-sixth of a molecule as calculated to one molecule of phenol alcohol. This same ratio holds good if substances equivalent to formaldehyde or to phenol alcohols are used.

This method has enabled us to gain clearer insight into the relations of all infusible condensation products to the phenol alcohols, and has furnished us the theoretical means for determining the optimum quantities of reacting materials in our technical methods of manufacturing. However, this process is more of theoretical than of practical interest, in as far as the third method accomplishes substantially the same result by starting from the anhydrides of phenol alcohols.

THIRD METHOD.

Action of Formaldehyde or its Equivalents (Paraform, Hexamethylentetramin, etc.) on Saliretin-Resins.—The method is another indirect method and consists in first preparing a saliretin-resin of the fusible soluble type, then reacting thereupon with formaldehyde or an equivalent of formaldehyde.[2] This method was first published by Lebach at the end of 1907.[3]

In these patents, it is clearly mentioned that paraform and hexamethylentetramin are equivalent to formaldehyde in the preparation of condensation products. Furthermore, it is described how the condensation products may be prepared in two successive steps by adding the formaldehyde or hexamethylentetramin, or other equivalents, in two successive quantities. Briefly stated, the process consists in first preparing a fusible saliretin-resin; to this resin is mixed a second quantity of formaldehyde, paraform, or hexamethylentetramin; this mixture submitted to heat produces the infusible product C. In reality, we prepare here in two steps a product which is practically similar to the solid initial condensation product described in the first or direct method. In that method the initial condensation product is obtained more directly by the addition of a sufficient amount of formaldehyde to phenol, in presence of ammonia, or other bases, or by the equivalent use of hexamethylentetramin or paraform. In the first or direct method, the reaction between the phenol and the formaldehyde ensues under elimination of water due to so-called chemical condensation. In the present case, however, a portion of the formaldehyde is first made to react on an excess of phenol, bringing about a corresponding elimination of water by chemical condensation; but in as far as the amount of formaldehyde is insufficient, fusible saliretin-resin is formed. In order to transform the latter into the product C, it is necessary to supply an additional amount of formaldehyde, or some paraform, or hexamethylentetramin, etc.; hence the necessity of adding a certain amount of those methylen compounds to the fusible saliretin-resin, before the mass is submitted to hardening or polymerization by heat. The chemical reaction of the methylen compound on the fusible saliretin-resin is accompanied by the further elimination of water which can easily be demonstrated by direct experiments.

If hexamethylentetramin is used, an abundant liberation of ammonia takes place at the same time; but even with the use of the latter, a certain amount of water is liberated by the action of the hexamethylentetramin on the free phenol contained in the fusible soluble saliretin-resin.

Barring those minor differences in preparation and proportions, the final product C is practically the same as that obtained by the first or direct method as described above.

If hexamethylentetramin be added to the fusible resin, and heat be applied, the violent exothermic reaction which ensues causes an abundant liberation of ammonia gas. The mass raises like bread, and a hard spongy product is the result. Aylsworth[1] utilizes this foaming to prepare this substance in powder form by first producing porous masses of the final condensation product which can be crushed more easily to a fine powder than if solid lumps of this refractory material have to be pulverized.

In molding processes where high temperatures are needed, so as to insure hardening, this violent liberation of ammonia gas can easily be counteracted by suitable counter-pressure. In this case, the pressure is not only required for shaping the article, but first and foremost, for avoiding porosity. This can easily be demonstrated by heating the mass in an open mold, at the same high temperature as is used in the press; under these conditions, direct application of these high temperatures causes foaming and porosity unless suitable counter-pressure be applied.

It has been claimed that by the use of hexamethylen-

[1] "The Synthesis, Constitution, and Uses of Bakelite," *loc. cit.* See also Baekeland Belgian additional patent 213,657; Baekeland French additional patent 11,628.

[2] Baekeland, U. S. Patent 1,038,475.

[3] Knoll Belgian patent 204,811, Dec. 31, 1907, and Wetter (Knoll), British patent 28,009, 1907, all owned by the Bakelite Gesellschaft, of Berlin.

[1] Aylsworth, Belgian Patent 240,116.

tetramin in connection with perfectly dry fusible soluble phenol-resin, no water is liberated, which is supposed to be an advantage for certain applications where high dielectric properties are required. However, it should be noted that such fusible soluble phenol-resins all contain considerable amounts of free phenol and by the action of hexamethylentetramin on this phenol, water is formed besides the ammonia that is set free.

Moreover, the presence of large quantities of free ammonia is, if anything, more objectionable for certain purposes than the possible presence of small amounts of water.

It is true that free ammonia can be expelled by sufficiently long after-drying of the molded articles, but by the same means it is just as easy to expel the last traces of water. The most striking fact is that there is no serious difficulty in obtaining articles of extremely high dielectric properties, even when starting from raw materials containing considerable amounts of water, provided the manufactured articles be submitted afterwards to a drying treatment which can be performed in any suitable drying stove.

It should be noted that almost all molded commercial articles made of phenol-formaldehyde condensation products contain various amounts of fibrous materials, preferably wood pulp or finely divided sawdust. These organic fibrous materials, at the high temperature at which the molding in the hydraulic press takes place (140° to 160° C., or over), begin to liberate variable amounts of water and other products of decomposition, which depress the dielectric properties. This is another reason why all molded articles intended for purposes where high dielectric properties are essential should be submitted to oven-drying after they are molded. Those who are unfamiliar with the technical side of the subject may ask why it would not be simpler to omit altogether the use of fibrous organic materials. They might suggest the use of asbestos. But asbestos has other drawbacks, which limit its use. For instance, asbestos is a relatively poor insulator, and the strength imparted by its fibers is not so great as that imparted by vegetable fiber; furthermore, its specific gravity makes the articles compounded therewith very heavy; moreover, any asbestos compositions which have to be machined or milled are very severe on the tools. Another objection is that asbestos compositions do not take the excellent and easy polish which can be so easily developed on articles made with wood-fiber compositions, nor do they possess the elasticity and strength of the latter.

It might also be suggested to drop entirely the use of any fibrous material, and to use amorphous or pulverulent fillers. But the technical requirements forbid this. Indeed, the main characteristic of the final phenol-formaldehyde condensation products, is that although they are exceedingly hard and resistant and have a remarkably high crushing strength, their flexibility and elasticity are very limited. In regard to these latter qualities, they occupy a position between hard rubber and glass. A sudden shock or limited bending shatters them, and this would restrict enormously their technical applications. I found that the shattering wave induced by impact could be considerably modified by the suitable introduction of fibrous or cellular materials, like wood-fiber. This behavior is quite different from that of other plastics like celluloid or rubber, which lose their best and characteristic qualities by the incorporation of filling materials. The phenol-condensation products, on the contrary, are enormously improved for commercial use, if compounded with filling materials, provided the latter be of a fibrous nature; in the latter case, they lose their natural brittleness and can stand shock and impact, without shattering; they can be rendered flexible and yet maintain all their other excellent properties of high resistivity to physical and chemical agents.

Hence, some of the most important industrial applications of these condensation products are precisely those where they are used in conjunction with fibrous bodies; for instance, they serve to impregnate fibrous materials like wood, pulp-board, and to indurate the latter, or to agglutinate firmly loose fibrous substances, like wood-fiber, or fine sawdust, which then act as a structural skeleton distributed throughout the indurated mass.

This important technical result is easily demonstrated by comparing the enormous strength and resistance to impact or shock of molding compositions containing wood-fiber with others containing the same amount of structureless filling materials, for example, powdered materials. Compositions made with the latter will be found incomparably more brittle and very much less appropriate, if not entirely unsuitable, for most industrial purposes, more especially for molded articles where great strength is required.

Other important technical results are accomplished with the use of filling materials; for instance, the highest dielectric properties have been rendered possible by the joint favorable action of fibrous material and heat and pressure.

It might be cited here that paper impregnated with these condensation products, and submitted to hardening under heat and pressure, has made it possible to manufacture sheets which show an astonishingly high disruptive test (puncture test), averaging 77,000 volts a. c. on sheets of $^1/_{16}$ of an inch thickness corresponding to 1,230 volts per mil. or about 48,500 volts per millimeter.

Under these favorable conditions, the vegetable fiber of the paper is thoroughly impregnated with the condensation product, and the high pressure has excluded the possibility of porosity induced by foaming.

YONKERS, N. Y.

LABORATORY AND PLANT

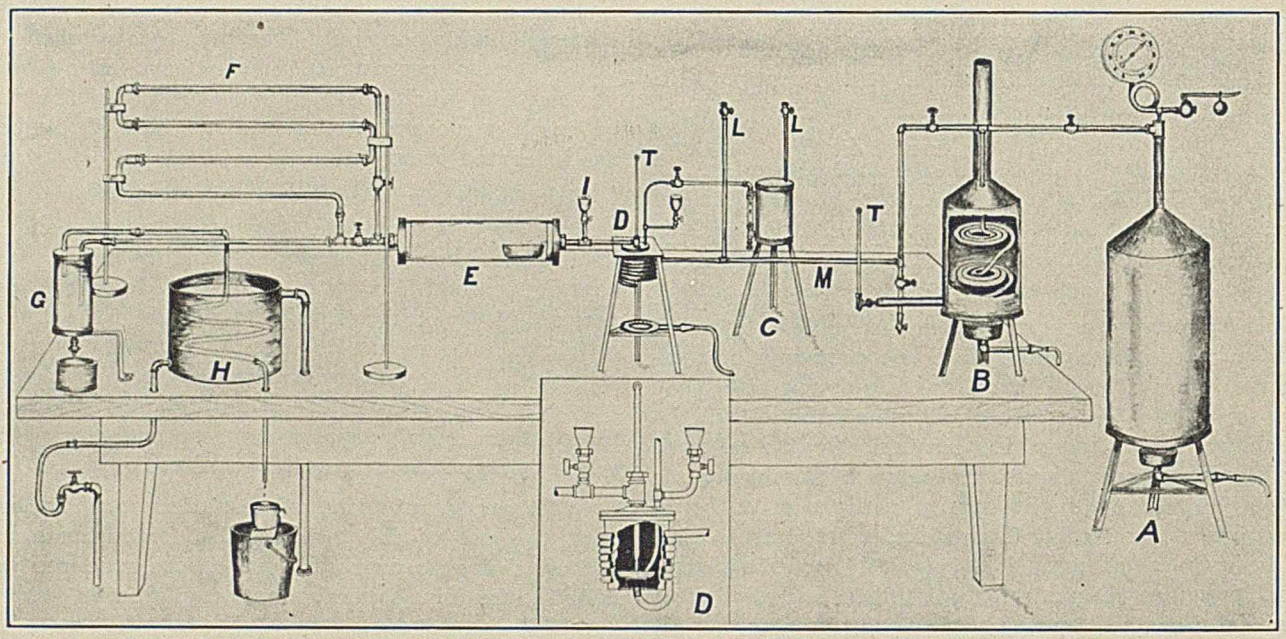
APPARATUS FOR THE EXAMINATION AND STUDY OF THE BEHAVIOR OF VALVE AND CYLINDER OILS AND OTHER PETROLEUM LUBRICATING OILS IN SATURATED AND SUPERHEATED STEAM, CARBON DIOXIDE, AIR AND OTHER GASES.[1]

By P. H. Conradson.[2]

The introduction of a high degree of superheated steam in locomotive and stationary engine practice has brought about the necessity of adding tests to the ones usually made of cylinder oils, whether straight petroleum stock, or mixture of the same with smaller or larger amounts of saponifiable fats.

The writer has constructed and used an apparatus for some time in the investigation of cylinder oils suitable for the lubrication of valves and cylinders in connection with the use of highly superheated steam in locomotive service.

The apparatus is essentially as follows (see photographic cut):



A, small steam boiler with gas, steam gauges and pipe conditions.

B, superheater with armored thermometer, T, and steam connections (a small circulating water heater with double copper coils, answers very well).

C, sight feed lubricator with connections.

D, steam vessel (a conical cast iron retort for distilling mercury, about 95 mm. deep and about 75 mm. in diameter at top provided with two strong screw clamps to keep the lid tight, answers very well) surrounded on the outside, as indicated, by a coil of copper pipe 5–6 mm. inside diameter, for further heating of the steam and gases used in the tests: this coil is tapped into the bottom of the steam vessel containing a suitably supported dish of about 25 cc. capacity (an ointment box about 55 mm. in diameter, 18–20 mm. high) into which the oil to be examined is fed drop by drop from the sight feed lubricator C (or, a given amount of oil is poured into the cup I). Through the lid is inserted an armored thermometer, T, reaching down into the dish. The steam vessel thus arranged and connected is surrounded and covered by a suitable asbsetos hood.

L, pipe connections for the gases used.

E, heavy glass cylinder about 200 mm. long and 18–20 mm. inside diameter containing a small rectangular boat or dish; beyond E is a glass tubing system, F, connected up as shown with brass fittings; each glass tube is about 500 mm. long and 8–9 mm. inside diameter; at the further end is attached a steam separator and oil collecting vessel, G, consisting of an ordinary glass chimney fitted up with brass caps; to this condenser H is connected by means of copper tubing

In this apparatus any desired temperature may be maintained at least up to 1000° F.; this is 300°–400° higher than is required under the most exacting service conditions as far as superheated steam temperature is concerned.

In studying the behavior of valve and cylinder oils in an atmosphere of superheated steam, the steam is passed from the small steam boiler through the superheater B and into the steam vessel D through its pipe coil (lamp being lit under D), and out through E, F, G and H.

When the temperature reaches and is regulated in D to 400° F., oil is fed drop by drop from sight feed lubricator C (or the cup I is filled); the steam is shut off and the valve in C (or I) opened, letting the oil run into the dish in D; the steam valve is then very gradually and carefully opened so as to let through any desired amount of steam.

[1] Paper presented at the Eighth International Congress of Applied Chemistry, New York, September, 1912.

[2] Chief Chemist, Galena-Signal Oil Co.

The temperature in D is maintained for a given length of time at or near 400° F., noting if any oil vapors are coming over; by shutting and opening the steam valve it is easy to see if any vapors are coming over with the steam.

The temperature is increased in increments of 25°–50° F., at a time, until the desired temperature is reached, noting the behavior of the oil vapors passing on with the steam through the glass pipe system, etc. It is interesting to note that cylinder oils containing rather a large percentage of saponifiable fats or fat oils generally come over at much lower temperatures than the main portions of the petroleum stock oils that are commonly used in compounding first class cylinder oils.

In further study of the behavior of oils, the boat in the glass cylinder E may be filled through the cup I to the left, and subjected at various temperatures to slow currents of superheated steam, carbon dioxide and air or mixtures of the same. The glass cylinder E during the last test is surrounded by a heavy asbestos covering to prevent radiation.

The cylinder oils may leave a residue in the dish in D at steam temperatures below 700° F.; if so, such residue should give a clear solution in 90 cc. of 0.65 sp. gr. (87° B.) petroleum ether (Pennsylvania) and show no precipitate on standing. At steam temperatures of 850°–900° F., all the oil has usually volatilized with the steam; good oils should leave no carbonaceous or coky residue.

While this apparatus was designed principally for the study and behavior of valve and cylinder oils in atmospheres of steam at various temperatures, it can be adapted very readily for the study of other oils at various temperatures in currents of air, carbon dioxide or other gases or mixtures of same with and without steam.

The accompanying table of comparative tests of five samples of cylinder oils, A, B, C, D, E and F, a petroleum distillate of interest in connection with the study of cylinder oils in superheated steam:

	A.	B.	C.	D.	E.	F.
Flash point (open cup)	545° F.	550° F.	605° F.	595° F.	550° F.	365°F.
Burning point	610° F.	630° F.	695° F.	680° F.	630° F.	415°F.
Gravity at 60° F. Baumé	26.4	26.1	24.7	25.9	...	33.5
Sp. gr. at 15° C.	0.895	0.897	0.905	0.898	...	0.856
Color	Light	Dark	Dark	Very dark	...	Yellow
Gas, test before fire test	Good	Good	0.5 cc.	4.0 cc.	...	...
Gas, test after fire test	Good	Good	Good	3.0 cc.	...	...
Cold test flows	+55° F.	+32° F.	+45° F.	+34° F.	+30° F.	Zero
Saponifiable fats	Trace	Trace	Trace	Trace	15 per cent.	None
Vis. Saybolt at 212° F. (60 cc.)	133 sec.	146 sec.	215 sec.	216 sec.	...	...
Barbey Ixomet 500° F. (180 units = 30 cc.)	45 sec.	51 sec.	61 sec.	60 sec.	...	...
Hot air test at 540° F. (loss)	15 per cent.	11 per cent.	2.5 per cent.	5.5 per cent.	...	...
Gas, test after	Good	Good	0.5 cc.	3.5 cc.	...	...
Carbon test residue	2.15 per cent.	2.70 per cent.	4.90 per cent.	5.10 per cent.	...	...
SO_3 in residue	0.023 per cent.	0.03 per cent.	0.03 per cent.	0.04 per cent.	...	...
Loss in superheated steam at 400° F.	0.0 per cent.	0.0 per cent.	0.0 per cent.	0.0 per cent.	0.0 per cent.	32 per cent.
Loss in superheated steam at 500° F.	5.0 per cent.	4.0 per cent.	1.5 per cent.	1.0 per cent.	5.0 per cent.	67.0 per cent.
Loss in superheated steam at 600° F.	18.5 per cent.	18.0 per cent.	6.5 per cent.	8.5 per cent.	21.5 per cent.	...
Loss in superheated steam at 700° F.	44.0 per cent.	34.0 per cent.	32.5 per cent.	40.5 per cent.	...	...
Total loss up to 700° F.	67.5 per cent.	56.5 per cent.	40.5 per cent.	50.0 per cent.	26.5 per cent.	99.0 per cent.
Gas test of oil:						
Residue from 700° test	Good	Good	1.5 cc.	3.0 cc.	...	...

Hot Air Test = 13 grams oil in shallow round flat bottom iron dishes exposed six hours at 540° F. in a specially designed air bath.

Gasoline Test = 10 cc. oil, 90 cc. petroleum ether 0.65 sp. gr. (from Pennsylvania crude) in graduated flat precipitating tubes, taking reading after 1 hour's standing.

Carbon Test using 35 grams Oil, according to Conradson's apparatus and method.

Superheated Steam Test = 13 grams of oil used.

Sample "A" in a superheated steam test at 800° F. (427° C.) left no residue. Sample "C" left 2.5 per cent. dry carbonaceous residue.

Sample "E" containing 15 per cent. of saponifiable fats subjected to the superheated steam test lost 26.5 per cent. up to 600° F.; the oil residue from this test contained 17.5 per cent. saponifiable fats; this indicates that the petroleum oil stock ("B" used) goes off with the steam somewhat faster in proportion to the fat oil up to 600° F. (350° C.).

The steam pressures used in these tests were about ten to twelve pounds per sq. in. A large volume of superheated steam passed through the apparatus during the tests (about 40 cc. condensed steam per minute).

In these superheated steam evaporating tests about 13 grams of oil were weighed into the small dish placed inside the steam vessel D. (The capacity of the small iron dish is 50 cc. having a diameter of about 48 mm. and 30 mm. high, with flat bottom.)

The steam vessel with the oil in the dish was heated up to about 350° F. (176° C.), passing a slow current of natural gas through the apparatus, then superheated steam was admitted, the gas shut off, and the temperature raised up to the required degree and kept constant for about 75 minutes; the volatile matter in the oils at the given test temperature generally were carried over with the steam inside of 60 minutes, allowing about 15 minutes' extra steaming. At the end of each given temperature test the steam and heat were shut off; after cooling, the dish containing the oil was weighed and replaced in the steam vessel and the operation repeated for the next temperature test.

GALENA-SIGNAL OIL COMPANY,
FRANKLIN, PA.

A NEW CALORIMETER BOMB WITH SPECIAL ADVANTAGES AS TO MATERIAL OF CONSTRUCTION AND METHOD OF OPERATION.[1]

By S. W. Parr.

In attempting to improve upon the oxygen bomb for calorimetric use, the efforts have been directed along two distinct lines to meet what seemed to be the most pressing needs of the case: *first*, the discovery of some substitute for platinum which would resist the corrosive action of the acids formed and, *second*, the improvement of the methods for closing the receptacle so that a perfect seal could be secured with certainty and ease.

With reference to the first item, the development of a substitute for platinum, the problem is not without serious difficulties. It is to be borne in mind that in many instances, as with coals and similarly constituted substances, the nitric acid resulting from the combustion is produced under the best possible conditions for promoting a solvent action. The concentration of the acid in the bomb after a reaction is considerable. Moreover, the temperature, at least for a short period, is relatively high and the presence of corroding gases under high pressure may contribute to the activity. Again, in many substances a high percentage of sulphur exists and this burns to SO_3 or in the atmosphere of the interior, saturated as it is with water vapor, to H_2SO_4. For example, a very large part of the coals of the Mississippi valley have a content of sulphur amounting to 3 or 4 per cent. of the gross weight of the coal. Indeed, a content of sulphur is not infrequently met with of five and even six per cent. We have then in these cases of common occurrence conditions wherein both sulphuric and nitric acids are formed and these of a rather concentrated character. One of the common methods of counteracting the action of the acids is by use of some sort of resistant covering. As will be seen later, the method devised for closing the bomb involves the machining of the parts of dimensions accurate within $^1/_{50}$ of a millimeter. This feature, therefore, would make it impracticable to make use of an enamel as a protective covering. This expedient is also found, in practice, to be objectionable, owing to the frequent ruptures that are certain to occur in the enameled surface, thereby admitting the acid to the metal beneath. So far as a platinum lining is concerned in the device contemplated, and this was given an extended trial, the difficulties were as follows: First, the cost of platinum, representing at the current prices approximately $400 per bomb, made the use of that metal prohibitive, especially where a considerable number of bombs were desired such as for use with large classes. Second, the method of closing the bomb called for an exact relationship as to dimensions, and, as in the case of enameling, this could not easily be secured or maintained with an inner shell or lining. Moreover, the device to be employed for the inlet valve was such as to make it a very difficult problem of construction to make use of a second metal in that part of the apparatus. Third, the inevitable corrosion which sooner or later begins under the platinum shell roughens the surfaces, especially those coming in contact with the gasket. In time the entire surface under the platinum is affected and the water equivalent as well as the strength of the bomb is modified. These reasons alone, even if there were no others, are quite sufficient for indicating that the bomb, if made at all in conformity with the design contemplated, should be made of a metal capable of being machined to exact dimensions and in conformity with a desired pattern.

For this purpose, therefore, a study of alloys was undertaken with a view to determining if one could be devised sufficiently resistant to acid to effectually replace platinum, and that at the cost in the massive form necessary to easily compete with that metal. It must be possible, moreover, to either cast or stamp the metal into proper form suitable for machining into the final and exact shapes desired. The alloy finally developed has proved to be eminently satisfactory as far as its acid-resisting properties and strength are concerned. It is complex in composition, having as the chief components nickel, copper, tungsten and chromium with smaller and more or less adventitious amounts of manganese, aluminum, titanium, boron and silicon. The details of composition and properties of the alloy as finally adopted are presented under another title.[1] Concerning the securing of this material in forms suitable for machining to the desired patterns, only the method of melting and casting has so far been undertaken. The difficulty of securing perfect castings has seemed at times almost insurmountable. This is due to the fact that the melting point of the alloy is relatively high, approximately 1300°, and at the point of solidification the shrinkage is so great that cracks or flaws are opened up which render the casting unfit for use. Again, the occlusion of gases at the high melting temperature is great and pin holes are apt to be a source of much annoyance. The overcoming of these difficulties is, however, a mechanical rather than a chemical problem and need not be entered into here.

That the material may fairly be considered a substitute for platinum in the service here described is shown in the article above referred to, wherein is given a table of solubility tests. Also in another article accompanying this discussion[2] data are given upon a bomb of this new material in practical operation, which indicate that the alloy is entirely suited for use in the manner described.

The second improvement sought for relates to the method of closing the receptacle. The difficulties attending the use of lead gaskets relate chiefly to the stress and strain required to secure a perfect seal. Other objections relate to the chemical action upon the lead, and to the pitting or corrosion of the needle valve or seat, making it necessary to frequently reseat or repoint the valve parts. The substitution of rub-

[1] Paper presented at the Eighth International Congress of Applied Chemistry, New York, September, 1912.

[1] "A New Alloy with Acid-Resisting Properties," by S. W. Parr, Inorganic Section (Sec. II) this Congress.

[2] "Some Tests on a New Calorimeter Bomb," by Richard H. Jesse, Jr., This Journal, p. 748.

ber for lead is found to be entirely practicable if the conditions under which it is used are such that flame or any of the processes of combustion are not allowed to come in contact with the rubber. This is easily accomplished by interposing between the rubber gasket and the inner chamber a shoulder of massive metal so constructed that the cross section of the space between the two metallic parts is so small, say $^1/_{25}$ of a millimeter, and the longitudinal measurement of the space, that is the distance from the rubber to the inner chamber, is so great, say $1^1/_2$ or 2 millimeters, that the combustion processes may not travel along so narrow a passage and therefore do not come in contact with the rubber gasket. This principle is carried out in closing the main opening of the bomb and also in closing the valve through which oxygen is admitted. This will be made clear by reference to a sketch.

In Fig. 1, *B B* are the walls of the bomb which enclose the space *O*. The cover *C* is made with an encircling rim, *R*, which retains the rubber gasket *G*. The cover is so made that a shoulder, *S S*, passes the wall of the bomb as it comes up to position against the gasket. The machining of the parts is such that the space between the shoulder and the wall is about $^1/_{25}$ mm. Moreover, the distance from the lower edge of the shoulder to the gasket is about 2 mm. This is increased slightly by the pressure of the cover upon the gasket when the screw cap is brought down upon it. Conditions are thus secured which prevent the traveling of flame or any of the processes of combustion from the combustion chamber *O* to the rubber gasket *G*. The same principle is observed in the arrangements for the inlet valve *V*. The small gasket *g* is protected from the reactions or heat of the combustion chamber by narrow passages between metal walls.

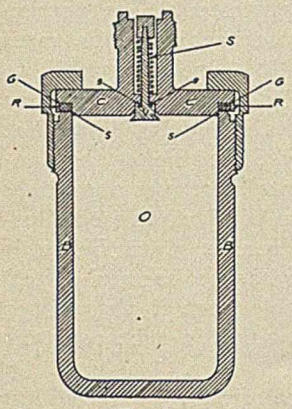


Fig. 1.

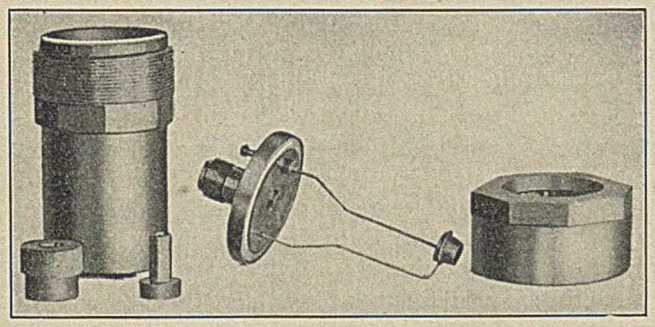


Fig. 2.

In this manner it is entirely possible to secure a perfect seal with a minimum amount of compression, by use of rubber gaskets and this without any burning whatever of the rubber.

A word further as to convenience of operation. The valve *V* works automatically thus: The valve is held lightly in place by the springs, but upon the admission of the oxygen above the valve it is forced downward admitting the gas to the chamber *O*. When the proper amount is admitted, say 25 atmospheres, the oxygen supply is shut off and immediately the valve is lifted into place by the spring. The strong pressure from within tends to seat the valve more firmly in place. After an extended experience with

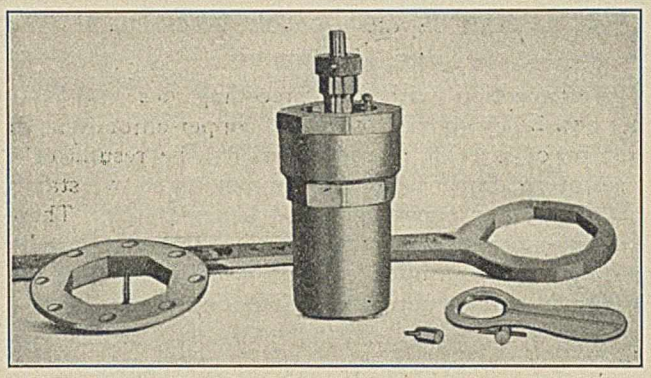


Fig. 3.

this type of valve, involving numerous modifications, the present form shown herewith has been found to be exceedingly effective and satisfactory. Thumb pressure on the top of the stem is found sufficient for releasing the gas at the close of an experiment. The most striking characteristic, however, in the manipulation of the bomb is the ease with which the cover may be fastened to withstand the necessary pressure without leakage. As may be seen in the accompanying illustrations, a simple octagon plate is set into the table or shelf and an octagon wrench about 50 cm. long affords ample leverage for screwing down the cap and seating the cover. The expenditure of a

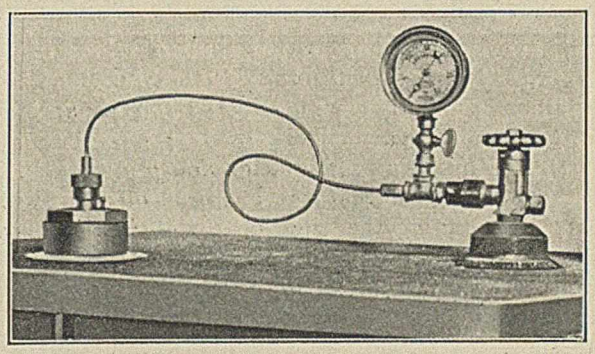


Fig. 4.

great amount of force in this part of the procedure is quite eliminated. The ease and readiness with which a perfect seal can thus be obtained have done much to revolutionize the work of operating a calorimeter of the oxygen bomb type.

Fig. 2 shows the cover and screw cap removed from the bomb. The small parts at the base of the bomb are couplings for oxygen connection at the top of the cover.

Fig. 3 shows the bomb with the parts assembled

with the octagon holder and wrench for setting the screw cap.

Fig. 4 shows the shelf fittings and connection with the oxygen tank. The shelf is hinged at the left-hand edge. It may be unfastened at the right-hand edge and lifted for the removal of the tank when it is required to renew the supply of oxygen.

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SOME TESTS ON A NEW CALORIMETER BOMB.[1]

By Richard H. Jesse, Jr.

In connection with the preceding description of the new alloy bomb of nickel-copper-chromium[2] it may be of interest to report briefly the results of a series of experiments on the combustion of two standard substances, cane sugar and benzoic acid. These experiments were undertaken not only for the purpose of standardization but also to test the behavior of the instrument under actual working conditions.

The principal features of difference between this bomb and other types are: (1) the substitution of an alloy, very resistant to the action of acids, for the usual platinum, gold, or enamel lining; (2) the use of a well protected rubber gasket for sealing the bomb instead of a gasket of lead; (3) the replacement of the ordinary steel needle-valve by a seated valve bearing a rubber gasket. For one who has spent much physical and mental effort in trying to seal completely bombs fitted with needle valves and gaskets of lead and gold, a very short experience is sufficient proof of the superiority of the present method of sealing in so far as speed and ease of manipulation are concerned. Former experience in this laboratory has offered evidence that these features do not cause a decrease in the accuracy desired for commercial fuel analysis. It has remained, however, to prove that they will answer the purposes of investigations where the highest attainable accuracy is desired.

A series of semi-quantitative corrosion tests in which specimens of the alloy were exposed at ordinary temperatures and for varying lengths of time to the action of 4 *N* sulphuric and nitric acids and mixtures of the two have indicated that the amounts of alloy which would dissolve in the time of a determination are negligible. To test the corrosion under working conditions, the washings from eight runs, which had been titrated in the usual manner for nitric acid with potassium hydroxide, were combined and analyzed for copper and nickel. The copper was precipitated by hydrogen sulphide in acid solution and was weighed as cuprous sulphide; the nickel was determined by the dimethylglyoxime method. In the eight determinations 1.6 milligrams of copper and 6.2 milligrams of nickel were dissolved. In a single determination therefore we have the solution of 0.2 mg. Cu and 0.8 mg. Ni. The quantity of the metal nitrates would have a heat of formation of approximately 1.8 calories.[1]

Since in these experiments the total amount of heat measured in a run was 9500 calories, about 0.02 per cent. of the rise was due to the solution of the alloy. This is a quantity which cannot be directed with certainty even in the very best calorimetric work. This particular bomb was the first successful casting. Since the work was begun, there have been slight modifications in the composition of the alloy which have probably increased its acid resistance. Quantitative evidence on this point is, however, lacking as yet. In coal calorimetry, sulphuric acid will be present in addition to the nitric acid. The corrosion tests already mentioned show that the mixture of these two acids is not much more active than nitric acid alone.

There is only indirect proof to show that the use of rubber gaskets is without effect on the accuracy of the bomb. The construction of the instrument is such that the rubber is well protected. The portion of the gasket which comes in contact with the gases in the bomb is a ring about $^1/_{1000}$ inch in width; to reach this the hot gases have to pass through a very narrow space with massive metal on each side so that they would almost certainly be cooled below the danger point. In these experiments there was absolutely no smell of burnt rubber in the bomb after a combustion. The constancy of the results given below is further proof that the rubber has no harmful effect, because it is hardly conceivable that if the rubber were burnt at all it should be burnt in such constant amount each time.

The method of adiabatic calorimetry[2] devised by T. W. Richards was used for these combustions.

The principle of the method is that the calorimeter is surrounded on all sides and on top by a bath of caustic soda, the temperature of which is at all times kept the same as that of the calorimeter. By running in sulphuric acid in measured amounts the temperature of the bath can be readily changed so that it conforms to that of the calorimeter even during the first rapid rise. This method has already proved itself capable of extreme accuracy. The mercury thermometer used was of the Beckmann type and was calibrated by the Bureau of Standards. The results with it were very satisfactory. Three different samples of sugar were used. They were supplied at different times during the past three years by the Bureau of Standards. Two samples of benzoic acid were burnt, one from the Bureau of Standards and one that had been carefully purified in this laboratory; experiment marked No. 10 was on the latter sample. The agreement is all that could be desired.

All the experiments fell within the temperature range 21–25° C. Since the temperature rise measured was about 3°, it follows that the mean temperature of any experiment did not differ from that of any other

[1] Paper presented at the Eighth International Congress of Applied Chemistry, New York, September, 1912.

[2] This bomb was devised by Professor S. W. Parr, of this laboratory, and is described in the preceding paper.

[1] Thomsen's results in Landolt-Börnstein:

$Ni + 2N + 60 + Aq = Ni(NO_3)_2Aq + 113{,}200$ cal.

$Cu + 2N + 60 + 6H_2O = Cu(NO_2)_2.\ 6H_2O + 92{,}900$ cal.

[2] *Proc. Amer. Acad.*, **42**, 573 (1907); *Z. physik. Chem.*, **59**, 532; *J. Am. Chem. Soc.*, **32**, 431 (1910).

by more than 1°. This is worthy of mention because in this neighborhood the heat capacity of water changes by about 0.02 per cent. per degree. However, since the metal portions of the system have a larger temperature coëfficient of opposite sign, the effect of the changing heat capacity of water is at least partially neutralized.

CANE SUGAR.

No.	Weight substance in air. Grams.	Observed rise corrected for bore protruding thread and stirring.	Correction for iron wire burnt.	Correction for HNO_3 formed.	Corrected rise.	Rise per gram substance.	Deviation from mean. Per cent.
1	2.4994	2.909°	—0.008°	—0.003°	2.898+°	1.1596°	+0.05
2	2.5018	2.908	—0.006	—0.004	2.898+	1.1585	—0.05
3	2.4987	2.910	—0.008	—0.004	2.898—	1.1597	+0.06
4	2.5004	2.909	—0.006	—0.004	2.899—	1.1593	+0.02
5	2.5035	.911	—0.008	—0.003	2.900	1.1583	—0.07
6	2.2743	2.646	—0.007	—0.003	2.636	1.1590	0.00

Average rise per gram sugar (weighed in air) = 1.1591°.
Average rise per gram sugar (weighed in vacuum) = 1.1584°.

BENZOIC ACID.

7	1.5089	2.812°	—0.007°	—0.003°	2.802°	1.8570°	+0.02
8	1.5390	2.870	—0.008	—0.004	2.858	1.8570	+0.02
9	1.5059	2.809	—0.008	—0.004	2.797	1.8574	+0.04
10	1.4467	2.698	—0.008	—0.003	2.687	1.8572	+0.03
11	1.5635	2.913	—0.008	—0.003	2.902	1.8561	—0.04
12	1.5630	2.912	—0.007	—0.004	2.901	1.8560	—0.04
13	1.6584	3.090	—0.008	—0.004	3.078	1.8560	—0.04

Average rise per gram benzoic acid (weighed in air) = 1.8567°.
Average rise per gram benzoic acid (weighed in vacuum) = 1.8552°.

The internal agreement of the two series on sugar and benzoic acid indicates that the new bomb can be safely used for work involving the highest accuracy. The greatest deviation from the mean is 7 parts per 10,000 in the case of sugar and 4 parts per 10,000 in the case of benzoic acid. This is probably as close an agreement as can be expected from a mercury thermometer and, indeed, it compares very favorably with the best work with electrical thermometers.

The results described in this paper are not absolute, but are purely relative. Therefore, it is interesting to compare the ratio of sugar and benzoic acid. The ratio resulting from this series (vacuum weights) is 1.6014. A similar comparison of a very high order of accuracy has been made by Emil Fischer and Wrede.[1] They have made two series of determinations on benzoic acid. The ratio from their first and most concordant series is $\frac{26.478\text{Kj}}{16.545\text{Kj}} = 1.6003$; that from the average of the two series is $\frac{26.472}{16.545} = 1.6000$; while the ratio from their three highest determinations of benzoic acid is 1.6008. The differences between these ratios and that found in this paper are respectively 0.07 per cent., 0.09 per cent., and 0.035 per cent. The value of the ratio found by the Bureau of Standards is 1.6016.[2] The agreement here is even more satisfactory; in fact, it is identical within the possible experimental accuracy. In spite of the concordance of their ratios the absolute values assigned by Fischer and Wrede and the Bureau differ by a quarter of a per cent. The reason for this discrepancy is not apparent at present.

UNIVERSITY OF ILLINOIS,
URBANA.

[1] *Sitzber. K. Acad. Berlin*, **19, 20, 21**, 687 (1904); *Z. physik. Chem.*, **53**, 161 (1903); **69**, 218 (1909); **75**, 81 (1910).

[2] Private communication from Dr. W. F. Hillebrand.

ADDRESSES

THE LATEST ACHIEVEMENTS AND PROBLEMS OF THE CHEMICAL INDUSTRY.[1]

By CARL DUISBERG.

Probably in no domain of human knowledge and endeavor have the combined forces of theory and practice, intimately acting and reacting upon each other, made such immense strides and led to the solution of such difficult problems as in the Chemical Industry, an industry which, indeed, had its beginnings in the distant past, but in its vast development and international character is essentially a child of modern times. Success has so emboldened this industry that it considers itself capable of solving any problem, provided the men in its service are well trained in theory and practice and ready to devote themselves to the best of their ability, with patience and perseverance, to the object in view. This has been shown by the struggle between the contact process of producing sulfuric acid and the old "chamber process," by the rivalry between the Solvay process and the Le Blanc method in the manufacture of soda; by the production of nitric acid and its salts by direct oxidation of nitrogen of the air under the influence of the heat of the electric discharge; by the manufacture of ammonia from atmospheric nitrogen indirectly *via* calcium cyanamide, and directly by combination with hydrogen; by the replacement of madder by alizarine, and of natural by synthetic indigo, as well as by innumerable other instances in the color, perfume and pharmaceutical industries.

If I venture before an audience not wholly consisting of chemists, within the brief period of an hour, to describe the latest achievements of the chemical industry and to recount the problems that are engaging our attention, I must restrict myself to a great extent both in the choice of the subject matter and its mode of presentation. We can, indeed, merely touch upon the most important happenings in our industry and must, from the very outset, refrain from a thorough discussion of the subject, either from the purely chemical or the technical side. However, what cannot be described for lack of time, and what we should very much like to add for the sake of those chemists who are present, is illustrated by our rich collection of diagrams, products and materials of all kinds. What can neither be mentioned in my paper nor illustrated by these exhibits, will be demonstrated by means of lantern slides, and, should you possess patience enough, I shall show you at the conclusion of my address one of the newest factories which the German Chemical Industry has

[1] General lecture by Geheimer Regierungsrat Prof. Dr. Carl Duisberg, Managing Director of the Farbenfabriken of Elberfeld Co. Eighth International Congress of Applied Chemistry, New York, September, 1912.

built on the Rhine, with its various manufacturing departments and, above all, its provisions for the welfare of its employees.

In the spirit of Faust, "Who brings much will bring something to many," I invite you to make a flight with me in an airship, as it were, over the fields where the Chemical Industry holds sway and, from our point of vantage, to take a bird's-eye view of the latest achievements of this industry. Now and then, we shall make a landing and examine the most attractive features a little more closely.

PRODUCTION OF POWER.—The question of power, which is of the utmost importance in every industry and especially in the great synthetic processes by means of which nitric acid and ammonia are manufactured, is now dominated by the perfected utilization of hydraulic power and the development of the turbine. Not only does the transmission of electric energy render it possible to utilize water power at great distances, but it also permits the transmission of power evolved at the coal mines and the peat fields to distant points, thus eliminating the necessity of transporting the fuel itself. Recently, we also learned to apply the principles of the water turbine to the steam turbine. But this advance over the piston steam engine, which Watt so ingeniously constructed about 150 years ago, has already been surpassed by benzine, petroleum or oil motors (Diesel motors), and, above all, by the reliable gas engines which are driven by blast furnace gases, Mond gas, and, more recently, by peat gas.

PRODUCTION OF BY-PRODUCTS.—The manufacture of by-products goes hand in hand with this more direct generation of energy from fuel. These products include ammonium sulphate, of such great importance in agriculture, and the tar distillation products so indispensable in the color industry. The latest and most rational method of utilizing the peat or turf beds, so plentiful in Germany and in many other countries, is practiced in Schweger Moor near Osnabrück according to a process discovered by Frank and Caro. There, peat gas is produced and utilized and ammonia obtained as a by-product, the required power being generated in a 3,000 H. P. central electric power station. The moorland, after removal of the peat, is rendered serviceable for agricultural purposes.

At that place, nearly 2,500–2,600 cubic meters of gas with 1,000–1,300 calories of heat were obtained from 1,000 kg. of absolutely water-free peat in the form of air-dried peat with 45 to 60 or 70 per cent. of moisture. This gas represents energy equal to 1,000 H. P. hours, equal to 700 kilowatt hours, after deducting the heat and power used for the operation of the gas works. In addition 35 kg. of ammonium sulphate were produced from the above quantity of peat which contains 1 per cent. of nitrogen.

The greatest problem of power production, the direct conversion of coal into electric energy by means of gas batteries, a problem which we had hoped to solve 25 years ago, is still to-day nothing more than a dream.

PRODUCTION OF COLD.—Besides the problem of power and heat, the question of refrigeration is one of growing importance to the chemical industry. Instead of the ammonia machines with which a temperature of —20° C. can be attained, we employ to-day sulphurous acid machines or, better still, resort to the carbonic acid gasifier which yields a temperature of —40° C. It is hoped in the near future to produce refrigerating machines, which, by the use of suitable hydrocarbons, will give temperatures of —80° C. Plants for the liquefaction of air, producing as low a temperature as —190° C., are becoming more and more common and are especially profitable where gas mixtures, rich in oxygen, or where pure nitrogen, which is simultaneously produced, can be utilized. Diagrams showing the process invented by Linde for the rectification of liquid air with the object of isolating nitrogen and oxygen are exhibited here. The Badische Anilin and Soda Fabrik in Ludwigshafen on the Rhine intends to manufacture hydrogen from water gas in a similar way and to utilize the carbon monoxide, which is simultaneously obtained, as a source of power. In a large plant which is being erected, the firm is going to produce ammonia synthetically by combining, according to Haber's invention, pure nitrogen, obtained by the liquefaction and rectification of air, with hydrogen manufactured as above. Particulars about this process will be given during the Congress by Professor Bernthsen in his lecture on "Synthetic Ammonia."

SIZE OF APPARATUS.—Influenced by the Solvay process for the manufacture of soda and its pecuniary advantages, the apparatus used in the chemical industry have enormously increased in size. In this respect the United States, no doubt on account of the example set by the iron industry with its blast furnaces with a daily capacity of 500 tons, its giant conveyers (50-ton wagons), its huge hoisting cranes, is ahead of other countries. But careful calculations have proved that there is a limit in this direction. The failure, on account of size, of the Mactear sulfate furnace, with a daily output of 25 tons, is well known, while the mechanical sulfate furnace of the Verein Chemischer Fabriken in Mannheim, which produces only 7 tons a day, is a success everywhere. It is not improbable that the high cost of construction and the great loss which accidental stoppage entails will necessitate a reduction in size of the wonderful Wedge furnace, a creation of the United States, which roasts 30 tons of iron pyrites per day.

In the organic chemical industry, the iron vessels for chlorination, sulfonation, nitration, reduction and oxidation, as well as the wooden tanks in which we diazotize and produce colors, have developed from the small vessels and vats of former years into apparatus of mighty size, their limit being generally determined by the capacity of the mechanical industry. But here, too, the mistakes which often occur in manufacturing processes and the extra losses which they involve, teach us that a wise moderation should be exercised.

Wherever possible, continuous operations have replaced those processes which worked intermittently. In this way loss of time and expense, caused by cooling and reheating, are avoided. This is exemplified by Uebel's new method of the production of nitric acid from Chili saltpetre with retorts lying above each

other and without stirrer, and by that of the Badische Anilin and Soda Fabrik, where the chambers are back of each other with stirrer, these methods having replaced the old single retort process.

MATERIALS FOR APPARATUS.—As regards materials for chemical apparatus several new wares must be referred to:

Quartz.—Apart from the fact that the saltpetre industry of Norway taught us how to absorb dilute nitrous gases in towers 20 meters high, made of granite, a substance which was rarely used for chemical purposes, we have to-day at our disposal tubes, dishes and vessels of fused quartz, which are stable against acids and heat and which are manufactured in the same sizes and dimensions as the well known earthenware vessels.

Refined Steel.—The greatest progress, however, has been made in the manufacture of iron alloys or refined steel.

Thanks to the kindness of Friedrich Krupp, of Essen, I am in the fortunate position to describe a large number of hitherto unknown substances of great importance, of which I exhibit magnificent specimens, photographs, and lantern slides. Just here, however, I must ask you to make one of the landings from the upper air and permit me to deal with the subject at greater length. You will be astonished at the immense progress which has been made to the general benefit of our industry.

Of the greatest interest are the alloys of iron with other heavy metals and metalloids, *i. e.*, alloyed steel.

Instead of carbon, other elements are employed, which likewise enhance the hardness of steel, but prevent the formation of a crystalline micro-structure liable to cracks and flaws. The most important of these elements is nickel.

Nickel Steel.—The readiness with which nickel forms an alloy with iron has long been common knowledge. Even in Bessemer's days, attempts were made in Great Britain to turn out cannons made of steel containing 2 per cent. nickel. The experiments were not successful because the nickel obtained at that time contained impurities, such as copper, arsenic and sulphur, so that the steel could not be forged. Thirty years later pure nickel, as we know it to-day, made successful results possible. The same was the case with chromium, silicon and manganese, and not until these elements were produced pure, could successful alloys be manufactured with them, either alone or together with nickel. The chief aim in the manufacture of these alloys is the formation of an amorphous, pliable structure of the steel. This result is attained not only by removing more or less carbon, but above all by a certain thermic treatment, namely, by suddenly cooling steel heated to a high temperature, heating again and keeping it at a certain lower temperature. Here you can see two samples of steel; in the one case, the coarse crystallization of the pure carbon steel before it is forged, and in the other, the same steel refined by the thermic treatment. The difference in the micro-structure of the forged carbon steel and that of the forged and thermically treated nickel steel must also be noted. While carbon steel after forging still shows a crystalline structure with visible cleavage planes of the crystals, the section of nickel steel displays an amorphous structure closely resembling that of welded iron. For comparison sake, a sample of a welded iron fracture is exhibited. It must not be overlooked, however, that nickel and chrome-nickel steels are twice or three times as hard as welded iron. There are also exhibited test pieces of alloyed steel construction parts to be used in the automobile industry. Notwithstanding the high tensile strength of about 90 kilos per square millimeter (*i. e.*, about 55 tons per square inch), no fracture is noticeable although they are greatly bent.

Aside from these improvements, which are of such great moment for structural steel, the iron alloys have found many new applications.

I merely mention the different nickel alloys for shipbuilding, electric appliances, and for valves. These valuable alloys containing 23 per cent. and more nickel, are non-magnetic, and not affected by atmospheric influences; those containing 30 per cent. nickel possess great resistance to electricity, while the coefficient of expansion of steel with 45 per cent. nickel is only one-twentieth of that of ordinary steel and not greater than that of glass.

Chromium, Tungsten and Molybdenum Steel.—It is a very interesting and novel fact that by the thermic treatment alone the micro-structure of the cheaper kinds of unalloyed iron plates and iron shapes is so changed that it becomes three times as resistant to the destructive effect of acids. If alloys of iron with chromium, tungsten, molybdenum and aluminum in certain proportions are thermically treated, this resistance is increased five-fold, as is shown by samples of ordinary carbon steel and chrome-nickel steel which underwent a treatment with dilute sulfuric acid for 56 days.

An alloy of ordinary iron with 5 per cent. nickel is an excellent material for withstanding hot caustic soda. Most astonishing properties are displayed by steel alloys containing more than 10 per cent. of chromium and a small addition (2–5 per cent.) of molybdenum. Such alloys are manufactured in the form of malleable cast and forged iron pieces by Krupp according to the patents of Borchers and Monnartz in Aix-la-Chapelle and in the form of rolled tubes by the Mannesmann Röhrenwerken in Remscheid. These alloys are insoluble not only in dilute hydrochloric acid and sulphuric acid, but also in dilute nitric acid, even with the addition of alkali-chlorides, and if they contain about 60 per cent. chromium, 35 per cent. iron, and 2–3 per cent. molybdenum they withstand even boiling aqua regia. You see here samples of this extraordinary steel, after treatment with acids, compared with ordinary steel and cast iron.

Tool Steel.—It must be especially mentioned that the alloys of iron with chromium, tungsten and molybdenum tempered by a special process invented by two Americans, Taylor and White, find most important uses as quick turning steel for all kinds of tools.

Vanadium Steel.—The most recent improvements in

the manufacture of steel for tools which must of necessity keep pace in hardness with structural steel have been made by the employment of vanadium. Unfortunately, this metal whose use is steadily increasing is still very dear, and the chemists' problem is to produce it more cheaply. If the price could be reduced perceptibly, metallurgists prophesy a great future for this metal, which exercises a very favorable influence on the micro-structure of steel.

Of great importance are those alloys of iron with chromium, tungsten and vanadium which possess a high degree of hardness even at 400°–500° C. They are needed by engineers for the construction of steam turbines and for the embossing and spraying of metal objects heated to redness, a process which has lately found extensive application. Chemists use these kinds of steel whenever chemical reactions are carried out at high temperatures and pressure, *e. g.*, for the synthesis of ammonia according to Haber's process.

The very latest alloy has now been patented and is being manufactured by Krupp for the construction of safety vaults and safes. This steel can neither be drilled nor exploded, nor can it be cut by the oxy-hydrogen flame.

Two samples of steel are exhibited, one of ordinary steel in which great holes have been cut in $5^1/_2$ minutes by using an oxy-hydrogen flame and in 6 minutes by an oxy-acetylene burner, and a specimen of this new alloy which has remained intact after being treated with the same oxy-hydrogen and oxy-acetylene flames for $1^1/_2$ hours. Let us hope that on this hard and infusible material the scientific safe-burglar will exercise his noble art in vain.

Manganese Steel.—Of the alloys made with manganese, the manganese steel or hard steel, first produced by Robert Hadfield, because of its great wearing qualities, is chiefly used for cast iron parts of disintegrators and rails of electric tramways. On account of its hardness, this steel is not malleable, but it can be bent in the cold state and is thus very safe against breaking. It is therefore of much interest to the chemical industry where, in almost all branches, grinding operations are carried out.

Silicon Steel.—Finally, I wish to refer to alloys of iron and silicon which contain 1.5–2.5 per cent. silicon and a high percentage of carbon. This steel is excellently adapted for tools and springs which must stand high strain. Since steel alloys containing much silicon, although brittle and porous, have proved very stable against acids, they are now being used more and more where such a property is of importance.

Alloys with about 4 per cent. silicon, but very poor in carbon, are of greater value than the above. Robert Hadfield first pointed out the importance of this alloy, while Krupp, working in connection with Capito and Klein, a firm of fine-plate rollers in the Rhineland, considerably improved it and introduced it for electric purposes. It is employed in large quantities in the form of sheets of 0.35 mm. ($^1/_{70}$ inch) thickness for the construction of dynamos, alternate-current motors and transformers. In Germany alone, the consumption of this alloy already amounts to 8,000 tons a year. This material has a resistance to electricity 4 or 5 times greater than that of ordinary iron and loses only half as many watts, so that the injurious Foucault currents are reduced to a minimum. The manufacture of transformers has therefore become much cheaper, for the proportion between iron and copper is much more economical. The production of this silicon iron alloy with its very low percentage of carbon, and that of the chrome-nickel steels almost free from carbon, became possible only after silicon and chromium, entirely free from carbon, could be manufactured by electric smelting processes.

Electro-Steel.—Since the electric smelting furnace has come into use in the steel industry, the problem of removing sulphur, which engaged the attention of chemists for so many years, has been solved. It has been found that the electric furnace process produces a slag free from metal, and such a slag is the prime requisite for the complete desulphuring of the steel bath.

Electrolytic Iron.—Superior to the silicon steel, poor in carbon, in its electric properties the "Ideal" metal for electromagnets, is the pure electrolytic iron—first produced by Franz Fischer, of Charlottenburg, and now manufactured by the firm Langbein-Pfanhauser & Co., Leipzig. Formerly it was impossible to produce it free from hydrogen, consequently it was hard and brittle and was not malleable. Only by electrolyzing at 100°–120° C. and employing an iron salt solution mixed with hygroscopic salts, such as calcium chloride, the iron became free from hydrogen. Its hardness then sinks far below that of silver and gold and is not much greater than that of aluminum. It possesses the valuable property of becoming magnetic more quickly than ordinary iron containing carbon or silicon, and also of again losing its magnetism more readily, thus considerably increasing the efficiency of electro-motors for which it is used. Among the exhibits, you will find several objects made of this electrolytic iron; for example, a cathode made from an electrolytic iron plate during 5 days of uninterrupted operation; also plates made by rolling; further a motor which, if constructed of silicon iron, would furnish 0.5 H. P., but being composed of electrolytic iron, though in use for several months without appreciable signs of wear, it now furnishes 1.3 H. P., in other words, it is $2^1/_2$ times as efficient.[1]

With all these new materials at our disposal, among which I must also mention copper, with 10 per cent. silicon, and copper nickel, we shall surely be able to improve all sorts of chemical apparatus that suffer so much from wear and tear.

After this short invasion of the domain of metallurgy, we shall now turn our attention to the chemical industry proper, first dealing with the manufacture of the heavy inorganic chemicals.

SULPHURIC ACID.—The triumphal progress of the contact process for the manufacture of sulphuric acid in the United States scarcely has its parallel in Germany, where it originated. Platinum, in spite of the fact that its price has increased three-fold, is still our

[1] See *Zeitschrift für Elektrochemie*, No. 16 (1909).

principal contact agent. As it is possible to carry out other contact processes with various contact materials, we shall certainly find other agents than platinum available for sulphuric acid anhydride. It ought therefore to be a fruitful field for research to find cheap substitutes for platinum. In the 20 years that have elapsed since Knietsch first successfully carried out the contact process, the Americans have increased their output three-fold for the same weight of platinum. Nevertheless, the old lead-chamber process still competes with the new method, and the steady improvement of this process and the purity of the resulting acid must be acknowledged. In fact, the lead-chamber process promises to make further progress in the future in view of the success of Falding's high chambers and Opls towers in which large quantities of acid flow down.

The Gaillard tower is supreme for concentration and recovery of the acid and for the regeneration of the various waste acids.

Ammonium Sulphate.—A new way of manufacturing sulphuric acid, together with ammonia, from the gases which are produced by the dry distillation of coal, is looming above the horizon. Burkheiser is seeking, with the aid of especially prepared wet iron compounds, to bind the sulphur, simultaneously absorbing cyan, and to convert the ammonium sulphite thus produced into ammonium sulphate by oxidation with atmospheric air.

In competition with Burkheiser, Walter Feld is endeavoring to recover sulphur directly as ammonium sulphate by a series of interesting reactions, in which thiosulphates play an important part. Such plants are in operation in Königsberg and here in New York.

Nitrogen Compounds.—So much has been written concerning the progress made in the last 5 years in the utilization of atmospheric nitrogen, that I need not enter into a description of Birkeland-Eyde's, Schonherr's or Pauling's process for the direct oxidation of nitrogen by means of the electrical discharge, nor of Frank-Caro's method of forming cyanamide from carbides [the world production of cyanamide is, according to Dr. N. Caro, 120,000 tons per year, of which 31,000 tons are manufactured in Germany (16,000 in Trostberg and 15,000 in Knapsack near Cologne), 19,000 tons are made in Niagara Falls by the American Cyanamide Co., and during the next three years the total production is to be increased to 200,000 tons], nor is it necessary to describe the Serpek process for the production of ammonia from aluminum nitrides combined with the utilization of alumina which is simultaneously obtained. I will mention, however, that the problem of concentrating the dilute nitric acid, as obtained in the large absorption apparatus from nitrous gases, has been solved by Pauling's method, in which sulphuric acid is used in a battery of towers. It is also possible now to economically convert cyanamide into ammonia and this again into nitric acid.

Soda and Chlorine.—The 50-year old Solvay process, which has conquered the whole world, still remains master of the situation. This is all the more remarkable since it is still imperfect as far as the yield is concerned; a quarter of the salt used in the process is lost as such and the whole amount of chlorine in the form of calcium chloride.

Although the materials employed in the LeBlanc process are completely utilized, this fact will not give it any chance of surviving, and it would seem to be now chiefly of historical interest.

Not less remarkable is the 25 years' career of the alkali-chloride electrolysis. The limited market for chlorine compounds and the great space taken up by the electrolyzing baths were great obstacles to the progress of this apparently simple method. For the same reasons the most approved processes, such as the Griesheim cement cell, the quicksilver cathodes of Castner and his successors, the Aussig Bell and the wire-gauze diaphragm of Hargreaves, with its many varieties, of which the Townsend cell is the latest and best, did not develop as expected. The limited demand also quickly restricted the operation of the brilliant method of manufacturing chlorates by electrolysis.

Tin.—Tin is not only produced from natural ores, but also in more than 20 detinning establishments from tin-plate and tin-can waste; 200,000 tons of tin-plate waste are subjected to this treatment and about 24 million Marks ($6,000,000) worth of tin and iron are recovered. The electrolytic detinning process, on account of high wages, the great cost of current, and the considerable manufacturing loss, has been replaced—where there is a market for chloride of tin—by the patented process of Thomas Goldschmidt, of Essen. This process takes advantage of the properties of chlorine gas, in the dry state, to greedily take up tin without reacting on iron if certain temperatures are observed. Instead of the inferior quality of electrolytic tin mud, which must be converted into marketable tin by costly smelting operations, the new process yields an anhydrous tin chloride used in large quantities for weighting silk. The detinning with chlorine is not carried out with cuttings, as in the electrolytic process, but with waste pressed in hard packages so that 20 times as much material can be treated in the apparatus at the same time. In the United States this process is operated by the Goldschmidt Detinning Company of New York.

Reducing and Oxidizing Agents.—One of the most brilliant successes in applied chemistry has been achieved by the persevering experiments of some chemists with a long neglected substance, the constitution of which had never been properly understood. The old hydrosulphite of Schützenberger, rendered stable and easily transportable in powder form as an anhydrous sodium salt or as Rongalite in combination with formaldehyde, has now become a most important article of commerce. It is chiefly used in vat dyeing and for reducing purposes in general, such as stripping dyed fabrics and as Decrolin for bleaching sugar.

Peroxides, Persulphates and Perborates.—Peroxid of hydrogen and its derivatives at present find less favor in commerce, although their future appears to be very brilliant. Recently the Farbenfabriken vorm. Friedrich Bayer & Co. succeeded in rendering

this important oxidizing agent, which easily decomposes and can be marketed only in water solution, solid and stable by the addition of urea.

This powder is in the market under the name of Ortizon, but on account of its relatively high cost is intended not so much for technical as for hygienic and pharmaceutical purposes.

The interesting manufacture of sodium peroxid from sodium and the many scientific investigations of the persalts, have not been followed by great commercial success. The persulphate and perborate, however, the latter under the name of "Persil," are being manufactured on a large scale. The reason of this failure seems to be the high cost of production.

Rare Metals.—The most interesting alloys discovered by Muthmann and Auer have found little application in the arts, and the use of cerium and thorium preparations is still confined to the incandescent gaslight industry. Only the "Auermetal," consisting of 35 per cent. iron and 65 per cent. cerium, is employed and this only to a limited extent for the manufacture of pocket cigar lighters.

In the metal filament lamp industry, tungsten, which shows the highest melting point of all metals, namely 3100° C., has replaced tantalum, which melts at about 2300° C. This became possible only after successful experiments to render the metal ductile by hammering.

The elements cadmium, selenium and tellurium are obtained in great quantities as by-products; the first is produced in the zinc industry and the other two from the Tellur gold ores found in Cripple Creek, Colorado. Although sold at relatively low prices they find but little use in the industries.

Artificial Precious Stones.—Finally, I will, in but a few words, touch upon a new industry, *viz.*, the synthetic manufacture of precious stones from alumina with additions of chrome oxide, iron oxide or titanic acid. Artificial rubies and white, yellow and blue sapphires, which cannot be distinguished from natural stones, are being manufactured in great quantities in Paris and recently also by the Electrochemische Werke, Bitterfeld. They are used extensively for jewelry and especially as bearings in watches and measuring instruments.

All this will give you a striking picture of the development of inorganic chemistry which is taking a more and more important position beside organic chemistry.

Applied Organic Chemistry.—In the organic chemical industry the reactions are considerably more complicated and the apparatus mostly smaller than in the inorganic industry. Here the chemist, like a juggler with his balls, gives every atom a definite position in the many thousand combinations which carbon forms with hydrogen, oxygen, nitrogen and sulphur, and there exist the most varied reactions and processes which may lead to the same result. This chemistry of the carbon compounds has been most wonderfully perfected in the coal-tar color industry, and in every factory of this branch there are hundreds of scientifically trained chemists always experimenting and daily finding new combinations possessing properties of technical value. Before these products become finished articles to be sold as colors, perfumes or pharmaceutical preparations, they must further go through a series of numerous intermediary operations, which finally lead to the marketable chemicals.

Coal-Tar.—The starting material of the important coal-tar color industry is the black tar which is obtained by the dry distillation of coal and is known to contain about 150 different chemical products, of which, aside from carbolic acid, the aromatic hydrocarbons, benzole and its homologues, toluol and xylol, naphthalene and anthracene, play the greatest part.

More recently carbazol has been isolated from tar on a large scale and has become a most important raw material for the manufacture of the color "Hydronblue" by Leopold Cassella & Co., Frankfort a/M. Hydronblue is a sulphur dyestuff distinguished by its fastness against washing and chlorine. Acenaphthen, which also occurs in coal-tar as such, is the starting material of a red vat dye "Cibanonred," discovered by the Society of Chemical Industry in Basle. It is to be regretted that hitherto no technical use has been found for phenanthrene, which is also one of the constituents of tar.

Besides carbolic acid, its homologues and the various cresols, etc., are being isolated by Dr. F. Raschig in Ludwigshafen on the Rhine. These substances are largely employed in the manufacture of explosives and coloring matters.

As long as coal gas is produced for illuminating and heating purposes and as long as coke must be used for the reduction of iron ores, tar will always remain the cheapest raw material for the manufacture of these hydrocarbons. But since it may become necessary in the future—as is already possible to-day—to use coal in a more rational way, at the same time producing hydrocarbons, the coal-tar color industry need not fear a scarcity of this important raw material, the less so as certain kinds of petroleum, *e. g.*, Borneo petroleum, contain large quantities of aromatic hydrocarbons from which the Rheinische Benzinwerke, in Reisholz near Düsseldorf, has already isolated toluene in the form of nitrotoluene in a commercial way. If, however, a still greater demand for these hydrocarbons should occur, other methods of obtaining them must be found. We shall then surely succeed in producing them synthetically either directly from the elements carbon and hydrogen or indirectly from carbide of calcium by passing acetylene through glowing tubes—a reaction which was already carried out successfully in the early sixties of the last century by Berthelot and recently by Richard Meyer. At the present time about one-quarter of Germany's annual output of coal is converted into coke, *viz.*, 26 per cent. for foundry purposes and 4 per cent. in gas works, while in England the quantities are 12 per cent. and 6 per cent., respectively.

Distillation of Tar.—The point of greatest importance in the distillation of tar is still the separation and isolation, in the cheapest possible way, of the different hydrocarbons in their purest form. The

stills have been continually enlarged, those employed to-day having a capacity of 60,000–80,000 liters (13,000–17,500 gallons). On the other hand, a continuous process, such as is possible in the bituminous coal-tar industry, has not yet been found. A large number of patents have been taken out for apparatus intended to solve this problem, but none of them have proved satisfactory in practice.

Organic Intermediate Products.—The conversion of the aromatic hydrocarbons into intermediate products necessary for the color industry is almost always carried out by treatment with concentrated sulphuric and nitric acid and subsequent reduction of the thus obtained nitro-compound by means of metals or metallic oxides and sulphides. In the production of amines, iron is the principal agent of reduction, while zinc and tin are mostly used in the production of azo-compounds. The electrolytic reduction has not proved useful for these processes.

The methods of producing nitro- and amido-compounds have been very little changed as far as chemical operations are concerned, but with the increase of their production their poisonous properties became more and more apparent and forced manufacturers to modify the processes so that they could be carried out in tightly closed vessels in order to protect the life and health of the workmen.

In Germany legislation has been recently enacted, based on the experience of the individual factories, which lays down rules and regulations for strict observance.

Several trinitro-compounds have been shown to be explosives, and, like trinitrotoluene, are now largely employed as substitutes of picric acid in the manufacture of explosives.

The introduction of oxy-groups into the molecule is mostly brought about by melting sulpho acids with alkalies, and, according to more recent methods, with alkaline earth metals, such as calcium and barium hydrates. Since chlorine, produced electrolytically, is obtainable in unlimited quantities and chemically pure, chlorine substitution derivatives of the hydrocarbons have been employed for all kinds of synthetical purposes. Many of these chlorine derivatives can not only be converted into oxy-derivatives by melting with alkalies, but, like paranitro-chlorbenzole, they also directly exchange their chlorine for an amide group when treated with ammonia or its derivatives. Colors also often change their shade when a halogen atom is introduced into their molecule and acquire more valuable properties. Chlorine has therefore proved exceedingly useful in the preparation of intermediate products and will undoubtedly become of still greater service in the future.

In the naphthalene series, the method discovered by Bucherer and Lepetit for the conversion of the hydroxyl group into the amido group and *vice versa*, employing sulphurous acid esters, has proved of great practical value. Phosgene, too, is to-day being more and more employed. Several decades ago it became an important substance for the production of the urea of paramidobenzolazo-salicylic acid, introduced into the market, under the name of "Cottonyellow," as a beautiful yellow cotton color of great fastness to light. Its principal use, however, was for the manufacture of the bright but fugitive triphenylmethane colors. It is now especially used to combine 2 molecules of aromatic compounds with free amido groups, thus producing urea derivatives, and if the starting material is an azo color, the resulting urea derivative is, as a rule, much faster to light than the original color. Imidazol, thiazol and azimido compounds of the most varied kinds are also manufactured and converted into azo colors.

In the series of the aldehydes and carboxylic acids there are no epoch-making discoveries to be recorded. Chemists still start from hydrocarbons chlorinated in the side chain or directly oxidize the homologues of benzole. Kolbe's synthesis of salicylic acid, of which large quantities are used in the color industry, is also applied at an ever-increasing rate for the production of the oxycarboxylic acids. But the direct introduction of the carboxylic group into the benzole molecule, unsubstituted by hydroxyl, is a greatly desired achievement which, however, has not yet been attained. It is also a matter of greatest importance that in substitution reactions of the aromatic nucleus we should be able to vary at will the ratio of the isomers to be formed.

Besides the biochemical production of ethyl alcohol from wood waste and from the waste liquors of the sulphite cellulose industry, I wish to mention the synthesis of organic compounds by the addition of water to acetylene. In this manner we produce in a simple way acetaldehyde, which can be easily converted into acetic acid, a very important starting material for the manufacture of numerous products.

The steady search for new raw materials and new intermediate products to be utilized in the manufacture of colors has often been crowned with success. We need only to recall the many intermediate products which have been made available for the production of vat dyes and sulphur colors and which have led to the discovery of new substances with most valuable properties. Very often new lines of research are not always based upon preconceived theoretical ideas, but are opened up by mere accident. A keen power of observation, however, is the most necessary equipment of the chemist who aims at success.

Coal-Tar Colors.—In no branch of technical chemistry has such intense work been performed as in that of the coal-tar color industry. The outsider long ago may have thought that so much had been accomplished in this field that nothing more was left to be done. The countless dyestuffs, giving all the colors of the rainbow, might well have given rise to the belief that there was already a surplus. But here the course of events was just as it generally is in life. With growing possessions, man's needs and demands also multiply. While people were formerly content to produce with coal-tar colors every possible shade in undreamt-of brightness in the simplest way, they gradually began to make more and more exacting demands as regards fastness. Not only had materials

to be dyed a pleasing shade, but they also had to be fast to washing and light. Thus new, alluring problems were submitted to the color-chemist, and his indefatigable efforts have already carried him a long way towards the desired end. Strange to say, among the public, you will frequently meet the view that artificial colors do not give fast dyeings. This is a decided error which cannot be too emphatically contradicted. To-day we can produce almost any shade with any desired degree of fastness on any kind of material, whether it be wool, cotton, silk or paper. If the dyer does not always produce such shades it is the fault of the trade which does not express its demands forcibly enough. Of course, the dyeing with fast colors entails a somewhat greater expense which must naturally be borne by the consumer.

Just at this point, before discussing the progress made in the manufacture of fast colors and in order to prevent misunderstanding, I should like to emphasize the fact that the old colors, though not as fast as those more recently discovered and though, perhaps, quite fugitive in some respects, still have a right to exist. It would be quite foolish to dye certain kinds of paper intended to be in use for only a very short time, with colors absolutely fast to light, or to dye cloth never to be washed, with expensive colors fast to washing, or, again, to treat lining, which is but slightly exposed to sunlight, in the same way as materials which must be exceedingly fast to light. Everything according to reason. For many purposes, however, the need for shades fast to light or to both light and washing is so great that it must be given every consideration. How mortifying it must be to notice shortly after you have decorated the walls of your home with most beautiful and expensive materials, that the lovely colors daily grow more unsightly, and to see a solitary patch showing up in all its pristine glory amidst a faded background when a picture or other piece of furniture is moved to another place. As it is possible to guard ourselves against such occurrences, we should certainly do so. To-day we are able to produce the most beautifully colored wall-coverings, whether of paper or of woven or printed fabrics, to meet every requirement in regard to fastness. This is proved by the large collection of all kinds of woolen and cotton fabrics (after washing and exposure to light) and especially of wall-papers, of carpets, rubber material and balloon coverings, which the different firms of the German color and dyeing industry have placed at my disposal for exhibition.

If you now inquire how chemists have been able to make such great progress, my only answer is by logical and untiring efforts along well known ways, undaunted by failures, and by diligently following any track, however faint, that gave promise of advance.

In every branch of the color industry these methods have led to faster and ever faster dyestuffs, from the multicolored benzidine colors, described as fugitive to light and not stable to washing, to the anthraquinone colors and the indigoid vat dyes. In all these classes we have gradually learned to recognize certain regularities and to accomplish certain results by systematically grouping the components and fixing the position of the substituting groups; thus we have succeeded in increasing the fastness to light of the individual chemical according to a preconceived plan.

Indigoid Colors.—The synthetic production of colors allied to indigo was stimulated by the successful synthesis of indigo which almost entirely displaced natural indigo and called the attention of both chemist and consumer in an increased measure to the advantages of vat-dyeing. The King of Dyestuffs, Indigo, now finds itself in the company of a whole series of other colors, the brome indigos, the thio indigos and alizarine indigos, the shades ranging from blue to red, violet, gray and black. Even the "purple" of the ancients has been reproduced by Paul Friedlaender, who by isolating the dyeing principle found in certain glands of the purple snail living in the Mediterranean, has demonstrated the fact that this natural color is identical with a dibrom-indigo which had been long before produced synthetically. These indigoid colors possess the same, if not better, properties than indigo itself.

Alizarine Colors.—The fastness of the alizarine colors, *e. g.*, alizarine red, used for Turkey red, was well known in ancient times. But, whereas formerly only mordant colors were considered to be fast, and consequently only these were looked for in the anthraquinone group, which led to the discovery of alizarine-orange, -brown, -blue and the alizarine cyanines, Robert E. Schmidt in 1894–1897 succeeded in finding acid-dyeing anthraquinone colors which dye every shade, rivalling the old and well known triphenylmethanes in brightness and simplicity of application and the alizarine mordant colors in their extraordinary fastness to light. I merely mention alizarine-cyanine-green, alizarine-sky-blue, anthraquinone-blue, alizarine-sapphirole, -astrol, -irisol and -rubinol. Their fastness to light is so excellent that in the famous "Manufacture Nationale du gobelins" in Paris, they have replaced the older dyestuffs for the dyeing of wool used in the manufacture of gobelins. This means a great deal if it be borne in mind that a square meter of these gobelins for the production of which an operator needs more than a year, costs, on the average, about 6,000 francs.

Indanthrene and Algole Colors.—An entirely new era began for the alizarine series when Réné Bohn in 1901, found that his new color, indanthrene, could be used as a vat-dye for cotton. This color can be dyed in its reduced state like indigo, but is far superior to the latter in beauty and brightness of shade, as well as in fastness to washing and light. Indeed, the fastness to light is so great that in this respect it must be termed indestructible.

On account of this phenomenal fastness, indanthrene blue caused chemists to look for other vat colors in the anthraquinone series. Their efforts did not remain unrewarded, and we already possess colors of this class giving every possible shade. The Badische Anilin and Soda Fabrik sell them under the name of "Indanthrene Colors," the Farbenfabriken vorm Friedrich Bayer & Co. under the name "Algole Colors." Chemically most of these vat colors belong to the ind-

anthrene type; some of them are still more complicated nuclear products of the condensation of several anthraquinone molecules; others, again, are di- and tri-anthraquinonylamines. It must also be noted that to the greatest surprise of all experts in this branch, it was discovered in the laboratory of the Farbenfabriken vorm. Friedrich Bayer & Co., that even some of the simplest acyl derivatives (-benzoyl) of the aminoanthraquinones are excellent vat colors.

Lake Colors.—We must not leave out of sight the importance of some colors of the aniline group and especially the anthraquinone group for the production of lakes for paints and pigment colors for wall paper. The alumina lake of alizarine, the so-called madder lake, with its fine shade and great fastness to light, is best known. Other alizarine colors also yield valuable alumina lakes; thus, alizarine sapphirole gives a blue lake of excellent fastness to light. But it is not always necessary to precipitate lakes. Some of the difficultly soluble vat colors may be directly employed in a finely-divided form. Thus indanthrene and algole blue already play important roles as substitutes for ultramarine for bluing higher class paper, textiles and even sugar.

The development of the anthracene colors, aside from the tinctorial progress, brought about remarkable results in pure chemical research, for example the peculiar action of boric acid and the catalytic action of quicksilver in the sulphonation processes of anthraquinone.

But in this branch of our science as well there is still much room for development. Many problems remain unsolved and new ones are continually arising. To satisfy the demand of the dyer many dyestuffs must still be synthesized.

The ceaseless efforts of the color chemist will undoubtedly bring us farther and farther along this road, and complaints about the insufficient fastness of dyed materials will be silenced at last. If this goal is to be reached, it is absolutely necessary for the consumer to support the manufacturer, and I take this opportunity to state that in the United States of America these fast colors are to-day more generally used, and found recognition and wide-spread application here earlier than in any other country.

Pharmaceutical Chemistry.—I will now deal with the progress and problems of the pharmaceutical industry in the synthetic production of medicinal drugs. This industry is the youngest daughter of the coal-tar industry and it is not long since she celebrated her 25th anniversary. Those, who, like myself, had the good fortune to stand at her cradle when Ludwig Knorr discovered antipyrin, and to guide her first tottering steps at the time phenacetin and sulfonal were brought out, must look back with a joyful heart to this period of splendid growth. Much brilliant work has been accomplished but a vast amount still remains to be done. Here we see chemistry and medicine intimately bound together, the one dependent upon the other and powerless without its aid. What an organization, what boundless intelligence is necessary and what immense energy has to be expended in order to discover a new synthetic remedy and to smooth its path through the obstacles of commerce! First, we need a fully-equipped chemical laboratory, then a pharmacological institute with a staff of men trained in medicine and chemistry, an abundance of animals to experiment upon, and finally—the latest development in this field—a chemo-therapeutic and bacteriological department equipped according to the ideas of Professor Ehrlich; all these must be in close connection with one another. Whatever has been evolved, and after much painstaking effort selected as useful, finds its way into the manufacturing department, there to be elaborate in the most minute details and brought to the highest possible pitch of perfection. Now begins the arduous work of the scientific department! Here the right sponsors must be found, here all prejudices must be brushed aside and an extensive propaganda initiated. Next, a host of clinicians and practitioners must be called into requisition so that what has been evolved in the silent workshop will be conducted on a staunch ship into the wide sea of publicity. And, finally it is the calculating salesman's turn; he must bring in enough to cover all the expenses of the innumerable experiments that have been made, if the new drug, which has swallowed so much money, is to survive and prosper. Truly, all this is a task which only too often is misunderstood and insufficiently appreciated. If, however, a great hit is made—an event almost as rare as the Greek calends—then the envious, the patent- and trademark-violator, and even the smuggler, cling to our heels and seek to rob us of our profits which, taking everything into consideration, are really not large. But despite all this, and though unfortunately opposed by druggists and physicians even to-day, the pharmaceutical industry serenely pursues its task. For besides certain economic aims, we also have ideals to strive for. We combat systematically the symptoms of disease and are the faithful auxiliaries both of the doctor and the harassed nurse. The agonizing pains of the patient we allay with narcotics and anesthetics. When sleep flees the couch of suffering, we compel it to return; fever, we banish. We destroy the minute organisms which cause and spread diseases. Thus we add to the store of what is valuable, and perfect what already exists. We also isolate the active principles of various drugs and thus assure exact dosage and freedom from undesirable or even dangerous by-effects.

In the chemical works of Germany pure chemical science receives its due. In every branch of inorganic, organic and physiological-biological chemistry we are working with an army of scientifically trained men. In synthetic chemistry, brilliant achievements have fallen to our share. Quite recently, Stolz succeeded in building up adrenalin,[1] Decker in making hydrastinin and Emil Fischer and Wilhelm Traube in producing purin bases. All of these are magnificent

[1] 1 kg. adrenalin, which is now prepared synthetically, and has been introduced under the name of "supreranin" by the Farbwerke of Hoechst, requires for its production the adrenal glands of 40,000 oxen. This product, as well as numerous other glandular preparations, is nowadays manufactured by the large American slaughter-houses themselves.

accomplishments, and many of them have been effected in the laboratories of the industry.

That even yet, as at the beginning—the antifebrin period—we must trust to chance is shown by the discovery of atophan, the latest valuable antiarthritic, which is due to a fortunate accidental observation. In the subject of the old ergot problem, research work is gradually bringing more light and makes the possibility of synthetically producing a substitute a thing of the near future. The publications on this subject show that hemostatic alkaloids possess a comparatively simple constitution. That sedatives have their place in an age when nervous disorders are so common is not to be wondered at. I need merely remind you of the new adalin which has proved exceedingly useful. Recently, Emil Fischer, the master of chemical research, to whom the pharmaceutical industry is indebted for the synthetic purin bases, *viz.*, caffein, theobromine, and theocin, as well as the valued remedies, veronal and sajodin, has succeeded, after long and fruitless labors, in elucidating the constitution of tannin and producing it synthetically. He has thus proved that it might be possible to manufacture tanning agents of all kinds artificially and has opened up a new and promising field for research.

Chemotherapy.—But a short while ago, Ehrlich drew attention to another promising branch of pharmaceutical-medical chemistry, *viz.*, the treatment of infectious diseases by chemical means. After many years' arduous labor and many thousand experiments on different animals, this master of medicine and chemistry succeeded in demonstrating that it is possible to produce chemical substances which will kill the parasites in the human body without injuring their host and that this action is a function of the chemical constitution. The new science, with its magical bullets directed only against the injurious organisms in the body but not affecting its cells, pursued its course from aminophenyl-arsinic acid (atoxyl) to diamino-oxyarsenobenzole (salvarsan). Thus a new synthetic preparation, an arsenic compound, is added to the old and highly effective remedies, mercury, quinine and salicylic acid. It is certain that we are here only at the beginning of a new development. We know already that we are able to combat not only spirochetes but also bacterial diseases, like tuberculosis. Even carcinoma and sarcoma, those growths so destructive to humanity whose cause is, however, not yet understood, can probably be influenced in a like manner by means of selenium compounds, as first pointed out by Emil Fischer. But were we to learn to cure diseases due to trypanosomes and plasmodia, what a great work we should have accomplished in the interest of humanity and social economy, for it is in the most fruitful lands indeed that these diseases, malaria and sleeping sickness, are to be found, and man and beast are ruthlessly destroyed by them. Neither salvarsan nor atoxyl are of service here, and therefore other hitherto unknown remedies must be found.

While the treatment of syphilis, with its terrible consequences, is still imperfect in spite of mercury and salvarsan, let us hope that systematic laboratory experiments with the innumerable products chemistry is able to produce from mercury and from arsenic will finally lead to complete success.

Synthetic Perfumes.—In the perfume industry the developments made since the scent of the violet was imitated with jonon, and since the successful synthesis of camphor from turpentine, are not of such nature that we need to deal with them at great length. The importance of this industry appears from its yearly turnover of 45–50 million Marks (10–12 million dollars). Here the efforts of the chemists are directed towards determining the constitution of the complex and simple natural perfumes, isolating the various products of decomposition obtained during the investigation, and finally reproducing the natural perfumes synthetically. Such results have already been achieved in the case of the odor of the rose, lily-of-the-valley and violet. Very often certain substances are needed in the compounding of perfumes which, like indole, possess anything but a pleasant smell.

Artificial Silk.—Even if doubt be expressed as to whether artificial silk (the yearly consumption of which amounts to about 7 million kilograms) still belongs to the chemical industry because it stands in such close relation to the textile industry, with its weaving and spinning machines, yet the raw materials needed for its production, such as nitro-cellulose, copper ammonia cellulose and cellulose-xanthogenate are of such importance that the chemist and engineer equally divided the responsibility in this branch of manufacture. Viscose silk from xanthogenate of cellulose, the production of which has been recently very much improved, seems to replace nitro-cellulose silk and the copper ammonia silk. This viscose silk surpasses all other artificial silks in luster and is the cheapest to manufacture, so that the apparently simplest process of all, the copper ammonia cellulose silk, cannot compete with it any more. Among the exhibits are fine specimens of this silk from the Vereinigten Glanzstoff-fabriken of Elberfeld and their factory in Oberbruch in Dremmen near Aix-la-Chapelle, including the various raw materials, wood, cellulose, alkali cellulose and the cellulose-xanthogenates produced by treatment with bisulphide of carbon and the viscose solution itself.

Acetylcellulose. *Cellit Films.*—From acetylcellulose soluble in aceton, called cellit, the Farbenfabriken vorm. Friedrich Bayer & Co. first produced cinematograph films, but although they have the great advantage over those manufactured from nitro-cellulose of being non-inflammable, it has not been possible to introduce them generally. In all their properties the cellit films are equal to the old inflammable ones, yet the proprietors of moving picture theatres do not take them up because they fear the competition of the schools and the home where the cellit films would be largely used on account of their non-inflammability. The only help then would be such action by those in authority as to make it difficult to employ inflammable films and to facilitate the use of cellit films. There are prospects of such legislation at least in Germany, which would put an end to cinematograph fires with their great danger to life and property.

NON-INFLAMMABLE CELLULOID (Cellon).—The problem of manufacturing non-inflammable celluloid by mixing cellit with suitable camphor substitutes which burn difficultly or not at all may be considered as definitely solved. Eichergrün has simplified the manufacture to an extraordinary extent by showing that certain acetylcelluloses may be gelatinized in the same way as nitrocellulose. As is well known, nitrocellulose with camphor in the presence of a solvent yields a so-called "Solid solution," and even in the dried state may be easily cut or formed into sticks, tubes or threads. Cellit, when treated in exactly the same way with appropriate camphor substitutes, can be converted into "cellon," the non-inflammable substitute for celluloid. Single blocks weighing 200 lbs. are already produced on a large scale which, like celluloid, can be sawed, cut, and polished; when heated can be pressed or bent; and when subjected to steam at a high temperature can be drawn and molded. Compared with celluloid, cellon has the advantage of being more elastic, soft and ductile. It is therefore frequently used as a substitute for hard rubber, gutta percha, leather, etc. Cellon, in the form of a highly viscous, syrup-like solution, may be employed for coating fabrics, wood, paper, metal, etc., with a thick enamel-like, uniform and pliable surface. Thus patent leather, artificial leather, insulators, balloon covers, etc., may be produced. In France this varnish is already employed for enameling aeroplanes. Objects made of this novel and widely useful material are to be found among the exhibits, being manufactured by the Rheinisch-Westfälische Sprengstoff Actien Gesellschaft in Cologne and the Société Industrielle de Celluloid in Paris.

RUBBER.—Finally, I will refer to one of the greatest successes and yet one of the most difficult problems of the chemical industry, *viz.*, the production of synthetic rubber. I am proud of the fact that its production was successfully accomplished in the works which are under my management, and that I was able to follow every stage of this important discovery. Perhaps you would be interested to hear, although it is getting late, how the whole thing happened, especially as much that is untrue and misleading has appeared in the press during the last few weeks.

But first a few words about natural rubber. The old world owes its knowledge of this substance to the new. This wonderful product became known in Europe shortly after Columbus discovered America. If I, coming from across the ocean, now bring you this colloid prepared there synthetically, I merely repay part of the debt which we owe America.

Hardly a generation ago, the southern part of this great American continent furnished the whole supply of the different kinds of rubber. Since then extensive plantations of rubber trees have been established in various tropical countries and their yield has grown so enormously that the old home of wild rubber will soon be thrust into the background. This is a matter which involves many millions; consequently a very serious economical problem confronts South America.

You all know that caoutchouc is made from the milky sap of numerous species of trees and shrubs and the grotesquely formed lianas by various coagulation processes, and that this product, on being suitably treated with sulphur or sulphur compounds, *i. e.*, by vulcanization, acquires its valuable and characteristic properties. The synthetic method took quite a different route. By breaking up the very complex molecule which rubber doubtless possesses, by pyrogenetic processes, *i. e.*, by dry distillation, a veritable maze of all kinds of gases, oils and resins was obtained, as well as a colorless fluid resembling benzine, to which the investigators gave the name "Isoprene." It was the French scientist Bouchardat who first expressed the belief that this isoprene, which is obtained in very small quantities and in an impure form by the dry distillation of caoutchouc, might be closely and intimately related to caoutchouc itself. This important question was then eagerly discussed for several decades by the scientists of all countries and opinions were sharply divided. As far back as the eighties, the Englishman Tilden claimed to have prepared artificial rubber from isoprene by treatment with hydrochloric acid. But neither Tilden nor his assistants, though they worked strenuously for years, succeeded in repeating the experiments. Moreover, numerous other investigators were unable to confirm the results. Dr. Fritz Hofmann, of the Farbenfabriken vorm. Friedrich Bayer & Co., is to be regarded as the real discoverer of synthetic rubber, for, by the application of heat, he succeeded, in August, 1909, in polymerizing the isoprene molecules into the complex rubber molecule. Somewhat later Harries discovered independently another method of arriving at the same result. Everyone is now in a position to repeat this exceedingly simple experiment himself, but in order to confirm Hofmann's results, it is necessary to employ *pure* isoprene.

The practical value of this rubber, of which many samples are among the exhibits, has been tested by the highest authorities in this branch of the industry, while Professor Karl Harries, whose unremitting labors extending over many years prepared the soil for Hofmann's synthesis, has carefully examined the chemical constitution of the substance.

Isoprene belongs to the butadienes. It was therefore to be assumed at the start that betamethylbutadiene would not hold a peculiar and isolated position among the butadienes in general. It was argued that other members of this interesting group of hydrocarbons would yield analogous and homologous rubbers on being heated. In the synthesis of products occurring in nature, there is always a possibility of producing such variations, and our endeavors to find out whether this was true in the case of rubber were crowned with success, for to-day several representatives of the new class of caoutchoucs possessing different properties are known and are being submitted to technical tests. Exact proof of the existence of the class of isomeric and homologous caoutchoucs was also first presented by Elberfeld.

To you who hear this account and see these beautiful specimens, the matter appears very simple, intelligible and clear. In reality, however, it was not so. The difficulties which have been overcome were great

indeed and those which still remain to be surmounted in order to produce a substance equal to Para caoutchouc in quality and capable of competing with cheap plantation rubber costing only 2 marks per kilo, are still greater. But such difficulties do not intimidate the chemist and manufacturer; on the contrary, they spur them on to further efforts. The stone is rolling, and we will see to it that it reaches its destination. The end in view is this: that artificial rubber may soon play as important a role in the markets of the world as does natural rubber. The consumption of rubber is simply enormous. Finished articles to the value of 3 milliard marks are manufactured every year, and the raw material from which they are made, calculated at the present market price of 12 marks per kilo, costs one milliard marks. Other tasks which the chemist has on hand shrink into insignificance compared with this gigantic problem. The laurel wreath will not adorn the brow of the wild dreamer but that of the scientist who, cool and persevering, pursues his way. The seed he sows ripens slowly, and though according to the statements in the press, all this is mere child's play and the problem has been solved. I leave it to your judgment whether this is true or not, like much that printer's ink patiently transfers to paper. I am right in the midst of this excitement. I have employed articles made of synthetic rubber, and for some time I have used automobile tires made of this material. Yet, if you ask me to answer you honestly and truly when synthetic rubber will bring the millions which prophets see in its exploitation, I must reply that I do not know. Surely not in the immediate future, although synthetic rubber will certainly appear on the market in a very short time. But I hope to live long enough to see Art triumph over Nature here also.

We are now at the end of our journey. We have flown not only over the field of Germany, but also over all other countries where the chemical industry is cultivated. We have taken a passing glance at the untiring striving for advance, the restless search for the hidden and unknown, the ceaseless efforts to acquire more technical knowledge as witnessed in the great laboratories and factories of our mighty and ever-growing industry. We shall now guide our airship into the haven whence we set out and land where our co-workers have gathered from all the countries of the earth to recount whatever progress each has achieved, and to discuss, in public and private, the problems which have been solved and those which still await solution.

This is the purpose and aim of the Congresses of Applied Chemistry, and in this way they promote directly and indirectly the interests of our industry. But they also serve another purpose—to spread far and wide knowledge of our great deeds. It is thus that they impress the importance of our science and the arts founded on it upon the public in general and especially upon those who have influence in social or official positions, so that our profession may advance equally with others, and so that the importance of the chemical industry and of those connected with it from an economic, hygienic and social standpoint may become better and better known.

That the effulgent light of this knowledge will also be diffused by the Eighth International Congress of Applied Chemistry is assured by the magnificent organization which our friends, the American chemists, have provided, the skillful manner in which the affair has been conducted, the hospitable reception which has been extended to us, not only by our colleagues but by the people-at-large, and which is still awaiting us in our tours of inspection of the flourishing industry of America, in so many respects a model for others. For Chemical Science and the Chemical Industry the following words of Schiller are beautifully descriptive: "Only the serious mind, undaunted by obstacles, can hear the murmuring of the hidden spring of Truth."

SYNTHETIC AMMONIA.[1]

By H. A. Bernthsen.

You all know that of the chemical elements that occur in large quantity on our planet, nitrogen is one which is characterized by its complete indifference to chemical attack. Berzelius already says of it: "it is difficult to recognize because it does not differ from other gases by any conspicuous property, but can only be recognized by means of properties which it does not possess." We see therefore both in science and in arts that nitrogen is frequently used when it is desired to protect bodies from chemical attack by oxygen or when the commencement of an oxidation is to be prevented. The vacuum of the thermometers in instruments which are intended for high temperatures is, as you are aware, filled with nitrogen. The storage of readily combustible liquids, such as coal-tar benzene and light petroleum naphtha, is effected by covering these bodies with nitrogen; their transport by applying compressed nitrogen. It is to the indifference of this element to chemical attack that the curious state of affairs must be attributed, that although we are dependent for all the conditions of life on compounds of this body and although we live in an infinite ocean of nitrogen, yet up to a short time ago we were not in a position to obtain nitrogen compounds from it. We were forced to cover our requirements of saltpeter for gunpowder, of nitric acid for gun-cotton and for nitration and many other applications, of ammonia for refrigerators, for instance, and so on, not by drawing upon the nitrogen of the air, but by utilizing ready formed nitrogen compounds, which ultimately result from the processes of plant life of earlier times. On the one hand Chili saltpeter and on the other hand the ammonia liquor obtained in small proportions as a by-product in the manufacture of gas or coke from coal served to supply the wants mentioned. We were also and in particular dependent on these two sources of nitrogen for the requirements of agriculture, which are far greater than all the other taken together.

[1] Lecture by Herr Hofrat Prof. Dr. Heinrich August Bernthsen, Managing Director of the Badische Co., Ludwigshafen-on-Rhine, Germany. Eighth International Congress of Applied Chemistry, New York, September, 1912.

But now, while the requirements of nitrogenous manures are constantly increasing, in order to guarantee to the inhabitants of the world sufficient harvests, we have in all probability to reckon with a comparatively rapid diminution of the supply of natural Chili saltpeter. On the other hand we cannot expect the balance to be maintained by a rapid increase in the production of ammonium sulfate, for this is dependent on the manufacture of gas and of coke, which increases but slowly. To this, some working up of peat may be added, but a production of ammonia in this way as the main object of manufacture is impossible. The problem of the conquest of elementary nitrogen, of forcing this obstinate scamp into the service of our civilization, has consequently attained immediate importance for some time. Already three years ago at the Seventh International Congress of Applied Chemistry in London, I therefore had the honor of reporting on the utilization of atmospheric nitrogen and a new way for the production of nitrates from the air.

It might appear that the American continent, which is so richly blessed with the treasures of nature, can perhaps await with greater patience the development of events than could most European countries. For while the soil of the latter has been worked to the uttermost through centuries of agriculture, the unexampled development of this country has been caused, to a great extent, by the fact that agriculture had virgin soil at its disposal wherever it developed. There may still be places, such as the English poet Browning sings of:

"Nature frames
Some happy lands, that have luxurious names,
For loose fertility; a footfall there
Suffices to upturn to the warm air
Half-germinating spices; mere decay
Produces richer life; and day by day
New pollen on the lily petal grows,
And still more labyrinthine buds the rose."

In general however a change is occurring. The soil of the eastern states, if it is to yield full harvests, in the future already requires the addition of manures above all of the nitrogenous manures, for lack of the latter is most quickly noticed by the plants. A similar treatment would further be of great advantage in many parts of the southern cotton states. Finally, in the course of years, the same requirements will be noticed in the west more and more, as the development of hitherto uncultivated land even there hardly comes any more into consideration. Nature will only continue to shower her favors on man if he adapts himself with reason to her immutable laws, as expressed by the poet:

"Nur der verdient sich Freiheit wie das Leben,
Der täglich sie erobern muss."

I therefore count upon your interest if I deal to-day in some detail with the nitrogen question, and announce to you some of the progress that has been made since the last Congress.

The three methods employed for the fixation of nitrogen are: *first*, the direct oxidation of nitrogen of the air forming nitric acid, nitrates, etc.; *second*, the synthesis of ammonia from nitrogen and hydrogen; and *third*, the fixation of nitrogen to metals or metalloids and, if desired, subsequently decomposing the resulting products, nitrids, etc., producing ammonia. Three years ago it was the first of these ways with which I dealt principally. I was in a position to announce that in the processes of Birkeland of Christiania, on the one hand, and of Schönherr and the Badische Anilin- & Soda-Fabrik, on the other hand, two important ways had been opened up for oxidizing the atmospheric nitrogen with the aid of electricity obtained from water-power. Two companies had been formed by a Norwegian-French group, the Norsk Hydro Elektrisk Kvaelstofaktieselskab, and a German group, the Badische Anilin- & Soda-Fabrik together with the Farbenfabriken of Elberfeld and the Actiengesellschaft für Anilinfabrikation of Berlin. These undertakings and some other associated enterprises have in the meantime been developed with great energy and the factory at Saaheim, which converts about 120,000 H. P. of the Rjukan fall into oxids of nitrogen, is now in full swing. The management of these works has passed into the hands of the Norwegian-French group by an arrangement with the German group.

The processes for the combination of nitrogen with metals, etc., producing metallic nitrids, cyanamids, and the like, and from these ammonia, have also progressed.

On the one hand the nitrolim obtained for instance by the union of nitrogen with calcium carbid, which is produced in several factories, is in part utilized directly as manure; in part a beginning has been made with the manufacture of ammonia from it by treatment with steam. On the other hand the nitrids, and especially those of aluminum and silicon, have been more closely studied. The process of Serpek for the production of aluminum nitrid has been developed by the Société Générale des Nitrures on a manufacturing scale in order to obtain on the one hand, pure alumina for the production of aluminum, and on the other, ammonia. Then again the Badische Anilin- & Soda-Fabrik in following up its work on barium cyanid from nitrogen, barytes and carbon took up the study of the production of titanium-nitrogen compounds and that of silicon nitrid from silica, nitrogen and carbon, and then in connection with this the production of mixed nitrids of silicon and aluminum, and of aluminum nitrid itself. In this field of work also an arrangement has been made between the firms working it, the Badische Anilin- & Soda-Fabrik having assigned their patents to the Société Générale, retaining for themselves certain rights of preparing the nitrids in question according to the patents of both companies. It is to be expected that this branch of industry will also develop satisfactorily.

I refrain from discussing any of these methods of fixing nitrogen and refer to the communications made by the inventors themselves and in particular to the

lecture delivered a few days ago at this Congress, by Dr. Eyde, the general director of the Norwegian companies referred to.

I propose to deal to-day however, from my own direct experience, with the development of the problem for the synthetical manufacture of ammonia from its elements. A few years ago the solution of this problem appeared to be absolutely impossible. It has recently been the object of very painstaking investigations by Professor Haber and the chemists of the Badische Anilin- & Soda-Fabrik, and numerous patents have been taken out with reference to the manufacture. Apart from what is already published in this way, however, we have refrained from any other announcements until we were in a position to report something final with reference to the solution of the technical question.

This moment has now arrived and I am in the agreeable position of being able to inform you that the said problem has now been solved fully on a manufacturing scale, and that the walls of our first factory for synthetic ammonia are already rising above the ground at Oppau, near Ludwigshafen-on-Rhine; this factory will be opened by the middle of next year.

Permit me therefore to explain to you the fundamental points upon which this latest achievement of chemical industry is based.

The affinity of nitrogen for hydrogen, as is well known, is so small that the two do not appreciably unite with one another either at ordinary or at a raised temperature. It has long been known that by electric sparks or by a silent discharge very minute quantities of ammonia can be formed from nitrogen and hydrogen. Also by conducting a mixture of hydrogen with nitrogen prepared in a particular way over spongy platinum, Johnson (1881) thought that he had obtained ammonia, in a quantity amounting to 0.0059 gram of NH_3 per hour. The nitrogen had been obtained from ammonium nitrite and passed through ferrous sulfate solution in order to remove nitric oxids. But nitrogen prepared in other ways did not yield the ammonia, so that Johnson assumed that there were two modifications of nitrogen. Wright (1881) proved that ferrous sulfate did not absorb all the nitrogen oxids and that the ammonia was produced by the action of hydrogen on nitrogen oxid in the presence of platinum. When using pure nitrogen he also obtained no ammonia. Baker (1883) also came to the conclusion that Johnson's statements as to the production of ammonia from its elements were mistaken. In no case could Baker notice any signs of the formation of ammonia, and he decided that hydrogen does not combine with nitrogen under the influence of heated platinum sponge.

Ramsay and Young on the other hand (1884) determined the decomposition of ammonia by heat at various temperatures. In this research, among other experiments, a mixture of dry nitrogen and hydrogen was passed through a red-hot glass tube filled with iron filings, or through an iron tube. The presence of ammonia could again not be proved. When using moist gases they noticed the presence of traces of ammonia, the formation of which they explained by the decomposition of water and the production of nascent hydrogen.

Again Perman, twenty years later, occupied himself with the question of the formation of ammonia from its elements. Upon slowly passing a mixture of nitrogen and hydrogen (1 vol.: 3 vol.) through a glass tube heated to red heat, he obtained no ammonia, and the same result was attained when the tube was filled with porcelain. But when the mixture, in a moist condition, was passed over red-hot iron or several other metals, or over asbestos, pumice, pipe-clay, etc.,[1] traces of ammonia were formed, according to Perman's statement.

The investigations entered upon a new phase when Haber, armed with the weapons of modern physical-chemical methods, attacked the problem of the estimation of the ammonia equilibrium in 1904 in conjunction with van Oordt.[2] These investigators showed that at a temperature of about 1000° C. decomposition of ammonia into its elements was almost, but not quite, quantitative (of 1000 molecules of ammonia 999.76 were decomposed at a temperature of 1020° C.), and that consequently from these elements and under the same conditions very small quantities of ammonia were formed. The authors used as contact material, iron prepared from iron oxalate by heating to red heat in a current of hydrogen, and the iron was spread out upon purified asbestos. Further, for some experiments nickel was precipitated from nickel nitrate upon pure silica. From a mixture of nitrogen and hydrogen corresponding to 100 parts of ammonia they obtained at the temperature mentioned about 0.02 parts of ammonia, and even this figure was subsequently, by more accurate examination (see below), shown to be still too high. In a further publication in 1905,[3] these results were confirmed and summarized in the following statement: at the temperature of commencing red heat and upwards, no catalyzer is capable of producing more than traces of ammonia. The work was carried out at ordinary atmospheric pressure "for practical reasons," and it was pointed out that even under considerably increased pressure the position of the equilibrium would remain very unfavorable. Manganese was also taken into consideration as a catalyzer, but its effect, as also that of nickel, was less satisfactory than that of iron.

While Haber in company with Le Rossignol[4] pursued this line of research, Nernst communicated the results of similar investigations to the general meeting of the German Bunsen Gesellschaft at Hamburg in 1907.[5] He was induced to take the matter up by the fact that Haber's figures showed a remarkable discrepancy from the equilibrium figures calculated according to the famous "heat theorem" of Nernst

[1] The action of these latter bodies was explained by the presence of iron in them, but it may be stated that the alleged action of asbestos, pipe-clay and pumice is due to a mistake.

[2] *Z. anorg. Chem.*, **43**, 111.

[3] *Ibid.*, **44**, 341.

[4] *Ber.*, **40**, II, 2144 (1907).

[5] *Zeit für Elektrochemie*, **13**, 521 (1907).

himself. In order to determine the otherwise so minute quantities of ammonia, Nernst worked under pressure, using as a rule about 50 and up to 75 atmospheres, for according to the well known laws the concentration of the ammonia increases with the pressure. These results were published more in detail a year later by his co-worker, Jost.[1] The latter used as catalysts besides platinum foil or iron (prepared from iron oxid in a current of hydrogen) also manganese (obtained from an electrically prepared amalgam by driving off the mercury in a current of ammonia). The figures here obtained for the equilibrium were still lower than Haber's, a fact which Nernst said was very regrettable, for otherwise one might really have thought of preparing ammonia synthetically from hydrogen and nitrogen. Haber and Le Rossignol made a further publication in 1908,[2] having now made their measurements also at a pressure of 30 atmospheres. By this means, it is true, the differences as against Nernst's experiments on account of the position of equilibrium, as also the maximum percentage of ammonia obtainable at a given temperature, were not quite got over, but at all events the figures of both scientists agreed in showing that this maximum is extremely low. At a temperature of 1000° C. the volume percentage of ammonia calculated for atmospheric pressure is 0.0048 per cent. according to Haber and 0.0032 per cent. according to Jost, the corresponding figures at 700° C. being 0.0221 per cent. and 0.0174 per cent.[3] That is, at these temperatures the ammonia equilibrium is extremely unfavorable, while at lower temperatures the catalytic action of the metals in question was too low to be able to work with them.

To sum up all these investigations on the direct combination of nitrogen and ammonia, it can be said that the problem seemed now to have become more than ever a mere dream, of which the realization appeared to be quite beyond the bounds of possibility, so that there was every reason why the scientist should turn his back on so unfruitful a field.

In spite of this, Haber had a feeling that a technical synthesis of ammonia from its elements could be rendered possible, and placed himself in communication with the Badische Anilin- & Soda-Fabrik for the promotion of the work. He then showed, still in 1908,[4] that the technical preparation of ammonia from its elements can in fact be carried out, in spite of the unfavorable equilibrium and the low catalytic capacity of the contact metals used, if the mixture of nitrogen and hydrogen is kept under constant pressure during the whole of the operation and is subjected alternately to the catalytic formation of ammonia at a high temperature and then freed from ammonia by absorption or condensation at a lower temperature. Care must at the same time be taken that the heat of the reaction gases containing ammonia is transferred afresh to the gas mixture about to be acted on. In other words, the nitrogen-hydrogen mixture circulates under continuous pressure, through the vessel for the formation of the ammonia, the vessel for the separation of the ammonia and a circulating pump, all these being connected up to a closed endless circuit. Of course it is advisable at the same time to replace with a fresh nitrogen-hydrogen mixture as much of the gas as is converted into ammonia.

It was further found when working according to this continuous process of Haber's under conditions which induce a relatively high concentration of ammonia that the advantages of the heat regeneration are no longer of such vital importance, but that it is sufficient in this case to work continuously under pressure without at the same time regenerating heat.[1] Finally it was seen[2] that it is not even absolutely necessary to work continuously under pressure (that is, to circulate the gases continuously under pressure), if the reaction is carried out under very high pressure, for instance at about one hundred atmospheres, preferably however at from 150 to 250 atmospheres and even higher. A range of pressure is hereby introduced which had never been touched in the synthesis of ammonia and was also something quite new in any manufacture, for no one had previously so much as thought of carrying out technically a catalytic reaction with gas currents at the necessary high temperatures under such an enormous pressure.

By these means, under a pressure of 200 atmospheres, at a temperature of from 650–700° C. and using an iron catalyst prepared from the purest iron oxid, occupying a space of 20 cc., and with a gas speed of 250 liters per hour (measured at ordinary pressure) it is an easy matter to obtain for example 5 grams, or per liter of contact space, 250 grams of ammonia in an hour.

The following further point comes here into consideration. All previous publications had in view exclusively the determination of the ammonia equilibrium, which can be found theoretically most accurately in a steady volume of gas. If a current of gas is used, the rate of flow must naturally be kept low, so that one may be sure that equilibrium is reached. Now there were no indications as to how far the concentration of the gas would be reduced when the rate of flow is raised, and whether the concentration would be sufficient when such a rate of flow is taken as must be done when working on a technical scale. Haber has therefore rendered signal service in showing that one can work successfully with such higher rates of flow.

A diagrammatic exposition of an apparatus used by Haber is shown on the chart[3] before you. The catalyst is in a metal tube which opens in front into a heat regenerator. The gas mixture passes from behind into the metal tube, through the catalyst and then through the heat regenerator into a circulating pump. Leaving this it passes in countercurrent around the outside of the regenerator tubes and the tube containing the catalyst and then enters this in front, repeating

[1] *Z. anorg. Chem.*, **57**, 414.
[2] *Zeit. für Elektrochemie*, **14**, 181 (1908).
[3] *Z. anorg. Chem.*, **57**, 193; *Zeit. für Elektrochemie*, **14**, 193.
[4] German Patent No. 235,421, October 13, 1908.

[1] French Patent No. 406,943.
[2] German Patent No. 238,450, September 14, 1909.
[3] See the sketches in Haber's article in the *Zeit. für Elektrochemie*, **16**, 244–5 (1910); and also British Patent No. 17,951 1909.

this journey again as described. The apparatus can be protected against loss of heat to the air by packing it in isolating material and can be enclosed in an outer shell which can withstand the pressure. The whole of the circulation takes place at high pressure. The catalyst is kept at the suitable temperature by electrically heating from within or by applying heat from the outside. Between the heat regenerator and the circulating pump the gases pass through either an absorber or a condenser for ammonia. By means of a branch tube the nitrogen and hydrogen combined to ammonia can be replaced.

Finally, it was a great step forward when Haber found catalysts with the property of rapidly combining nitrogen and hydrogen to ammonia in sufficient quantity even at much lower temperatures than those previously required. He found this to be especially the case with osmium. This metal has such a very favorable action even at 550° C. and below, that under a pressure of 175 atmospheres a gas concentration of 8 volumes per cent. of ammonia can be obtained. This was all the more astonishing, as platinum, which is closely related to osmium, has but a very slight catalytic action. For use on a large scale, however, osmium scarcely comes into consideration, for the world's stocks according to Haber do not amount to much over 100 kg. and only small quantities (about 1 kg.) are obtained annually; this quite apart from its high price and very unpleasant properties.

Very soon Haber found in uranium a further very good catalyst; it can be employed in the form of the metal, of an alloy, or nitrid, or carbid. In the form containing carbon or carbid, such is as produced in the electric arc from uranium oxid and carbon, it crumbles in the gas mixture under high pressure to a very fine powder containing nitrogen, which even under 500° C. has an excellent catalytic action. No water, however, or impurities which give rise to water must be present in the gases, when uranium is used in this way. From the following table which shows the equilibria obtainable at different temperatures and pressures, can be seen the importance of the temperature at which a catalyst is active for the equilibrium of the ammonia produced.

EQUILIBRIA ($N_2 : 3H_2$).

Temp. Degrees Centigrade.	Pressure. 1 atm. Per cent.	100 atm. Per cent.
800	0.011	1.1
700	0.021	2.1
600	0.048	4.5
500	0.13	10.8
400	0.48	..

Haber published a short report of his work in 1910.[1] To my great regret Professor Haber has not been able to accept the invitation of the officers of this Congress to report personally here on his researches, owing to being hindered by pressure of work. I have great pleasure in fulfilling his wish and thanking the officers of the Congress to-day for the honorable invitation, and express his regret to this meeting that he is unable to be present.

[1] *Zeit. für Elektrochemie*, **16**, 244–5.

I now turn to the work of the Badische Anilin- & Soda-Fabrik on the technical development of the process. This work was of course at once taken up in 1908 after the first communications of Professor Haber, and Dr. Carl Bosch was entrusted with it. In conjunction with his colleagues and with equal energy and experience in the field of chemistry and engineering he has successfully carried out the practical application of the process.

The problems to be solved were quite new and strange and demanded the mastery of very unusual difficulties. Although working with compressed gases under pressure at very low temperatures was already known in the industry, the problem here was the totally different one of constructing apparatus which should be large enough and at the same time able to withstand the high pressure with temperatures not far from a red heat. How well founded were the doubts as to the possibility of a solution of this task can be gathered from the instance of the wrought iron autoclaves commonly used in the color industry. Here, in spite of a very low range of temperature of at most about 280° C., only pressures of from 50 to 100 atmospheres at the utmost come into consideration. But above 400° C. iron loses its solidity to a very extraordinary degree.

There is further the circumstance that the metals which come into consideration for the construction of the apparatus, and especially iron, are chemically attacked above certain temperatures by the gas mixture under pressure. Although the formation of iron nitrid from iron and ammonia, which could have been expected according to the work of Frémy and others, can be avoided, yet it is found, for example, that steel containing carbon loses its carbon at the temperatures in question owing to the action of the hydrogen, so that its capability of withstanding pressure is reduced to a minimum. It was further found, when using iron itself, that it is completely changed in its qualities, chiefly by taking up hydrogen. Again, at such high temperatures iron is pervious to quite a remarkable degree to hydrogen under high pressures. The question of materials for the apparatus therefore raised at once considerable difficulties, but at length these were more than overcome by suitable construction, details of which, I am sure, you will not expect from me to-day. The danger of serious explosions or of great sudden flames of hydrogen, if the apparatus happens to become defective, can be guarded against by setting it up in bomb-proof chambers.

Great care must naturally be taken that oxygen or air does not get into the apparatus or the piping, for at the high pressure obtaining the explosion range is reached with merely a slight percentage of oxygen. Special devices are used to watch over this content of oxygen, and immediately a definite percentage is touched the alarm is automatically raised. Besides this the proper constitution of the gas mixture in circulation is controlled by analysis from time to time.

The ammonia can be removed either by being drawn directly from the apparatus in liquid form, or an absorption agent can be suitably introduced into

the apparatus. The simplest absorbent, water, has been found to be suited for this purpose; under the pressure used a concentrated solution of ammonia is secured. Any ammonia that may remain in the gas after the bulk has been removed by one or other of these methods can be further removed by special chemical means, if it is not preferred simply to leave it in the circulating gases.

As before mentioned, Haber observed that there are contact agents which are much more active than those previously known (osmium and uranium being indeed found to be much more active than pure iron prepared from oxalate of iron or oxid of iron, platinum, pure manganese, chromium, and nickel, already at considerably lower temperatures). The Badische Anilin- & Soda-Fabrik therefore decided to study the various catalysts very minutely.

In the course of these investigations, the new fact discovered, that ammonia catalysts in general are made more active by the presence of certain foreign bodies, has proved to be of prime importance. Among these "promoters," as they have been termed, are oxids, hydroxids, or salts of the alkalies, of the alkaline earths and the earth metals, further many other substances of the most varied nature, especially other metal compounds or metals themselves. In many cases just a minute quantity suffices to raise the catalytic activity. This trait is common to all catalysts, for there is not one but its activity can be raised by these means. Care must however be taken (for reasons to be discussed later on) not to choose such mixtures that metalloids such as sulfur, selenium tellurium, phosphorus, arsenic, boron, etc., under the conditions prevailing, are incorporated in the catalyst. Similarly compounds of metals with a low melting point which are readily reduced by hydrogen and which themselves do not act as catalysts must be avoided; such metals themselves as lead, tin, zinc and bismuth must also not be added.

The promoters mentioned can be added either to the prepared catalyst or to the substances used in its preparation, or the catalyst can be prepared from such materials as already contain such additions in suitable mixture (for example magnetic ironstone). Under certain circumstances the action of these foreign bodies is specially powerful, *viz.*, if the metals, or oxids, or carbonates, or other compounds which are converted into oxids on heating, are first heated to high temperatures, preferably to melting point, and so that the resulting product consists chiefly of oxids. When proceeding in this way with metals, for instance iron, of course sufficient oxygen or oxygen-producing compounds must have access. The mass of oxids obtained as described is suitably broken up and filled into the contact stove either directly or after reduction. In this case extremely small quantities of foreign substances suffice to secure a high and continuous activity of the contact mass.

We consider the marked activity of catalysts prepared in this way to be in the first place due to the fact that the additions mentioned dissolve, on heating, in the highly heated metallic oxid or become finely divided in it, and that in this way during the following reduction a sort of skeleton, which however is hardly to be detected, is formed inside the metallic mass. This effectually prevents a diminution of the surface and therefore also of the catalytic properties of the mass.

It was then further found that good results can also be achieved with pure iron, that is to say, that we can work with it at temperatures of for example not much above 600° C., thus if the iron intended for the catalysis is prepared from the oxid or other iron compound at a comparatively low temperature, preferably not above 600° C. It can also be prepared by highly heating pure iron oxids, or pure iron in the presence of oxygen, preferably to melting point, and by reducing the mass of oxid preferably at a not too high temperature.

Also manganese, which is related to iron, gives under a specific condition good results, without the addition of foreign substances. This condition is that care be taken to free completely the mixture of nitrogen and hydrogn, before it enters the contact space, from oxygen, either free or combined, for instance as steam or water. Merely drying with calcium chlorid is not sufficient. In the case of several other catalysts too a similar careful drying has proved to be useful.

Again, it has been found that another member of the iron group, molybdenum, is by itself an excellent catalyst. Compounds of molybdenum can also be used, for instance molybdic acid or ammonium molybdate.

Under certain conditions, not published as yet, tungsten, either the metal itself or as an alloy or a nitrogen compound, has been found to be a suitable catalyst.[1]

In view of the shortness of the time I must refrain from a more exhaustive discussion of this most interesting chapter of the contact bodies. It will be quite evident from what I have said that the industry has now a number of active contact bodies for the synthesis of ammonia at its disposal, and can select from case to case the most suitable.

Another discovery of first-class importance for the industrial application of the catalysis of ammonia was the recognition of the fact that there are special poisons, so to speak, for the reaction. That is to say, there are substances which hinder or prevent the reaction, although the contact mass does not suffer a noticeable chemical change, envelopment, or destruction. In the literature there was no indication whether there were poisons at all for the contact mass in the catalytic manufacture of ammonia, or what their nature would be. In actual manufacture such contact poisons were known only in the case of the catalysis of sulfuric anhydrid and even here only when platinum was used. When employing other contact bodies, such as iron oxid, or burnt pyrites, there was nothing known of contact poisons; on the

[1] Such conditions are *e. g.*, that tungsten, or its compounds mentioned, is prepared at temperatures not much above 600° C., that they are prepared from tungsten compounds by means of ammonia, in which case there is no restriction to a temperature at about 600° C.

contrary, it has even been shown that the presence of arsenic, which is a poison for platinum, has actually a favorable action when iron oxid is used as catalyst.

It has now been ascertained that some of the poisons in the syntheses of ammonia are of quite a different nature from those of the sulfuric acid process; they are for instance, sulfur, selenium, tellurium, phosphorus, arsenic, boron, or the compounds of these elements such as sulphuretted hydrogen, arsenic hydrid, phosphorus hydrid, as also many carbon compounds and certain metals of low melting point which can readily be reduced by hydrogen from their compounds, for example lead, bismuth and tin, which do not act catalytically. Oxygen-sulfur compounds, such as SO_2, which acts directly and smoothly in the sulfuric acid catalysis, are very poisonous. Extremely minute quantities of these bodies, which are almost always present even in the purest commercial products or in the so-called pure gases, suffice to render the catalysts absolutely inactive or at least to diminish their action very seriously. Thus iron, for example, prepared from ordinary iron oxid with a content of one per thousand of sodium sulfate is, as a rule, inactive. Iron containing one-tenth per cent. of sulfur is generally quite useless, and even with one hundreth per cent. is of very little use, although in appearance and when examined with the ordinary physical and chemical methods no difference at all can be detected as compared with pure iron.

The recognition of these facts gave rise to two problems:

(*a*) The preparation of contact masses free from poison or the removal of such poisons from them.

(*b*) Freeing the gases to be acted on catalytically from all contact poisons.

In order to free the contact bodies from these harmful substances, the ordinary methods for removing them can of course be applied. The contact action can also be improved by heating contact metals which are inactive or of little use, owing to the presence of contact poisons, in the presence of oxygen or of bodies yielding oxygen. Or the metals can be heated, for instance, in the presence of oxygen with the addition of suitable compounds such as bases, and the resulting products reduced. These operations can be repeated if necessary. If more of such a body as mentioned is added than is necessary, it may act not merely by removing the poisons, but promote the yield, as I have already described to you.

On the other hand it is necessary, as I remarked, to take the greatest care that nitrogen and hydrogen are free or freed completely from all contact poisons. Thus a trace of sulfur, one part per million, in the gas mixture can under certain conditions be injurious, so that even electrolytically prepared hydrogen must generally be further specially purified. The minute purification of the gases is even more important when hydrogen prepared, for example, from water gas is used. The impurities too taken up from iron piping play sometimes an important part, and impurities which get into the gases during the compression, such as machine oil, often have a harmful effect.

The best method of removing impurities from the gas mixture depends in turn on the nature of these impurities and consists, for instance, according to the case, in filtering, washing, conducting over solid absorption agents and so on. One good method is to bring the gases into contact with the material of which the contact mass is prepared at a raised temperature, before passing them over the actual catalyst. The material takes up the impurities, and must of course be renewed from time to time. The negative results of earlier investigators in the formation of ammonia when using base contact metals (Wright, Ramsay and Young, and, more recently again, 1911, Neogi and Adhicary), according to which nitrogen and hydrogen do not combine in the presence of iron, are in my opinion probably due, for the most part at least, to the use of metals or gases not free from contact poison. That previous inquirers had not the remotest idea that sulfur in the contact metal could be injurious, is evident from the fact that they passed the gases without hesitation through concentrated sulfuric acid in order to dry them. The sulfuric acid thus taken up and the sulfur dioxid often contained in it can poison even the best catalyst very speedily and render it unfit for use. Or the contact metals were sometimes prepared directly from the sulfates, although a metal sufficiently free from sulfur can scarcely be obtained by this method.

A painstaking study, for which we are indebted principally to Dr. A. Mittasch and which involved literally many thousands of experiments, has afforded an insight into the importance of substances of the most varied nature as promoters and poisons and thus a sure foundation has been prepared for a reliable continuous manufacture with a good yield of ammonia.

[Here the production of synthetic ammonia by means of two identical apparatus brought from Germany by the speaker was demonstrated in two ways:

(1) The gases from the apparatus were passed over a large bowl of hydrochloric acid when dense clouds of ammonium chloride were formed.

(2) A large cloth was moistened with colorless organic compounds that give colored products when treated with bases: the gases from the apparatus were then played upon this cloth and the result was a brightly colored American flag.]

The question has not yet been touched upon in the foregoing, how the elements nitrogen and hydrogen which are requisite for the new ammonia process can best be produced on a technical scale. Theoretically, the task would be unusually simple. If you remember that the terrestrial atmosphere according to the studies of A. Wegener and others consists of practically pure hydrogen at a height of about 120 kilometers, indeed at a height of about 70 kilometers consists of almost exactly one volume of nitrogen and three volumes of hydrogen besides a trace (about one-half per cent.) of oxygen, you will understand that all the conditions were given for an ammonia factory according to Jules Verne. For it would then merely be necessary to suck down the gases from the higher strata of the atmosphere by a sufficiently long pipe line.

For us, poor mortals, matters are not so ideally simple, for, as the poet says,

"hart im Raume stossen sich die Sachen."

Fortunately, however, there is no great difficulty in separating nitrogen from the air, either by physical means, according to Linde's process, or chemically, by removing the oxygen with glowing copper, burning hydrogen, or the like. And for the preparation of hydrogen in recent times a great deal of useful work has been done too, owing to the extensive growth of its field of application. In certain works it is at disposal in large quantities as a by-product of the electrolysis of common salt. Besides this it can be produced, for example, by passing steam over red-hot iron, or from water-gas, for instance, by separating its constituents hydrogen and carbon monoxid by cooling to a very low temperature. All the methods of preparation which come into consideration we have of course minutely examined; owing to the comparatively trifling differences in the cost of production various methods can be employed. At all events, both elements, nitrogen and hydrogen, are at the disposal of the new industry to any extent and sufficiently cheap.

CHILI SALTPETER.

Year.	Chilian export.[1]	Price[2] per ton. Marks.	Total value. mill. M.	Increase.
1900	1,454,000	162.2	216.6	1901–11 995,400 tons
1901	1,274,000	172.8	...	that is an annual
1902	1,379,200	176.2	...	average of 99,500
1903	1,457,600	178.4	...	tons containing
1904	1,479,100	196.2	...	15.5 per cent., *i. e.*,
1905	1,652,200	204.8	338.2	about 15,400 tons
1906	1,731,800	215.0	...	nitrogen, valued at
1907	1,653,600	214.4	...	19 million marks.
1908	2,052,400	193.3	...	
1909	2,133,900	184.5	393.7	First six months 1912
1910	2,334,000	177.6	...	150,000 tons valued
				at about 29 million
Jan.–June				marks as against
1911	(1,299,000[3])	...	...	corresponding per-
1911	2,449,000	190.7	467.2	iod 1911.
1912	(1,449,000[3])			

[1] According to the figures of the Association Salitrera.
[2] Annual average Hamburg quotations.
[3] Semi-annual deliveries in Europe.

AMMONIUM SULFATE.

Year.	World production. Tons.	Price per ton. Marks.	Total value. mill. M.	Increase.
1902	543,000	241[1]	131	1908-11 329,000 tons, *i.e.*, an an-
1908	852,000	237	202	nual average of 110,000 tons,
1909	978,000	230	225	containing 20.5 per cent., *i.e.*,
1910	1,111,800	248.5	276	about 22,500 tons nitrogen,
		about		valued at about 30.6 million
1911	1,181,000	278	328	marks.

[1] Quotations fob. Hull.

As the production of these elements is not confined to the presence of cheap water power, all those countries where the manufacture of calcium nitrate, owing to the want of such power, is not practicable, as for instance in Germany, are now in a position to profit by the new industry. As I remarked at the outset, there is every reason to assume that this industry will find a fruitful field of employment in America, where the demand for nitrogen-manures will soon be greater than hitherto.

It can also be regarded as certain that the development of this new industry will not take place at the cost of other branches of industry and commerce. Bear in mind for a moment the present annual requirements for nitrogen manures and their continued growth. According to the tables before you these figures reached the remarkable total of 467.2 + 326, *i. e.*, 793.2 million marks (about 190 million dollars) in 1911, and each year sees an increase. In the last few years the increased demand for ammonium sulfate amounted to about 10 per cent. The increase of production from 1910 to 1911 amounted to 69,000 tons, and from 1908 to 1911 on the average as much as 110,000 tons, or 110 million kg. valued at about 30.6 million marks (7.3 million dollars). Similarly the nitrogen requirements of the world for manure purposes in the form of saltpeter is growing. Chili exported in 1908 about 2,052,400 tons of saltpeter, and already in 1911 the figure was about 2,449,400 tons, that is an annual increase of nearly 150,000 tons valued at approximately 29 million marks (7 million dollars). Indeed the European deliveries, according to the latest reports, from January to the end of June, 1912, reached as much as 1,449,000 tons, a demand which Chili was hardly able to meet.[1] The average annual increase from 1901 to 1911 amounted to 99,500 tons. That is to say, taking saltpeter and ammonium sulfate together and reckoning only the average increases, calculated on nitrogen, we have an annual increase in production of about 38,000 tons nitrogen, corresponding to nearly 185,000 tons of ammonium sulfate.

It can thus be seen what enormous quantities of synthetic ammonium sulfate must be produced to affect the total production by as much as one year. The saying so often applicable, that

"Das Bessere ist der Feind des Guten,"

will thus probably have no meaning in this field. A peaceful development of the various new industries for the combination of the nitrogen of the air side by side is to be expected, and without encroaching at all on the previous production of nitrogenous manures, a favorable horoscope may be cast for a fortunate career for the new industry.

PROGRESS IN INDUSTRIAL CHEMISTRY.[2]

By RUDOLPH MESSEL.

At a time when the latest discovery of interest may be instantly flashed to the remotest part of the world by wireless telegraphy, and the technical press discusses every possible problem as it arises, a presidential address seems to me to be almost an anachronism. In very few cases is it possible to communicate anything not already known. Whatever issue a speaker may desire to consider is sure to have been dealt with till it is almost threadbare, and I fear that the topics I venture to bring before you must be enrolled in the latter category.

I propose to deal with some aspects of the remark-

[1] During the first six months of 1912 the production in Chili was roughly 10,000 tons less than in the corresponding period of 1911, and at the same time stocks in sight in that country receded by round 50,000 tons.

[2] Address delivered by the President of the Society of Chemical Industry at the Chemists' Club, New York, September 3, 1912.

able progress made within my recollection. The ceaseless energy with which industry has availed itself of the achievements of pure science has made possible the manufacture, on a large scale, of products, either unknown but a few years ago, or seen as specimens in scientific collections, or produced only by nature. That I shall refer to relatively very few of these triumphs of chemical research and invention and mainly to inorganic products must be evident when I mention that the period covered embraces the discovery of the aniline dyes and that of artificial rubber, as well as the invention of the first electric telephone and of wireless telegraphy.

As my recollections unfortunately go back over so long a period, I feel tempted to drag in here one which may be of interest to some of my audience, though it has no connection with the matter I propose to deal with. In 1861, when I was at school at Friedrichdorf, in Germany, my master, Philip Reis, invented the first telephone. I was present at its birth, and assisted Reis in making the mechanical parts of some of his instruments and also repeatedly in his experiments, Reis being at one end of the circuit speaking or singing, I listening at the other, or *vice versa*.

The introduction of synthetic processes may be said to be the keynote of progress of modern industrial chemistry.

One of the most fascinating compounds recently introduced into industry is *calcium carbide*, CaC_2. It had lain dormant since its discovery in 1862, by Wöhler, until your countryman Wilson and Moissan made use of the electric furnace to produce it; now its manufacture constitutes a mighty industry, close on 300,000 tons being produced annually. Serving as it does as raw material for the manufacture of calcium cyanamide, it is now the parent of numerous other products of great importance. Among these may be mentioned *acetylene*, C_2H_2, so largely used as an illuminant, and for welding and cutting metals, and I may remind you that the possibility is foreshadowed that this gas will be of use as the starting point in making other chemicals. *Calcium cyanamide*, apart from its undoubted great value as a fertilizer, is coming to the fore as a source of *cyanides*, now so largely used in extracting gold. What may be of far greater importance, it is convertible by the action of superheated water into *ammonia*, which in turn may be converted into *nitric acid* and nitrate of ammonia by oxidation with air under the catalytic influence of platinum.

I have recently noticed alarming reports in the press that the impossibility of procuring supplies of nitrate of soda from Chili in time of war may prove a serious handicap to any country in the production of explosives and powder. Considering that the quantity of nitrate of soda used for the purpose is but a fraction of that required in agriculture and that large stocks are held for this purpose almost everywhere, I cannot share the writer's fear. But in view of the fact that ammonia salts are produced by all gas works and of the many attempts to produce it synthetically, the catalytic method of producing nitric acid from ammonia may deserve more attention than it has received up to now, especially if ammonia, no matter how produced, should become a sufficiently cheap raw material.

The most interesting feature in the production of calcium is the use of pure *nitrogen*. Of the various methods of preparing the gas, that which involves fractional distillation of liquefied air seems to be preferred. We are becoming familiar in industry with the impossible, but who *could have expected* such a possibility only a few short years ago? Think of the excitement caused in the scientific world when, in 1877, Pictet and Cailletet first succeeded in liquefying oxygen. Pictet's work was then described as the most brilliant achievement in modern science. The barrier between condensable and permanent gases was broken down and the latter term was deprived of its significance; but how much work remained to be done, what ingenuity had yet to be exercised, to translate this scientific discovery into a process for the industrial preparation of nitrogen! Success has been achieved by the exertions and ingenuity of several of our greatest authorities in physical and chemical science; nowadays, every gas that is required is readily procurable in the liquefied form (Cl_2, SO_2, N_2O, CO_2, NH_3, etc., etc.) in the well known steel cylinders capable of withstanding enormous pressures.

If I have laid stress on the conversion of ammonia into nitric acid, the reason is that ammonia is obtainable locally everywhere, either as a by-product of the manufacture of illuminating gas or Mond gas and from coke ovens, and that the installation for converting it into the acid is a relatively cheap one. The numerous attempts to produce ammonia synthetically from its elements nitrogen and hydrogen or from various *nitrides*, such as those of titanium, boron, magnesium, aluminum, and calcium, can moreover only be of benefit in solving the problem. True, the direct production of *nitric acid* by means of *the electric arc* from atmospheric air may appear to be a more rational process, but so long as this industry is tied to water power, and the difficulties of transporting nitric acid as such in aluminum or iron packages be not overcome, the case seems different in my judgment, particularly in countries where water power is not available and other power as yet too expensive. It is to be remembered that to carry nitric acid safely in iron packages, about 10 per cent. of concentrated sulphuric acid has to be added, and that if one or the other of the ammonia processes under trial should make it possible to transport it as nitrate of ammonia, from which it can readily be liberated at the place of consumption, the difficulty of carriage in the event of war would still remain.

My reason for referring at such length to the production of these compounds of nitrogen is their importance in agriculture. Food the nations must have, and it seems that to this end they will require the services of the chemist more and more as population grows. The great stimulus, our medalist, Sir William Crookes, has given to the production of nitric

acid by calling attention to the near approach of the exhaustion of the deposits of nitrate of soda is well known. His suggestion to utilize Cavendish's discovery of the direct interaction of the constituents of the atmospheric air and the success, so far achieved, have often been referred to; the work done by Birkeland and Eyde, by Schoenherr, Pauling, and others, is also well known, but it gives me particular pleasure to point out that here again America was the first to attempt the realization of this great problem. The realization of the other great problem, *i. e.*, the production of *ammonia from its elements*, appears likewise on the eve of accomplishment, and I hope it will not be long before we shall have details of the manner in which it has been solved in practice, and how the great technical difficulties have been overcome. It will likewise be interesting to learn something about the relative efficiency of the various uranium and iron catalytics used, etc. If the published particulars as to temperature (about 650°) and pressure (about 150 atmospheres) be correct, the task to be solved was one of no mean order. Meanwhile, we can only offer our best wishes to the ever enterprising Badische Anilin- und Soda Fabrik.

Two of the other processes mentioned before, namely, that of the production of ammonia from *calcium nitride* and from *aluminum nitride*, are likewise most interesting, the former for chemical reasons, *i. e.*, the conversion of metallic calcium first into calcium nitride, Ca_3N_2, then by the action of hydrogen on this compound into *calcium hydride* and ammonia, the calcium hydride being subsequently reconverted by means of nitrogen into calcium nitride and ammonia—so that a relatively small quantity of *calcium* is theoretically sufficient to produce an infinite quantity of ammonia. Numerous processes have been devised for producing *hydrogen*; one of the latest is Pictet's, who splits up hydrocarbons either directly into hydrogen and carbon or by means of steam, at the melting point of iron, into hydrogen and carbon monoxide, thus materially increasing the yield.

Inasmuch as *aluminum nitride* yields on hydrolysis, together with ammonia, a particularly pure form of *aluminum* hydrate, starting from an impure raw material, it may become of great importance to the aluminum industry. I well remember aluminum and more often magnesium being made by Bunsen by the electric arc on a diminutive scale as a lecture experiment. We students used to cough violently when the white fumes which were given off began to fill the lecture room, until Bunsen, smiling pleasantly, mentioned that the white fumes were due to the ammonium chloride he had added to keep the surface of the metal bright and that ammonium chloride was an excellent remedy for a cough. The coughing then stopped. As a curiosity, bars of the metal about 3 in. by 1 in. by $^1/_2$ in. were handed round and weighed by every one in his hand; the metal was doubtless produced by St. Claire Deville's sodium process. The annual output of aluminum in 1909 was over 24,000 tons, produced electrically. Now that the problem of autogenous welding of the metal, which so long defied all efforts, has been solved, the use of aluminum for chemical apparatus has become practical; apart from its utility in handling nitric acid, the metal has proved to be of the greatest value in breweries, in the food industry, and in varnish works.

The application of aluminum as a fuel by Goldschmidt has further led to the production, by his Alumino-Thermite process, of many metals in a relatively pure form otherwise only producible by the agency of the electric current. Chromium, manganese, and molybdenum prepared by this method, besides various alloys of nickel, iron and copper with these metals or with titanium and vanadium have found a use mainly in the iron industry. The igneous process of welding rails and repairing castings by means of the Thermite process is of course known to all, as well as the use of tungsten and tantalum as filaments in electric incandescent lamps. The fact that tantalum filaments, of vastly greater strength than those formerly produced by compression of the metal in powder form, can now be obtained by drawing the metal through diamond dies will doubtless give an increased stimulus to the use of the element. The mention of tantalum may call to your mind the fact that the expression rare is fallen into disuse, as the earths once known as rare are in every-day use, and, owing to the scientific acumen displayed by Auer von Welsbach, the gas industry is now well able to hold its own against the electrical. But electricity is in evidence everywhere in our industry. It threatens to displace the furnace in the alkali works, it provides us with chlorine and the time may not be distant when muriatic acid is made electrically. We are indebted to the electric furnace for the sodium industry (with its application to the cyanide, sodium amide and other manufactures) and to the production of ferrosilicon, carborundum and graphite, for which, in the form of electrodes and lubricants, America, thanks to Mr. Acheson, remains as yet unsurpassed. The manufacture of nickel by the remarkable Mond carbonyl process should not be forgotten. This metal would appear to have some future in the elimination of carbon bisulphide from coal gas and possibly as a catalytic in other industries. We do not, however, always want to get rid of sulphur. A most original idea, successfully carried into practice by Frasch, in Louisiana, is no doubt that of liquefying sulphur in the bowels of the earth and then pumping it up.

After thus rambling through the highways and byways of inorganic chemistry, we now arrive at a different class of industries. There is no need to go into any detail, but suffice it to say that their influence has been of momentous importance industrially, and in turn has acted and reacted greatly on science. Merely to mention them is sufficient. I refer, of course, to dyestuffs and synthetic organic products, including drugs.[1] I will not weary you by repeating what has been related so often and so fully. It is, however,

[1] Among synthetic drugs there figures now the famous indicator phenolphthalein. Being colorless and tasteless itself while turning pink on the addition of soda, it has been added by Government to earmark certain kinds of hock. The quite unexpected result is that the indicator is now sold as a splendid aperient under the name of "Purgene."

noteworthy that from the outset, the establishment of new industries, based on the discovery of aniline dyes, and of methods of producing alizarin and indigo artificially, has in turn given rise to many others, as the organic and inorganic chemicals they required, which were little, if at all known to commerce at the time, had to be produced on a large scale. Benzol, nitrobenzol, aniline, to mention only a few, were among the newcomers, later on came anthracene.[1]

The coal tar industry is now the largest consumer of inorganic products and was the cause of the invention of the catalytic process of manufacturing sulphuric anhydride. May I be allowed to relate how I came to be connected with this industry? I was a pupil of Professor Strecker at Tübingen in the later sixties. When subsequently, in 187–, I again met him and his brother—who was a chemist at Hoechst—and Dr. Brüning, one of his pupils, he spoke of the importance of fuming sulphuric acid in the alizarin industry. The process of sulphonating anthraquinone had been introduced or was about to replace Perkin's dichlor-anthracene process, the use of ordinary concentrated oil of vitriol having proved to be very destructive to the anthraquinone at the elevated temperature that had to be employed. To my question how this fuming acid could best be made, he replied, "that is a problem for you to solve." A few experiments convinced me that, given pure gases, the catalytic action of platinum was the rational solution of the problem; I had to wait, however, for an opportunity of carrying my idea into practice. This came when, in April, 1875, a telegram reached me from my then principal, Mr. W. S. Squire, asking me to read up that night about Nordhausen acid as it was required by an alizarin works. I showed Squire how simple a matter it was to bring about the combination of sulphur dioxide and oxygen by means of platinum and other catalytics, but it was not until at his request I had carried out a number of experiments with bisulphates, etc., which were not very successful, that he asked me "to try my dodge;" henceforward we worked conjointly on the production of the anhydride by catalytic action. Though the process was patented in Squire's name, Sept., 1875, as others were afterwards or in the name of Neal (a clerk in a Patent Agent's office), they are the joint work of Squire and myself. Soon after, in the 2nd October Heft of *Dingler's Polytechnisches Journal*, Winkler published an account of his process which was practically identical with ours. Both of us erred at that time in believing that stoichiometrical proportions of the gases were the best to use, and the various similarities gave rise to unpleasant comment. In letters, however, which I possess, Winkler freely acknowledges the independence of our work and only regrets that he had deprived himself of the benefit of the invention of his publication, but he was anxious to work with us.

I cannot leave this chapter without paying my tribute to the work done by others in developing the catalytic process, and foremost, to the late Dr. Knietsch and his co-workers in the Badische Anilin- und Soda Fabrik. At the same time, I will let you into one or two secrets. The one is that so far I have not been successful in working with the spent oxide of gas works. It has the advantage of relative freedom from arsenic, but the drawback of producing an acid which is not so bright and colorless as that made from pyrites. The color is due to the organic matter in the raw material and to the formation of nitric oxide from its nitrogenous constituents. Nitric oxide can be traced in the burner gases and it is not eliminated in the washing process to which the gases are submitted. Another point is that there is a loss of platinum amounting to about 1 grain per ton of monohydrated acid produced; the loss must be of a mechanical nature and can be detected in the drips, although actinium is not discoverable in the gases at this enormous dilution. I believe I can find confirmation of the assumption that the platinum is carried forward owing to the rapidity of the current because in none of the processes I have worked at a relatively low velocity have I found any loss of platinum, except such as is unavoidable in extracting the asbestos.

Fuming sulphuric acid has found its chief use in the coal tar color industry, in refining certain petroleum oils—mainly the Russian oils—and vaseline, and in the explosive industry. As nitrocotton forms the basis of the celluloid industry, which has been so greatly developed of late, I must mention it and the rivals which it has found in acetyl and cuprammonium cellulose and last, but not least, in the viscose discovered by Cross and Bevan. These materials are used in large quantities for the production of artificial silk, photographic films and artificial hair; nor must I omit to mention the important wood pulp industries depending on chemical processes.

Sufficient examples have been given to illustrate my case: to show that science and industry are working hand in hand, and the importance of the result which such coöperation has produced.

In fact, no branch of industry has been left untouched by the ceaseless and irresistible advance of chemical science and technology.

And now when we look back on this long list of chemical industries which I have brought before you and their great variety, we have to ask ourselves: Can a chemist be so trained that on entering into any kind of works he will at once be of use and efficient, apart from the expectation that, as a matter of fact, he is supposed to be a proficient analyst? My answer is in the affirmative, provided that the employer himself knows something about the industry in which

[1] It is interesting to note that in the early days of aniline dyes, certain chemicals were smuggled in the works under a wrong name to hide their identity. I was at the time in the employ of Dr. Eugen Lucius, later a member of the firm Meister, Lucius und Co., hence this recollection. Great difficulties were experienced in recovering arsenic or disposing of the residues. A story is told with reference to these difficulties, amusing perhaps to all except those concerned in it. All troubles seemed to be over when some stranger appeared who undertook to dispose of these residues and was richly paid for his services. Ostensibly he had interested some capitalist in a "perfect process" for the recovery of the arsenic and had been advanced considerable sums for the alleged purchase of the residues which were warehoused as a security. As may be imagined, the *chevalier d'industrie* presently disappeared and the illegal storage and the strict regulations as to the disposal of arsenical material entailed a further considerable expenditure on the enterprising capitalist.

he is engaged; in that case, he will be patient and not expect too much from a beginner.

My illustrations must serve to show that if the student is but to know the chemical and physical principles which underlie so wide a range of activity as any one of the industries I have pictured provides, his time will be more than occupied; to expect him to be conversant also with the technical and economical aspect of industrial problems and to be able to apply his knowledge forthwith is going too far. Technical training can be of real value only after a sound foundation in the principles and practice of pure science has been acquired. Again do I ask: Can such technical knowledge be acquired by the student before entering into practice as well as the scientific knowledge that will be of use to him and his employers in all or the majority of the industries I have enumerated? It is evident it cannot; and if it cannot be done, is it worth the student's while to sacrifice much time at the most important and critical part in his life, as far as learning is concerned, in acquiring technical knowledge which may be of no assistance to him in after life?[1]

Too early concentration on special subjects must have a bad effect on the development of the power and habit of thinking independently and on the development of the faculty of imagination in the student. If he can find time, apart from his bread and butter education, it is much better for him to turn his mind to subjects of general culture, such as history, art and literature. Experience teaches me that technique is very readily acquired in practice by one who has been scientifically trained. The most important task of the employer in industry, as in every other walk in life, is to find the right man; and the right man with scientific knowledge, who has imagination and power of observation and can select and command competent subordinates, is immeasurably more useful than the otherwise right man without scientific knowledge. Before all things, it is necessary to find the right man; experience and inventive faculty must do the rest. It is not that we do not possess sufficient knowledge when we leave our college as students; what we lack is experience and the power of applying our knowledge. Our great chemical industries have been originated and developed by scientifically trained men; to name only a few, men such as Perkin, Caro, Brunck, Solvay and Mond, Young, the Siemens's, Duisburg, have never found any difficulty in securing the coöperation of engineers or electricians competent to construct any kind of plant they have required to carry out their problems.

In fine, Carlyle has well said: "He who has learned how to learn can learn anything;" the best system of education is the system which teaches each man how to educate himself.

Our education really begins when we leave college and the storm of life forms our character. We have to study, as nothing in this world is given to us for nothing; books, our scientific and technical societies,[1] must assist us.

Had time permitted, much might have been said of industries which are almost specifically American and of developments that are now taking place in connection with the manufacture of food supplies. My difficulty has been merely to indicate the vast number of directions in which the chemist is now rendering service to Society. Each one of my hearers will be able to enlarge upon one or the other of the topics to which I have referred. I can ask you now only to reflect how much lies behind my story. The progress witnessed in my time is inconceivable. It is impossible for one of my position to do justice to such a theme, but of its infinite importance to our civilization there can be no question.

[1] To a father's request to lay stress on his son obtaining particular knowledge about his own (the father's) industry, one of my professors replied: "You do not teach your son gymnastics in order that he shall be efficient when a man is turning somersaults in competition with others."

[1] These societies, the intercourse with professional friends engaged in the same pursuit as ourselves or in kindred industries, are invaluable to our education and so are their papers and periodicals. Unfortunately, most of us have to keep not one but quite a number of scientific periodicals and here we are faced with the fact that they all contain abstracts and that the same matter is abstracted in most of them, yet we cannot find this out till we have waded through them. Professor Noyes made an attempt to prevent this overlapping about ten years ago and the International Association of Chemical Societies, which held its first meeting in Paris in 1910 and met again in Berlin this year, will consider this problem among others in London in 1913. In the case of purely scientific chemistry, there should not be much difficulty in succeeding; as regards applied chemistry, objections have been raised, which our Council is now considering. Were it possible to rid ourselves of the incubus of overlapping abstracts, it would doubtless be a great saving of time to all of us and its realization should not be lightly set aside.

OXIDATION OF ATMOSPHERIC NITROGEN AND DEVELOPMENT OF RESULTING INDUSTRIES IN NORWAY.[2]

By Samuel Eyde.

We all know that the atmosphere surrounding us is composed of nitrogen and oxygen; to create by the union of these two elements new chemical combinations that can be utilized in the world's household is the task of the new industry.

(The work of Priestley and Cavendish, Crookes and Rayleigh and Ramsay, and Lovejoy and Bradley along this line was mentioned briefly but with appreciation.) The difference between previous methods and that of Birkeland-Eyde is that the latter have applied large quantities of electric energy in the electric arc, and have first found out the best method of doing this, while it was previously believed that it was small quantities of energy that gave relatively the best results. It is on that assumption that the apparatus employed by them was constructed.

In the Birkeland-Eyde method, the electric flames used in the electric furnaces start between the points of the electrodes which are close to each other. By this an easily movable and flexible current is established, which, with the arrangements made, will be found in a highly magnetic field. The electric arc that has been formed moves on account of this magnetic field with great velocity perpendicularly to the lines of force, and the electric arc's foot draws back

[2] Abstract of lecture delivered by Dr. Samuel Eyde, of Christiania, Norway, at a joint meeting of the Sections on Inorganic Chemistry, Physical Chemistry, Electrochemistry and Agricultural Chemistry at the Auditorium of the American Museum of Natural History. Eighth International Congress, New York, September, 1912.

from the points of the electrodes. When the length of the electric arc increases, the electric resistance becomes greater and the tension increases until it becomes so great that the new electric arc starts from the points of the electrodes.

To regulate the current, an inductive resistance is used in series with the flame. With alternating current all the arcs are formed alternating in opposite directions and appear to the eye to be circular discs. This flame is a powerful technical means for the oxidation of the nitrogen of the air. The flame in our furnaces burns with a steadiness that is really astonishing.

The electrodes are thick copper tubing, through which water passes for cooling them. The chamber in which the flame burns is circular, of only a few centimeters width, and about three meters diameter.

The interior of the furnaces is lined with fire clay brick, through the walls of which the air is admitted to the flame. The nitrous gases formed in the flame escape through a channel made along the casing of the furnace, which, like the flame chamber, is furnished with fire-proof bricks.

Each furnace is furnished with an induction coil, by means of which the power is regulated as required. The induction coil serves to make the flame in the furnace steady even while working. This furnace burns for weeks without any regulation worth mentioning. The maintenance of the furnace and its repair are simple, as the most exposed portions, the electrodes, require change only every third or fourth week, and then only a small part of them, and the fire-proof masonry every fourth to sixth month.

The temperature in our flames exceeds 3,000° C. The temperature of the escaping gases may vary between 800°–1,000° C. The furnaces are made of cast steel and iron, the middle of the furnace being built out to a circular flame chamber. The electrodes are led radically into this flame chamber. By aid of centrifugal fans the air is brought into each furnace through tubes from the basement.

From furnaces no longer than could be held in the hand, and which took an energy of some few horsepower we have attained two types which can, as mentioned, take an energy of more than 5,000 H. P. We have had in the course of this period of developing our method four experimental stations.

Some years later than the invention of our furnace, Dr. Schoenherr, with the electrician, Hessberger, of the Badische Company, perfected an electric furnace for the oxidation of the atmospheric nitrogen, which is built on quite a different principle.

In place of the great disc of electric flame he develops a long slender arc in the axis of a narrow iron tube, through which a current of air is forced.

The type now used consists of a somewhat slender vertical column of iron plates seven meters in height. The inner tube is the reaction chamber; the others form channels for the entrance of the air current and its exit after coming in contact with the flame. In this way the heat of the outgoing gas is transferred to the ingoing current.

At the lower end is the main electrode, movable in a vertical direction. The reaction tube serves as the second electrode. By means of a lever the space between the electrode and the tube can be bridged over and the arc formed. The air current, forced by a powerful aspirator, enters in the lower part of the furnace and passes the channels. The entrance to the reaction chamber is through a number of small tangential openings arranged in several horizontal rows in the sides. The current passes in this way from the chamber and the arc is driven up in the midst of the rapidly moving current of the air.

As a quick cooling is of importance in securing a good yield, the upper third of the tube has a water-jacket through which the gases pass, and in this way the reverse reaction is prevented to a notable degree.

The reaction is identical with that obtained in the Birkeland-Eyde furnace, and the yield, as far as the results now obtained show, is practically the same.

At Notodden we have only furnaces of the Birkeland-Eyde system, from 1,000 to 3,000 kw.

At Rjukan there are, however, furnaces of the B.-E. system, 3,000 kw., as well as furnaces of the Schoenherr system, all of 1,000 kw.

When the air in the flame chamber has been treated by the electric flames the nitrous gases formed pass out through pipes which convey the gas to the steam boilers, in which the temperature, which was, as mentioned, 1,000° C., is reduced.

The steam produced in the boilers is utilized in the further treatment of the products. In the boiler house there are also air compressors which supply compressed air for pumping acid and lye in the factory's various chemical departments. The gases pass on from the steam boilers through an iron pipe into the cooling house. Each cooler consists of a great number of aluminum tubes over which cold water runs, while the hot gases pass through them and are considerably cooled. From the cooling chambers the gases go on to the oxidation tanks.

These oxidation tanks are vertical iron cylinders lined with acid-proof stone. The object is to give the cooled gases a sufficient period of repose in which the oxidation of the oxide of nitrogen may take place. The necessary amount of oxygen is present in ample quantity in the air which accompanies the gases from the furnaces. From the oxidation tanks, the gases, by blast engines, are led into the absorption towers. All the towers are filled with broken quartz, which is neither affected by nitrous gases nor by nitric acid. To assist the passage of the gases, there are centrifugal fans constructed of aluminum on each row of towers. The gases enter at the base of the first tower, pass up through the quartz packing, and by a large earthenware pipe into the top of another tower, then downward through the quartz to the bottom of the second tower, and so on until the air, relieved of all nitrous gases, leaves the last tower. Water trickles through the granite towers, and this is gradually converted into a weak nitric acid, while the liquid used in the iron towers is a solution of soda. The absorbing liquid

enters the top of the tower and is distributed in jets by a series of earthenware pipes, so that the permeating gases come in immediate contact with the absorbing liquid. In the granite towers nitric acid is thus formed, and in the iron towers a solution of nitrite of soda.

The liquid emerges in a constant, even stream from the bottom of the towers, that from the granite towers running into the granite cistern. Hence it flows into the "montejus" which serve to pump up the acid, which has to pass repeatedly through the tower before it has become strong enough for the purpose for which it is intended. The "montejus" are worked by compressed air, and send the acid up into large stoneware tanks. From these jars the acid again runs through the towers as described. The "montejus" work automatically.

The iron towers are percolated, as already mentioned, by a solution of soda; otherwise the whole process is practically similar to that in the granite towers. The solution of soda, owing to its far greater power of absorption, effects the separation of the last remains of nitrogenous gases from the accompanying air. Of the entire quantity of nitrous gases passed through the absorption system about 97 per cent. is absorbed. The finished nitric acid from the towers, which has a strength of about 30 per cent. by volume, is collected in granite cisterns, from which it is drawn to what is called the "dissolution works." These consist of granite vats filled with limestone, over which the acid is poured. This drives off with violent effervescence, the carbonic acid contained in the limestone, while the nitric acid takes its place and forms a watery solution of nitrate of lime or calcium nitrate. The rest of the acid is neutralized in small towers filled with milk of lime, and is now pumped into vacuum evaporating apparatus. The object of boiling in vacuum is the great saving in the heat required.

The steam required for the evaporation is obtained from the steam boilers, heated, as before mentioned, by the furnace gases. The concentration of the nitrate solution in the evaporizing plant is continued until the specific weight of the liquid at an even temperature shows a content of 13 per cent. of nitrogen. This solution is then sufficiently evaporated and can be pumped up into the solidification chambers, where it is conducted upon a revolving cylinder, cooled on the inside, where it stiffens so quickly that it springs off in small leaf-like pieces, which can be granulated in the crushing mill. The coarse powder so produced is raised by an elevator to a vat, from the bottom of which it is tapped into casks holding 100 kilos net weight.

The gas led into the iron tower forms with the solution of caustic soda a solution of nearly pure sodium nitrite. This is concentrated by evaporation in the same sort of apparatus as above, and is allowed to crystallize. The crystals are dried in a centrifuge and tapped into casks.

The barrels are made at our own cooper's shop and are lined with paper to guard against the damp.

Besides these two products, nitrate of lime and nitrite of soda, we have during the last years at our Notodden Works taken up the manufacture of concentrated nitric acid and of nitrate of ammonia, which products have already won a good reputation, and in comparatively large quantities are shipped to the U. S. A. and other countries.

We are, however, in our industry not confined to these products hitherto mentioned. We have possibilities for the development of a whole series of new industries.

Visitors to our factories are often under the impression that the works are not running at all. There is but little noise and hardly any workmen are visible. Indeed it is remarkable how few people are required to run the establishments in our industry. Comparatively large working forces are needed only in the packing and wrapping departments.

For the development of the atmospheric nitrogen industry the question of water power is a vital one. Our industry cannot exist unless it can procure for itself cheap water power. There is hardly a country in the entire world that can boast of more favorable conditions in this respect than Norway, and the enormous rise of our industry must be attributed to a very large extent just to Norway's magnificent opportunities regarding the supply of the factories with water power. It must be borne in mind that Norway has not only her magnificent and high waterfalls, but that she has big lakes likewise in her mountains, allowing the construction of enormous natural reservoirs for leading the water to the power stations. Especially in the districts of our industry we enjoy most favorable conditions in this respect. The works now built are all situated in the southeastern part of Norway, in the Telemark River district.

The first works, the Notodden Nitrate Factories, are admirably situated at the lake of Hiterdal, about fifty feet above the level. A short channel with a series of locks permits communication with the town of Skien, an important seaport at the head of the fjord. Under the present conditions vessels of 100 tons burden can ascend to Notodden. It is planned to enlarge the locks so as to allow the passage of seagoing vessels of 2,000 tons.

The Notodden factories, which now have about 60,000 H. P. working, get this power from two neighboring waterfalls, Lienfos and Svaelgfos. At Lienfos, about two miles from Notodden, a dam with a fall of about fifty-five feet was completed in 1911. The volume of water is seventy-five cubic meters per second. The power station is equipped with four units, each of 5,000 H. P.

The Svaelgfos power house is situated above, about one mile from Lienfos. The volume of water is the same as at Lienfos. The dam secures, however, a fall of about 165 feet. A tunnel takes the water to the reservoir, from which four flumes cut in the solid rock conduct the water to the station where there are four sets of turbine generators, each of 10,000 H. P. The generators are capable of evolving 13,000 H. P., and rank among the largest units in the world.

The power of these two waterfalls is transmitted to Notodden by six separate lines. Each line con

sists of six cables twelve millimeters in diameter. The three-phase alternating current of fifty periods is transmitted with a voltage of 10,000.

A second power station at Svaelgfos is now under construction. As the normal volume of water by an additional regulation of distant lakes in the same watershed soon will increase to ninety cubic meters, in the new power station likewise two additional units of 10,000 H. P. each are built.

About sixteen miles farther up the river the first regulating dam at the Lake of Tinn was constructed at the same time as the water station of Svaelgfos and the factories at Notodden. The immense basin regulated by this dam makes it possible to store up fully 300,000,000 cubic meters of water.

For the regulation of the water supply a dam was built at the Lake Mosvand by means of which the level of the lake is raised over 46 feet. As the surface of the lake is not less than 23 square miles, nearly 900,000,000 cubic meters can be retained. The minimum flow in the river is in this way increased from 5–47 cubic meters per second, or the water power at Rjukan only from 30,000 to 250,000 H. P.

To give you some idea of the development of our industry I let pass in review the factories we have had at the different times:

Dates.	Factories.	H. P. utilized.	Employees.	Workmen.
July 1903	Frognerkilens Fabrik.....	25	2	2
Oct. 1903	Anterlokken.....	150	4	10
Sept. 1904	Vasmoen and Arendal.....	1,000	6	20
May 1905	Notodden.....	2,500	4	35
May 1907	Notodden and Svaelgfos.....	42,500	12	103
Nov. 1911	Notodden, Svaelgfos, Lienfos and Rjukan I.....	200,000	143	1,340

According to the results of the use of our nitrate of lime, it is stated that it is the same as the Chile saltpeter and for certain soils it is even better. I have the pleasure of telling you that we to-day are sending many thousands of tons of the Norgersalpeter to California and Hawaii to be applied to the fruit orchards and sugar plantations; and the demand is twice as large as last year.

That our nitric acid and nitrate of ammonia are enjoying a good reputation is shown by the following extract from an English periodical, "*The Sphere*." It was a peculiar coincidence that just on my trip over here I happened to see this paper and the article in question. There it reads—"Nitric acid is the main constituent of guncotton, dynamite and smokeless powders. One of the chemicals made at Notodden greatly reduces the heat of discharge, thereby prolonging the life of a big gun," and further:—"Nitrate of ammonia obtained at Notodden by the marvelous electric process described here, is the principal constituent of many of the explosives for mines and is, therefore, of high importance to the navy." I could not wish anything better to be said in favor of our products; you would believe I had put it into the newspaper myself.

If you ask me what above all has contributed to such a rapid development of our industry, then I wish to mention the confidence the financial people gave and the good collaboration between engineers and myself. We all were filled with the same thought, to create something great and useful for our country, and we all had in view the great importance this new industry would have from an international point of view.

There is, however, one thing which I wish to tell you and which more than anything else has contributed to the great success attained in the development of this industry, and that is that I mainly have employed young men for this work. This assertion may appear strange but, I assure you that it is the "lack" of experience which has created this industry. If I had paid attention to all the doubt and hesitation brought forward by the so-called authorities during the development of our enterprise, the Norwegian people to-day would never have their nitrate industry. Thanks to the young people, to their undaunted courage, energy and love of action the work has been done, and it is in grateful remembrance of all our struggles in joy and sorrow, that I look backward to the work that has been done and the good results we have obtained to-day. The Norwegian nitrate industry is not alone a technical but also a financial success, and I have been able to keep my promise to the big financial institutions, the Banque de Paris and the Société Genérale, and also to our German associates, who to-day all are proud of the assistance and confidence they gave to the industry.

My own country, the small Norway, who is the youngest daughter of the family of the electrical industries, does no more need to be proud alone of the discovery of the South Pole, but is glad to be able to contribute her share in the solution of the most important questions relating to the world's household.

CURRENT INDUSTRIAL NEWS

By W. A. Hamor.

A NEW WOOD PRESERVATIVE.

"Aczol" is a new wood-preserving material, consisting of metallic ammoniates and an antiseptic acid. It is said to exert no harmful action on either wood or metal. Evidently the use of "Aczol" is based upon the process of permanently fixing large quantities of metallic salts in the wood, as in the patented process of Gerlache, wherein wood is impregnated with an aqueous solution containing free ammonia and ammonia compounds of copper and zinc (*e. g.*, ammoniacal solutions of copper sulphate and zinc chloride).

AIR COMPRESSOR LUBRICATION.

It is noted in *The Engineering and Mining Journal* (93, No. 23, 1125) that explosions within the cylinders of an air compressor are usually caused by the ignition of inflammable gas arising from the use of too much lubricating oil of low flash-point;

it is further pointed out that excessive use of oil tends to give rise to sticking of the valves. Attention is called to a lubricant which is free from these objections, namely, soapy water with which a small amount of flake graphite has been mixed. The graphite flakes remain suspended in the water until admitted to the interior of the cylinder, where they exhibit a tendency to attach themselves to the metallic surfaces, imparting a superficial glaze which is smooth, acquires a high polish and prevents actual contact of metal with metal. The soapy water may, however, cause rusting, so it is advisable to introduce a little oil into the cylinder when shutting down the compressor.

THE OXYGRAPH.

The oxygraph, described in *The Engineering Record* (65, No. 25, 701), is the latest appliance developed in connection with the oxy-acetylene-cutting process. It is constructed along the lines of the pantograph, the novel feature being a mechanically propelled tracer which gives uniform speed. The geared tracer is driven by an electric motor attached to the head of the machine. The oxygraph is said to cut steel 3 in. thick or less, at a speed of 6 in. per minute, and to be capable of cutting curves and right-angled corners. With high quality oxygen, the kerf is very narrow, and the cuts clean and sharp. The work is performed by guiding the tracer along the lines of the drawing on the tracer table, the torch cutting a reproduction in the steel ½ the size of the drawing. The appliance is said to be useful in die-making and for getting out difficult forms, as blanks for crank shafts of moderate dimensions.

THE MANUFACTURE OF LITHOPONE.

Lemaire states (*Sci. Am. Suppl.*, 74, 147) that the manufacture of lithopone is almost confined, in Europe, to Germany. A good deal of secrecy is observed in the manufacture—a fact which seems strange in view of the simplicity of the chemistry involved, but which is justified by the necessity of employing special machines in order to assure the cheapness and uniform quality of the product.

The quality of the lithopone depends largely upon the care exercised in the preparation of the two soluble salts, barium sulphide and zinc sulphate. These salts therefore are always prepared in the lithopone factory. Some German firms make a lithopone of the best quality, containing a large proportion of zinc sulphide, from which they obtain lower grades by admixtures of pulverized natural barium sulphate (heavy-spar), which is very cheap, but which absorbs oil far less perfectly than the precipitated barium sulphate which is contained in genuine lithopone.

The soluble barium sulphide is obtained by reducing heavy-spar (natural barium sulphate) by charcoal at a red heat, and

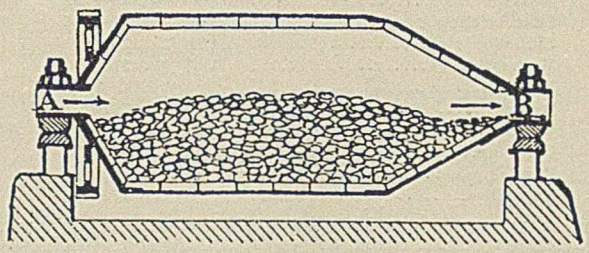

FIG. 1.—HARDINGE TUBE MILL.

leaching the mass after cooling with water. The heavy-spar and charcoal, according to Nagel, should be ground and mixed together in revolving tube mills, which can be cheaply operated. In the United States, the Hardinge tube mill (Fig. 1) is coming into use. The heavy-spar and charcoal are introduced at the end A and the pulverized mixture passes out at the opposite end B. Although the apparatus contains no sieve, the conical form of the vessel and its rotary movement produce an automatic gradation, so that only a finely ground mixture escapes at B, while the coarser particles remain in the mill for additional grinding. The reduction is accomplished in reverberatory furnaces, retorts or muffles. The operation may be either intermittent or continuous. In the latter case, the usual one when a reverberatory furnace is used, the mixture is deposited near the front of the furnace and pushed back at regular intervals. Continuously operating groups of vertical retorts (Fig. 2) or intermittently operating muffle ovens (Fig. 3) are also employed.

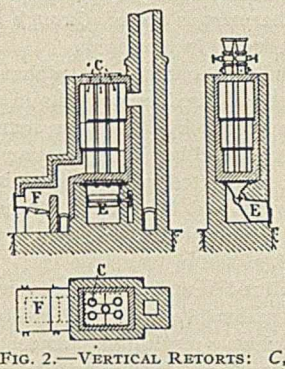

FIG. 2.—VERTICAL RETORTS: *C*, RETORTS; *E*, EXTRACTOR; *F*, FURNACE.

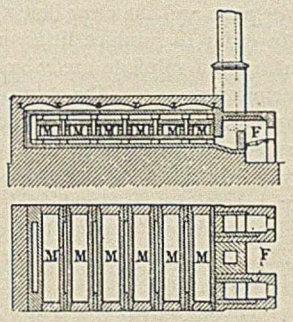

FIG. 3.—MUFFLE OVENS: *M*, MUFFLER; *F*, FURNACE.

In both of these cases the losses which are occasioned by oxidation in the reverberatory furnace are avoided, but the consumption of fuel is greatly increased.

In the United States, a revolving furnace like the Bruckner apparatus used in soda factories is employed. This furnace gives very good results, but its continuous rotation produces and disseminates dust, which must be removed by a collecting chamber placed between the furnace and the chimney. A furnace of this kind, 6 feet in diameter, 13 feet long, and making one complete revolution in two minutes, suffices for the production of 10 tons of lithopone per day. Nagel suggests the employment of the revolving furnace which is used for producing cement clinker, and which operates continuously and consumes little fuel.

The hot reduced mass is placed in iron cars, provided with sheet-iron covers, in order to prevent oxidation of the barium sulphide to sulphate, and allowed to cool. The leaching is

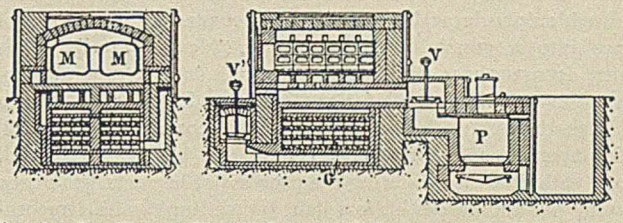

FIG. 4.—GAS-HEATED MUFFLE OVENS: *G*, RECUPERATOR; *M*, MUFFLER, *P*, GAS GENERATOR; *V*, GAS VALVE; *V'*, AIR VALVE.

accomplished in double-bottomed vats or in the Shank apparatus employed for the leaching of crude soda in the Leblanc process. The operation must be conducted rapidly in order to prevent oxidation.

All that part of the factory which is devoted to the preparation of barium sulphide should be separate and distant from the rooms in which the manufacture of lithopone takes place, for the smallest trace of charcoal dust or natural barium sulphate would destroy the whiteness of the lithopone. Natural barium sulphate is often very impure and frequently contains salts of iron and other metals. A trace of iron salt in the barium sulphide makes the lithopone sensitive to the action of light. Such traces of impurity are removed by methods which have been kept secret.

In Germany the zinc sulphate employed is obtained from

complex ores rich in zinc blende (natural zinc sulphide). These ores are roasted until the blende is converted into oxide and are then treated with sulphuric acid. In the United States, zinc white of inferior quality and natural oxides of zinc are sometimes used. It is also possible to employ zinc scraps dissolved in sulphuric acid. The crude solution of zinc sulphate is placed in a vat and mixed with granulated zinc or zinc scraps, which precipitate any copper and lead which may be present. The clear liquid is decanted and boiled with an admixture of chloride of lime, which oxidizes and precipitates the salts of iron and manganese as insoluble oxides. The mass is passed through a filter press and the clear liquid is collected in reservoirs.

In order to produce lithopone the solutions of zinc sulphate and barium sulphide are mixed in the desired proportions in a precipitating vat. The mixture is heated by steam for some time and the precipitate formed is separated in a filter press and washed with water. The drying is effected continuously in drying tunnels provided with blowers and heated by steam. The precipitate is placed in layers on wooden shelves in cars, which are drawn through the tunnel.

The dry product is heated to a dull red in muffles. The ovens are heated with charcoal or now, preferably, by recuperating gas generators (Fig. 4). The hot hard mass resulting is quenched in cold water, which causes it to crumble. It is again filtered out and dried, and is then pulverized and sifted. In general the final grinding is applied to the moist product before the final drying, unless it is possible to employ dry grinding in a tube mill of the Hardinge type.

THE POLLUTION OF STREAMS BY SPENT GAS LIQUOR.

H. M. M. Wilson (Industrial Hygiene Section, Royal Sanitary Institute, York, July 31, 1912) states that hitherto the large quantities of gas liquor produced in the manufacture of gas in England were regarded entirely as trade refuse, but are now considered of value, as considerable profit is derived from the recovery of ammonia from the liquor. The ever-increasing production of gas liquor is not dependent upon the manufacture of gas for illuminating purposes, but is also due to improved methods of coke manufacture and to the increased manufacture of power gas. Gas liquor contains ammonia in a free state and in combination with acids; this is recovered by distillation in two stages: by means of live steam and afterwards with the addition of lime. The hot vapors which pass from the still through sulphuric acid are cooled and condensed in a series of pipes into a grossly polluting liquid ("devil water"). This liquor is sometimes discharged as refuse, but is generally returned to the storage tank for gas liquors and is circulated again through the still. The bulk of the refuse comes from the still, being spent gas liquor after the ammonia has been expelled, along with lime added during the process. The spent gas liquor leaving the ammonia stills is a light brown liquid, of a temperature of some 100° C., turbid from particles of spent lime and tarry matters, and having a peculiarly offensive odor; it is strongly alkaline and exceedingly hard. The effect of a discharge like this upon a small stream is disastrous, the water being rendered poisonous, offensive, discolored, and unfit for ordinary use. Moreover, the great capacity of the refuse for absorbing oxygen is very detrimental to the stream in preventing self-purification. The purification of this kind of refuse has been a problem difficult to solve. It is easy to eliminate suspended solids by means of settling tanks; but these, though objectionable, are innocuous compared with the matters in solution. When diluted, the liquid is amenable to treatment on biological filters. Fowler has constructed a percolating filter of somewhat coarse material, 9 feet deep, and prepared it either by using material which had previously formed part of a sewage filter or by ripening the filter by the application of a weak sewage until nitrification was induced. To such a filter he has applied spent liquor from gas-works—clarified by settlement and diluted to 10 times its original volume either with clean water or with filter effluent—at the rate of 100 gallons of the diluted liquor per square yard per day. This treatment effects a marked reduction in the oxygen absorbed figure, and sulphocyanides and phenols are also greatly reduced. However, the cost of carrying out the Fowler process is considerable, 2 to 3 cubic yards of filtering material being required for every 10 gallons of the crude refuse produced daily. For a battery of 40 coke ovens yielding 20,000 gallons of spent liquor daily, nearly $^1/_2$ acre of filter 6 to 9 feet deep would be required; even after this purification, the liquor would still deleteriously affect a pure stream of small volume. It could, however, be used for many colliery purposes, *e. g.*, coke quenching and coal washing. Two methods of partial purification of spent liquor have been introduced by J. Radcliffe, who claims that all solids in suspension, all free lime, all hydrocyanic acid, 70 per cent. of the sulphocyanides, and 60 per cent. of the solids in solution, can be removed, and that the oxygen absorbed figure can be reduced by 75 per cent. In some collieries, the spent gas liquor is discharged into old pit workings, while in others the refuse is disposed of by passing it into trenches on the top of the spoil bank. Direct evaporation of the refuse in specially constructed furnaces has also been adopted in several instances. The latest developments in coke-oven plants will reduce the volume and alter the character of the refuse, so that the problem will be made easier.

THE MELTING POINTS OF FIRE BRICKS.

Kanolt (*J. Wash. Acad. Sci.*, 2, No. 14, 337) has determined the melting points of fire bricks, taking as the melting point the lowest temperature at which a small brick piece could be distinctly seen to flow. The experiments were conducted in an Arsem graphite resistance vacuum furnace, and the samples, which were from 1 to 2 cm. in diameter, were usually enclosed in a refractory tube to protect them from reducing gas and were heated at the rate of about 10° F. per minute when near the melting point. The temperatures were determined by means of a Morse optical pyrometer of the Holborn-Kurlbaum type.

It was found that in the case of certain bricks made of heterogeneous material of relatively low melting point, the melting points were slightly higher after six hours' heating to 1550°, apparently as the result of the gradual running together of dissimilar particles to form a mixture having a higher melting point than the most fusible of the original materials.

The results are summarized in the following table:

MELTING POINTS OF FIRE BRICKS.

Material.	Number of samples.	Melting point Centigrade.
Fire clay brick	41	1555–1725 mean 1649
Bauxite brick	8	1565–1785
Silica brick	3	1077–1705
Chromite brick	1	2050
Magnesia brick	1	2165
Kaolin	3	1735–1740
Bauxite	1	1820
Bauxite clay	1	1795
Chromite	1	2180
Pure alumina		2010
Pure silica		1750

The value 1750° given for silica is not the true melting point, but represents approximately the temperature at which the silica flows distinctly. It was found that silicon carbide does not melt below 2700°; it becomes unstable at much lower temperatures.

"PERSIL" AS A BLEACHING AGENT.

According to *Revue Sci.*, 13, 407, sodium perborate, under the name of "Persil," is now used for bleaching linen. A solution of sodium perborate heated to 60° C. gives sodium metaborate and oxygenated water. For bleaching cotton, it is first boiled with

"alkasil" (sodium monosilicate), and then in a bath containing 5 per cent. of sodium perborate. The temperature should be below 25° C. for bleaching flax, hemp, jute, and ramie, in which cases hypochlorites, sodium peroxide and sodium perborate are used concurrently. Sodium perborate gives a decided white color after steeping several hours at 70° to 80° C. and maceration, and after the use of hypochlorites acts as an antichlor. Straw may be bleached by the use of sodium peroxide or perborate in a solution acidified with oxalic acid, and a 1 per cent. solution of sodium hydrosulphite ("blankit") is also employed. Wool is bleached by sodium perborate, preferably in water acidified with lactic acid; but to bleach silk it is first necessary to wash in soapy water mixed with benzine, to remove the fatty matters, and then to treat with a bath of 1,000 liters of water containing 10 kilograms of cocoanut-oil soap and 2 to 3 kilograms of sodium perborate.

THE DISINFECTION OF POTABLE WATERS BY CHLORIDE OF LIME.

At the Fifty-third General Convention of the German Union of Gas and Water-gas Manufacturers at München, on June 24–28, 1912, Professor Bruns gave an account of the disinfection of drinking water by means of chloride of lime. Twenty years ago Traube used chloride of lime for the disinfection of water. His experiments were confirmed by Kratschmer and others, but were contradicted by Engel, who claimed that it is impossible to kill all pathogenic bacteria completely. This process has not been employed in Germany, but has been used for a number of years in the United States for the purpose of disinfecting water. The employment of this method is dependent upon the cheapness of chloride of lime, which varies with its hypochlorite content, the average being from 35 to 38 per cent. The disinfecting action of chloride of lime was first determined by Robert Koch, who showed that chlorine is one of the strongest disinfecting agents, and his experiments were confirmed later. Bruns states that the "chlorine" is dissolved in 100 parts of water and allowed to flow into the main stream so that the relation becomes 1 : 500,000. The number of bacteria is greatly reduced, but the taste is impaired, although this is not generally complained of. With larger amounts of chlorine, the results were bacteriologically satisfactory, but complaints were received on account of the foreign taste. Bruns performed experiments wherein equal quantities of chloride of lime and calcium thiosulphate were used; the thiosulphate served to render the free chlorine in the water inactive. When sodium thiosulphate was used, many complaints were received on account of the bad taste of the water. Bruns considers that chloride of lime can not be used for every purpose, but is still valuable for purposes of sterilization; this process can not be used in the purification of dirty waters unless filtration is also resorted to. It should always be borne in mind that chloride of lime is a disinfectant and not a purifying agent.

AMMONIA EVAPORATION AND TRANSFORMATION IN SOILS.

The lower fertilizing efficiency of ammonium sulphate as compared with sodium nitrate has been ascribed to various reasons, including slowness of nitrification, fixation of nitrogen in organic forms, and evaporation of ammonia. Von Wlodeck (*Chem. World*, 1, 287) reports experiments on soils in sunken cylinders to determine the loss and transformation of ammonia from soils containing varying amounts of lime, silt, and clay. In the course of his experiments, varying applications of ammonium sulphate, either alone or in combination with superphosphate, were made. The loss of ammonia by evaporation, when the ammonium sulphate was used under conditions as nearly natural as possible, was very small. With a high lime content of the soil, and heavy application of ammonium sulphate, the loss was larger. There was little or no loss where a mixture of ammonium sulphate and superphosphate was used, and the deep application of the ammonium sulphate greatly reduced the loss. The results of the observations of von Wlodeck on the fixation of the ammonia in organic forms were not entirely conclusive, but indicated that the fixation in the case of a loam soil was practically the same whether ammonium sulphate was used alone or mixed with superphosphate. On a light soil, superphosphate seemed to increase nitrogen fixation, and the addition of superphosphate apparently did not effect nitrification.

THE LOCATION OF UNDERGROUND PIPES.

A device for indicating the positions of pipes in waterworks systems, in cases wherein repairs or new connections are to be made, is being manufactured by a Quincy, Ill., concern and is now being used by a number of water companies. It is based upon the principle of causing a slight flow of electric current in the pipe, which thereby becomes a conductor. When an electric coil is brought within the field of this conductor, a current will be induced in the coil and cause a sound in a telephone receiver connected to the coil. The sound increases or decreases as the coil is carried nearer to or farther from the underground conductor, but ceases when nearest to it, that is, when directly over it. The situation of the pipe is thus determined by locating a number of points directly over it. In making use of the instrument, wires from a portable battery are attached to suitable connections and the operator, carrying the instrument in his hand and the receiver at his ear, walks across the supposed line of the pipe, the exact position being indicated by the absence of sound. In locating a service pipe, the battery wires are connected to the house cock and hydrant, causing a current along the service line.

THE CASTING OF MAGNESIUM ALLOYS.

Owing to the affinity of magnesium for oxygen, difficulties arise in casting alloys containing this metal. According to U. S. Patent 1,028,216, of June 4, 1912, Hoffman and Suchy have found that this reaction is mitigated by the addition of a small amount of calcium to the alloy. It is claimed that alloys thus formed may be cast without the formation of either magnesium oxide or nitride, or any other injurious action occurring. For example, magnesium and its alloys, when mixed with from 0.1 per cent. to 0.5 per cent. of calcium, flow without the occurrence of burning or the formation of a dark skin on the surface of the metal. The castings, moreover, do not effloresce in air and fill the molds perfectly, and the property imparted by the calcium is not lost on repeated fusion and casting. The calcium may be applied in the form of calcium oxide or may be added during the electrolytic production of magnesium. No characteristics of a calcium alloy are imparted, as the calcium or calcium oxide is used in such small quantities.

NOTES AND CORRESPONDENCE

OBITUARY—FREDERICK J. MAYER.

Mr. Frederick J. Mayer was born at Bremerhaven, Germany, July 4, 1853. He received his early education at the University of Stuttgart, Germany, and came to this country in 1870 after the Franco-Prussian War, in which he saw active service. Being an engineer, he engaged with the Bartlett Hayward Company of Baltimore, Md., as draftsman and while with them, up to 1906 as Chief Engineer, he designed, erected and operated many of the

large gas plants constructed by that company. In 1906 Mr. Mayer severed his connection with the Bartlett Hayward Company and organized and established the Didier-March Company in the United States, taking the position of General Manager.

Having made a life study of the carbonization of coal for metallurgical and domestic purposes, to him must be credited the establishing of some of the best foreign apparatus in the United States for the carbonization of coal by both the intermittent and continuous system in vertical retorts for gas house practice. He not only secured these rights for the United States, but he promoted the companies, erected the plants and put them in successful operation.

Mr. Mayer had invented many improvements for the manufacture of illuminating gas, patents of which were secured in the United States, Germany, France and England.

At the time of his death Mr. Mayer was 59 years old, an ardent and tireless worker, well known in the United States and abroad; a member of the American Gas Institute, the American Society of Mechanical Engineers, the Illuminating Engineering Society, Chemists' Club, American Peat Society, German Club and many other social and technical organizations.

Mr. Mayer is survived by his widow.

JAS. V. V. COLWELL.

THIRD INTERNATIONAL RUBBER CONFERENCE.

The Third International Rubber Conference convened at the Grand Central Palace in New York City, September 24–30, 1912.

After a careful consideration of the subjects discussed at the International Congress of Applied Chemistry, it was considered desirable to take up at the Rubber Conference those topics which appeared to be of more immediate importance to the manufacturer and consumer. Specifications for Materials, especially fire hose, were considered in detail. Probably the first attempt which was made to bring rubber goods manufacturers in consultation with the consumer was the Navy Conference, which was held within the past year, and which brought out such a frank expression of opinion.

The Executive Committee, which was formed to act in an advisory capacity to the Conference, consisted of the following:

Henry C. Pearson, New York, *President;* Frederic Dannerth, Ph.D., *Honorary Secretary;* E. S. Land, U. S. N., Washington; D. A. Cutler, New York; Dr. Lothar Weber, Boston; Dr. W. C. Geer, Akron, Ohio; Dr. S. P. Sharples, Boston; Dr. Eugenio Dahne, Brazil; C. E. S. Baxendale, Federated Malay States; F. Crosbie-Roles, Ceylon; A. Staines Manders, London.

Fifteen of the principal American railways were represented at the Conference through their chief chemists and engineers of tests.

The following organizations and Governments were represented by official delegates:

American Chemical Society, American Society for Testing Materials, Society of Chemical Industry, American Institute of Chemical Engineers, German-American Technical Society, Institute of Operating Engineers, U. S. Department of the Navy, U. S. Department of Commerce and Labor, U. S. Department of the Interior, U. S. Isthmian Canal Commission, The Official Material Testing Bureaus of the principal foreign Governments, The Factory Mutual Laboratories of Boston, Mass., Federal Government of Brazil, Federated Malay States and Straits Settlements, Ceylon, Hawaiian Islands, Province of Moro, Philippine Islands, Burma (India), The State of Amazonas (Brazil), The State of Matto Grosso (Brazil), The State of Para (Brazil), The State of Acre (Brazil), The State of Minas Geraes (Brazil), Bolivia, Republic of Honduras, State of Bahia (Brazil).

SCHEDULE OF MEETINGS.

Tuesday, Sept. 24th, at 2 P.M.—An address of welcome by the President, Mr. Henry C. Pearson. Topic discussed, *"Crude Rubber."* Special papers:

"Rubber Contracts," Arthur W. Stedman.

"The Plantation Industry," Cyril E. S. Baxendale, Esq., of the Federated Malay States.

"Various Manihots Producing Rubber in the Central States of Brazil," J. Santiago Cardwell-Quinn, Commissioner.

"Possible Rubber Producers in the Temperate Zone," Charles P. Fox, Akron.

"Some Effects of Acclimatization upon Guayule. Parthenium Argentatum," Francis E. Lloyd, Montreal, Canada.

Wednesday, Sept. 25th, at 10 A.M.:

"Problems in Vacuum Drying," J. P. Devine.

"Manufacture of Dipped Goods," T. W. Miller.

"Physical Methods of Testing Rubber and Rubber Products," P. L. Wormeley, Bureau of Standards, Washington.

"Factory Management and Organization Methods," J. C. Jurgensen (President of the Institute of Operating Engineers), and Frederic Dannerth (Consulting Chemist).

Thursday, Sept. 26th, 10 A.M.:

"A Brief History of Fire Hose Specifications," E. A. Barrier.

Topical discussion on specifications (mechanical rubber goods for railroads, Federal and Municipal Governments), including as sub-topics: Air brake hose, railroad steam hose, fire hose, navy packings, etc.

"The Commercial Possibilities of Synthetic Rubber," L. E. Weber, Boston, Mass.

Friday, Sept. 27th, at 10 A.M.—A report of the transactions of the Navy Conference at Washington, December, 1911, E. S. Land, U. S. N. Topical discussion on specifications: (*a*) Materials for insulated wire; (*b*) Textile materials (sheeting, duck and yarns).

A preliminary report of activity by the "Railroad Committee" on *"Standard Methods of Testing Rubber Products."*

At 7 P.M.—Informal dinner for rubber chemists and engineers.

Saturday, Sept. 28th, at 10 A.M.—Meeting for the presentation of resolutions and recommendation of official methods for physical testing and chemical analysis of crude gum and manufactured rubber goods.

MUNICIPAL WATER CONSERVATION EXHIBIT OF THE CITY OF PHILADELPHIA.

The Department of Public Works of the City of Philadelphia is to open on or about the seventh day of October this year, and continue for two weeks, a noteworthy exhibit pertaining to the use and waste of the municipal water supply. This exhibit will be held in the courtyard of City Hall and every endeavor will be made to make it of great educational value to the people.

Suitable booths will be erected so that all the interesting exhibits displayed at the time will be properly protected from any adverse weather conditions.

In addition to the official display of the Department of Public Works, all the local manufacturing and jobbing trade in water appliances have been invited to show every device and apparatus pertaining to the use, but particularly to the conservation of water.

It is the idea of the Department of Public Works to make this exhibit entirely along popular lines, easily understood by everyone and to so educate the consumer of water that the enormous waste which now obtains in this City may be reduced thereby to a minimum.

There will be much in this exhibit of interest to Engineers, and all those connected in any way with municipal water plants, architects, and students of civic affairs in general. All inquiries on the subject should be addressed to H. W. Benjamin, Room 790, City Hall, Philadelphia, Pa.

NEW PUBLICATIONS

By D. D. BEROLZHEIMER, Librarian, Chemists' Club, New York.

PAPERS OF SPECIAL INTEREST TO INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS FROM THE PROCEEDINGS OF THE EIGHTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.

Alcohol; Equilibria in Systems Containing Alcohols, Salts and Water, Including a New Method of— Analysis. By GEO. B. FRANKFORTER AND FRANCIS C. FRARY. Vol. 22, pp. 87–127.

Alcohol; The Production of— and Sugar from the Sap of the Nipa Palm. By H. D. GIBBS. Vol. 8, pp. 13–19.

Aldehydes; A Study of some Methods for the Determination of—. By B. G. FEINBERG. Vol. 1, pp. 187–203.

Alkaline Salts; On Recent Progress in the Electrolysis of—. By M. WILDERMAN. Vol. 21, pp. 185–196.

Alloy; A New— with Acid Resisting Properties. By S. W. PARR. Vol. 2, pp. 209–213.

Aluminium; The Influence of Pouring Temperature upon— Alloys. By H. W. GILLETT. Vol. 2, pp. 105–112.

Analysis; Cadmium Nitrate in Qualitative—. By ANTON VORISEK. Vol. 17, pp. 91–102.

Analytical; A Plan for Organized Research and— Chemistry in Successful Chemical Manufacturing. By WILLIAM C. FERGUSON. Vol. 2, pp. 95–102.

Arsenic; Some Factors Influencing the Quantitative Determination of— in Soils. By J. E. GREAVES. Vol. 15, pp. 121–128.

Assaying; Sampling and— of Silver Ores, Containing Cobalt, Nickel and Arsenic. By JAMES OTIS HANDY. Vol. 3, pp. 89–95.

Bituminous; Classification of— and Resinous Substances. By HERBERT ABRAHAM. Vol. 10, pp. 7–15.

Brass; The Tensile Strength of Copper-Zinc Alloys. By WILDER D. BANCROFT AND J. M. LOHR. Vol. 2, pp. 9–16.

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ORGANIC CHEMICALS.

Acetanilid	Lb.	20½	@	23
Acetone (drums)	Lb.	17	@	18
Alcohol, grain (188 proof)	Gal.	2.55	@	2.57
Alcohol, wood (95 per cent.)	Gal.	50	@	52
Alcohol, denatured (180 proof)	Gal.	40	@	42
Amyl Acetate	Gal.	2.75	@	2.95
Acetic Acid (28 per cent.)	C.	2.00	@	2.15
Aniline Oil	Lb.	10¾	@	11½
Benzoic Acid	Lb.	23	@	27
Carbon Tetrachloride (drums)	Lb.	11	@	16
Carbon Bisulphide	Lb.	14	@	15
Chloroform	Lb.	20	@	30
Carbolic Acid (drums)	Lb.	14	@	15
Citric Acid (domestic), crystals	Lb.	38½	@	39
Camphor (refined in bulk)	Lb.	44	@	—
Dextrine (imported potato)	Lb.	6	@	7
Dextrine (corn)	C.	3.20	@	3.31
Ether (U. S. P., 1900)	Lb.	14	@	20
Formaldehyde	Lb.	8½	@	9½
Glycerine (dynamite)	Lb.	17¾	@	18¼
Oxalic Acid	Lb.	7⅞	@	8⅜
Pyrogallic Acid (bulk)	Lb.	1.35	@	1.45
Salicylic Acid	Lb.	31	@	33
Starch (corn)	C.	2.45	@	2.56
Starch (potato)	Lb.	5¼	@	5¾
Tannic Acid (commercial)	Lb.	35	@	35½
Tartaric Acid crystals	Lb.	30½	@	31

INORGANIC CHEMICALS.

Acetate of Lime (gray)	C.	2.50	@	2.60
Acetate of Lead (brown, broken)	Lb.	7¾	@	8
Alum (lump)	C.	1.75	@	2.00
Ammonium Carbonate, domestic	Lb.	8	@	8½
Ammonium Chloride, gray	Lb.	6⅛	@	6¼
Aluminum Sulphate	C.	90	@	1.75
Aqua Ammonia (drums) 16°	Lb.	2¼	@	2½
Arsenic, white	Lb.	4¾	@	5
Brimstone (crude, domestic)	Ton	22.00	@	22.50
Barium Chloride	C.	1.40	@	1.55
Barium Nitrate	Lb.	4¾	@	5
Borax, crystals (bags)	Lb.	3½	@	4
Boric Acid, crystals (powd.)	Lb.	7	@	7½
Bromine, bulk	Lb.	25	@	30
Bleaching Powder (35 per cent.)	C.	1.25	@	1.45
Barytes (prime white, foreign)	Ton	18.50	@	22.50
Blue Vitriol	Lb.	5½	@	5¾
Calcium Chloride	C.	65	@	90
Chalk (light precipitated)	Lb.	4½	@	6
China Clay (imported)	Ton	11.50	@	18.00
Feldspar	Ton	7.00	@	9.00
Fuller's Earth, powdered	C.	80	@	85
Green Vitriol (bulk)	C.	55	@	60
Hydrochloric Acid (18°)	C.	1.15	@	1.55
Iodine (resublimed)	Lb.	3.05	@	3.10
Lead Nitrate	Lb.	8⅜	@	8½
Lithium Carbonate	Lb.	65	@	70
Magnesite (raw)	Ton	7.50	@	8.50
Nitric Acid, 36°	Lb.	3⅞	@	4¼
Phosphorus	Lb.	35	@	90
Phosphoric Acid, sp. gr. 1.75	Lb.	22	@	26
Plaster of Paris	Bbl.	1.50	@	1.70
Potassium Bromide	Lb.	31	@	34
Potassium Permanganate (bulk)	Lb.	9¾	@	10
Potassium Cyanide (bulk) 98–99%	Lb.	19	@	24
Potassium Iodide (bulk)	Lb.	2.60	@	2.65
Potassium Chlorate, crystals	Lb.	8¼	@	9½
Potassium Nitrate (crude)	Lb.	5	@	5⅛
Potassium Bichromate, 50°	Lb.	6⅞	@	7
Quicksilver, Flask		42.00	@	43.00
Salt Cake (glass-makers')	C.	55	@	65
Silver Nitrate	Oz.	39⅞	@	42
Soapstone in bags	Ton	10.00	@	12.00
Sodium Acetate	Lb.	4¼	@	5
Sodium Chlorate	Lb.	8¼	@	9½
Sodium Bicarbonate (English)	Lb.	2¾	@	3
Sodium Bichromate	Lb.	5⅛	@	5¼
Sodium Hydroxide, 60 per cent.	C.	1.60	@	1.65
Sodium Hyposulfite	C.	1.30	@	1.60
Sodium Nitrate, 95 per cent., spot	C.	2.52½	@	—
Sodium Silicate (liquid)	C.	65	@	1.50
Strontium Nitrate	Lb.	6⅞	@	7⅝
Sulphur, Roll	C.	1.85	@	2.15
Sulphur, Flowers (sublimed)	C.	2.20	@	2.60
Sulphuric Acid, 60° B.	C.	85	@	1.00
Talc (American)	Ton	15.00	@	20.00
Terra Alba (American), No. 1	C.	75	@	80
Tin Bichloride (50°)	Lb.	13¼	@	13½
Tin Oxide	Lb.	48	@	50
Zinc Chloride (granulated)	Lb.	4¼	@	4½
Zinc Sulphate	Lb.	2¼	@	2½

OILS, WAXES, ETC.

Beeswax (pure white)	Lb.	40	@	44
Black Mineral Oil, 29 gravity	Gal.	12	@	12½
Castor Oil (No. 3)	Lb.	9½	@	10½
Ceresin (yellow)	Lb.	9	@	15
Corn Oil	C.	6.10	@	6.15
Cottonseed Oil (crude), f. o. b. mill	Gal.	37¼	@	38
Cylinder Oil (light, filtered)	Gal.	19½	@	20
Japan Wax	Lb.	10¼	@	10½
Lard Oil (prime winter)	Gal.	87	@	92
Linseed Oil (double-boiled)	Gal.	70	@	72
Paraffine Oil (high viscosity)	Gal.	25½	@	26
Paraffine (crude 120 & 122 m. p.)	Lb.	3¼	@	3¾
Rosin Oil (first run)	Gal.	36	@	37
Spindle Oil, No. 1	Gal.	16	@	16½
Sperm Oil (bleached winter), 38°	Gal.	72	@	74
Stearic Acid (double-pressed)	Lb.	9¼	@	10
Tallow (acidless)	Gal.	62	@	65
Tar Oil (distilled)	Gal.	30	@	31

METALS.

Aluminum (No. 1 ingots)	Lb.	21½	@	22½
Antimony (Hallet's)	Lb.	7¾	@	8½
Bismuth (New York)	Lb.	2.10	@	2.15
Copper (electrolytic)	Lb.	17.35	@	17½
Copper (lake)	Lb.	17⅝	@	17¾
Lead, N. Y.	Lb.	5.10		
Nickel	Lb.	50	@	55
Platinum (refined)	Oz.	46.35	@	47.00
Silver	Oz.	63¼	@	—
Tin	Lb.	49.20	@	49.30
Zinc	Lb.	7	@	—

FERTILIZER MATERIALS.

Ammonium Sulphate	C.	3.30	@	—
Fish Scrap, domestic, dried	Unit	2.45	&	10
Blood, dried	Unit	2.75	@	—
Tankage, high grade	Unit	2.60	@	2.65 & 10
Bone, 4½ and 50, ground, raw	Ton	28.00	@	—
Potassium, "muriate," basis 80%	Ton	38.55	@	—
Phosphate, acid, 16 per cent.	Ton	6.75	@	7.00
Phosphate rock; f. o. b. mine:				
Florida land pebble, 68 per cent.	Ton	3.70	@	3.80
Tennessee, 68–72 per cent.	Ton	4.25	@	4.50
Pyrites, furnace size, imported	Unit	0.13⅛	@	0.13¼
Castor meal	Unit	nominal		
Mowrah meal	Ton	8.50	@	9.00