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Editor: CHAS. H. HERTY
Assistant Editor: LOIS W. WOODFORD

EDITORIAL OFFICES:
One Madison Avenue, Room 343
New York City
TELEPHONE: Gramercy 613-614

Cable Address: JIECHEM

ADVERTISING DEPARTMENT:
170 Metropolitan Tower
New York City
TELEPHONE: Gramercy 3880

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THE CHICAGO MEETING

A MEMORABLE COUNCIL MEETING

To one who has attended many, many meetings of the Council of the American Chemical Society that held in Chicago on September 6, 1920, stands out preëminently. It proved beyond a doubt that a large gathering can act as a truly deliberate body. Speakers argued directly to the point, a mass of business was transacted, full opportunity was afforded for presentation of every side of the various subjects under discussion. Where action was proposed which seemed to carry the possibility of danger to the Society as a great national organization the Council stood firm and proved itself thoroughly conservative. On the other hand, where progressive action was called for to meet the needs of the times, the Council did not hesitate to take action.

The official minutes of the meeting are published in full in the Proceedings in the October issue of the *Journal of the American Chemical Society*. Only a few of the more important matters are touched upon here.

FUTURE MEETINGS

The dates for the 1921 Spring Meeting, to be held at Rochester, N. Y., were fixed for April 26 to 29, 1921. The Council will meet on the afternoon of April 25. Invitations for the next Annual Meeting were received from the Pittsburgh and the New York Sections. The matter was referred to the President and Secretary with power to act, the understanding being that should a general meeting with other societies be arranged the invitation of the New York Section would be accepted.

By an overwhelming vote the Council rejected the proposal to hold only one general meeting each year. The reasons which determined this large vote were: There is no lack of invitations on the twice-a-year basis; there is an abundance of material offered for the programs; the policy of meeting in different sections of the country is highly stimulative; and the suggested substitution of intersectional meetings for one general meeting was considered to be a possible wedge which might eventually disrupt the Society. It was voted, however, that the entertainment features of future meetings be simplified, that visiting members participate in the expenses incident to the meetings, and that more time be provided on the programs for the reading of scientific papers.

While expressing appreciation of the invitation to become a charter member of the Federated American Engineering Societies, the Council voted unanimously against acceptance of the invitation. It was deemed preferable for the Society to act in a coördinate relation rather than as an actual member of the Federation. In the same spirit and for the same reasons the Council advised local sections to refrain from joining state and local engineering and technical societies. We shall discuss this latter point more at length in a subsequent issue.

By unanimous vote the following resolution was adopted:

> The Council of the American Chemical Society, regretting that Congress did not pass legislation for the protection of the dye industry in the United States, and inasmuch as the failure to enact such proper legislation has resulted in the withholding and preventing of proper and necessary development, wishes to reiterate its position taken at previous meetings.
>
> *Therefore be it Resolved,* That Congress be urged to take action on this important question at the earliest possible date.

At the request of Brigadier General Amos A. Fries, chief of the Chemical Warfare Service, a committee was appointed to coöperate with that Service. The details are given on page 958 of this issue.

DUES INCREASED

Following a delightful dinner in the rooms of the University Club, the Council resumed its sitting and took up the final matter for consideration, namely, the question of the increase of dues from ten to fifteen dollars. The report of the Finance Committee made clear the fact that the Society was facing a deficit of from twenty to thirty thousand dollars this year. The main cause of this unfortunate situation was the constantly increasing cost of paper and printing. Conditions indicated that for the same reasons this deficit would be even greater during the ensuing year. The testimony of many of the councilors connected with large laboratories showed clearly that the younger men, just graduating from college and entering upon an earning career, were to-day receiving salaries which averaged at least ninety per cent more than the same type of young chemist received five years ago. Therefore an increase of dues to $15.00 would not tax the income of the young chemist of to-day as much as did the $10.00 dues of five years ago. It was recognized that the Society was indulging in no unnecessary expenditures at the present time; a curtailment of the splendid activities of the organization would therefore be necessary if the dues were not raised. The Council thereupon, with only three dissenting votes, adopted the amendment increasing the dues to $15.00, effective January 1, 1921. The Council felt, however, that this action would work a hardship upon one class of men whose financial connection with chemistry was still one of outgo instead of income, namely, graduate students; so in the future all students, whether graduate or undergraduate, are to be given the privilege of membership and receipt of one journal for $6.00, or the same privilege and all three journals for $10.00. The question of defining the word "student" was referred to the President with power.

A feeling of relief passed through the entire body of the Council when the question of raising the dues was settled affirmatively. It was a critical moment in the life of the Society, and the situation was unhesitatingly met. With bankruptcy avoided the Society could go on with no uncertain step to that larger field of effort which the constantly growing importance of chemistry in our country makes imperative. Dr. Coates of the Louisiana Section reported that in advance of the Council meeting that Section, after full discussion, had voted unanimously that the dues should be increased. He predicted that the sentiment in other local sections would be found equally favorable.

GENERAL MEETING

The Sixtieth Meeting of the AMERICAN CHEMICAL SOCIETY opened with the calling to order of the thousand or more members and guests assembled in the Gold Room of the Congress Hotel on the morning of September 7, 1920, Dr. W. Lee Lewis, chairman of the Executive Committee of the Chicago Section, presiding. The address of welcome on behalf of the Section was delivered by the honorary chairman, Dr. Julius Stieglitz.

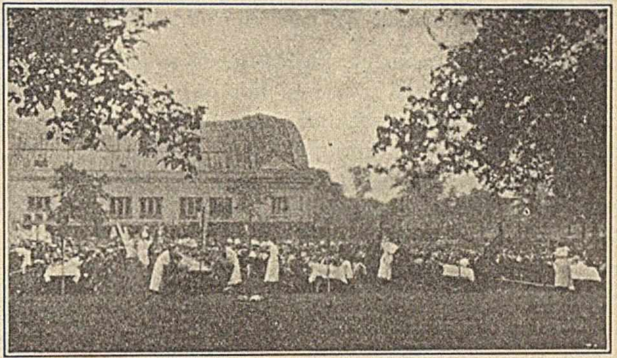
After a welcome on behalf of the city of Chicago had been extended by Mr. Joseph R. Noel of the Association of Commerce, Dr. Lewis turned the chairmanship of the meeting over to President Noyes, who responded fittingly to the words of welcome, and emphasized the responsibility of the SOCIETY in this reconstruction period, particularly in forgetfulness of personal interest in thinking of the great public interest which should be our first concern.

The representative of the SOCIETY at the meeting of the International Union of Pure and Applied Chemistry at Rome, Secretary Chas. L. Parsons, gave graphic impressions of the gathering and of the Italian chemical industry. The address delivered by Mr. Thomas E. Wilson appears, in part, pages 941 to 943. Dr. A. S. Loevenhart's address will be printed in the November issue of THIS JOURNAL.

MEETING AND ENTERTAINMENT AT NORTHWESTERN UNIVERSITY

At this stage of the program a delightful transformation in setting took place. Members and guests boarded special elevated trains, and were taken to the beautiful campus of Northwestern University, at Evanston, where the scientific program was completed in the auditorium of the Patten Gymnasium, a building whose novel architecture fits it admirably for the comfortable seating of large audiences, yet in no wise impairs its value as a gymnasium. Here Professor Talbot read a paper on "The Relation of Educational Institutions to the Industries," and Dr. W. A. Patrick discussed "Some Uses of Silica Gels."

The remainder of the day, and evening, were given over to entertainment features, taking the place of the usual smoker. The broad expanse of campus, bordered on the east by the blue of Lake Michigan, shone upon by the sun of a perfect September afternoon, and gaily decorated with flags and college pennants, was a spot of delightful memory to those privileged to be present. A swimming exhibition in the tank, dancing in the auditorium, a baseball game—Chicago *vs.* The World of Chemists, a band concert, and an organ concert furnished recreation for all and led to a spirit of good-fellowship which extended itself throughout the lawn supper, in which more than a thousand guests participated, and through the evening entertainment which included an orchestral concert, mass singing, and a charming presentation of Sullivan's opera "Cox and Box."



PICNIC SUPPER AT EVANSTON

DIVISIONAL MEETINGS

For the divisional programs of Wednesday and Thursday the setting changed again, this time to the buildings of the University of Chicago. Here the recitation halls of the group of science buildings afforded ample facilities for reading and discussion of reports of progress in the various branches of our science. The officers of the various sections reported interesting meetings, with good attendance. The programs are printed, pages 1022 to 1025.

The name of the Pharmaceutical Division was changed, with the approval of the Council, to Division of Chemistry of Medicinal Products. In this division an informal symposium was held on "The National Research Council and the Chemistry of Medicinal Products." The discussion was opened with a paper by Dr. J. M. Francis, read by Dr. F. O. Taylor. Dr. Francis emphasized the need of coördination of the pharmaceutical research now being carried on in various laboratories. He pointed out how the National Research Council could coöperate with the Division in this matter. Dr. Bancroft outlined some of the outstanding problems, touching particularly upon the need of an understanding of the theories of colloid chemistry in approaching work in this field. He emphasized that the actual work must be done by the research workers in each field, that the National Research Council found its special function the outlining and correlation of problems, and putting workers in the same field in closer touch with each other.

The chairman of the committee of the AMERICAN CHEMICAL SOCIETY on an Institute for Drug Research outlined briefly the progress of the committee's work, and the present problems, and stated that in the near future he felt there would be an announcement of real importance to be made. Dr. F. R. Eldred emphasized the necessity of fostering the research spirit among the pharmaceutical interests, particularly in the universities, and deplored the lack of men of adequate training who are particularly interested in this line of research.

Upon motion of Dr. F. O. Taylor it was

Resolved, That a committee of five, which may be enlarged at the discretion of the Executive Committee of the Division if need be, be appointed to take the papers and suggestions presented, and outline some tentative method whereby the Division can coöperate with the National Research Council, and ask for their coöperation in return, formulate a list of problems of varying degrees of difficulty, and with that work done there will undoubtedly be some further work that will be perfectly evident. Passed.

TRAINING OF DYE CHEMISTS

The Dye Division, having disposed of an extremely interesting program covering not only the results of original research on dyes and intermediates, but papers on the problems of training of men for that particular field, adjourned in regular order, but so interesting a discussion developed after adjournment over conflicting views on this subject that a lengthy informal and purely spontaneous symposium was held, which it is hoped to continue on the regular program of the Rochester meeting.

The especially noteworthy feature of the Leather Section's meeting was the increasing interest of the industries in scientific research, and their willingness to coöperate with university workers.

THE NEW SECTION OF CELLULOSE CHEMISTRY

The formation of a Section of Cellulose Chemistry was the marked event of the meeting of the Division of Industrial and Engineering Chemistry. This decision followed the reading of a series of papers on cellulose, in the second Cellulose Symposium to be held by this Division. Of outstanding value was the paper by Professor Harold Hibbert on "The Constitution of Cellulose."

A symposium on Fuels, led by Dr. A. C. Fieldner of the Pittsburgh Station, U. S. Bureau of Mines, brought out a wealth of important material on the development of new fuels and most efficient utilization of the more common varieties.

The minutes of the meeting are printed below:

The Division of Industrial and Engineering Chemistry enjoyed one of its most successful meetings at Chicago, all sessions being largely attended and the discussion of papers more spirited and extensive than has been usual. The following officers were elected for the ensuing year:

Chairman: H. D. Batchelor
Vice Chairman: C. G. Derick
Secretary: H. E. Howe
Executive Committee: J. G. Vail, Chas. H. Herty, W. F. Hillebrand, Edmund O'Neill, Edward Mallinckrodt, Jr., F. M. de Beers

A committee to consider a plan for encouraging research in educational institutions was reorganized with the following personnel:

W. J. Hale, *Chairman*, F. G. Cottrell, Chas. H. Herty, Henry Howard, George D. Rosengarten

A progress report of the Committee on Chemical Lime was received.

A motion was unanimously passed to ask the President and Secretary of the Society to approve the establishment of a Section on Cellulose Chemistry with the suggestion that Professor Harold Hibbert serve as chairman with G. J. Esselen, Jr., as secretary, until an election can be held.

It was the opinion of the Division that the practice of requiring abstracts was not only beneficial, but that in the future more extensive abstracts should be required. The intention of holding one symposium each meeting on some phase of chemical engineering was also discussed and approved.

The Division of Agriculture and Food Chemistry completed its program early in the day. It is hoped that in the future a more even distribution of material between this Division and the Division of Biological Chemistry may be effected.

Sessions of the Division of Physical and Inorganic Chemistry, Organic Chemistry, and Biological Chemistry brought out the results of intensive research in each of those fields. The Fertilizer Division, Division of Water, Sewage and Sanitation, and Sugar Section, completed their programs within the allotted time, and with profitable discussion of the papers.

In the Rubber Division a committee was appointed to consider the advisability of making some provision for the publication of an annual volume of reprints and lengthy abstracts of everything of interest to the rubber chemist made public during the year, and to report at the next meeting of the Division. Following the reading of the papers a symposium was held on the general subject of rubber analysis, in which many defects in present methods were pointed out. The Division was agreed on the impracticability of devising a scheme of analysis applicable to all samples of compounded rubber. In the round-table discussion of recent developments interest centered on the new Peachey process of vulcanization. It was felt that while the process is theoretically sound, there are many difficulties in the way of its commercial application.

ELECTION OF OFFICERS

Divisional officers for the ensuing year were elected as follows:

Physical and Inorganic Chemistry
Chairman: H. N. Holmes
Secretary: S. E. Sheppard

Industrial and Engineering Chemistry
Chairman: H. D. Batchelor
Secretary: H. E. Howe

Biological Chemistry
Chairman: A. W. Dox
Secretary: H. B. Lewis

Chemistry of Medicinal Products
Chairman: Charles E. Caspari
Secretary: Edgar B. Carter

Organic Chemistry
Chairman: Roger Adams
Secretary: H. T. Clarke

Dye Chemistry
Chairman: A. B. Davis
Secretary: R. N. Shreve

Fertilizer Chemistry
Chairman: F. B. Carpenter
Secretary: H. C. Moore

Agriculture and Food Chemistry
Chairman: C. E. Coates
Secretary: T. J. Bryan

Rubber Chemistry
Chairman: W. W. Evans
Secretary: A. H. Smith

Water, Sewage and Sanitation
Chairman: W. T. Mason
Secretary: W. W. Skinner

Section of Leather Chemistry
Chairman: J. A. Wilson
Secretary: Geo. D. McLaughlin

Section of Sugar Chemistry
Chairman: C. A. Browne
Secretary: F. J. Bates

Section of Cellulose Chemistry
Chairman: Harold Hibbert
Secretary: G. J. Esselen, Jr.

The local committee on excursions was successful in arranging series of trips, taking place on Wednesday afternoon and Friday, to many of the industrial chemical plants in Chicago's vicinity, and those who were so fortunate as to participate therein feel that the educational value of these excursions makes them an important feature of the Society's meetings.

On Wednesday evening the annual address of the president was delivered by Dr. William A. Noyes, in the Gold Room of the Congress Hotel. The subject was "Chemical Publications." The address will appear in full in the *Journal of the American Chemical Society*.

ENTERTAINMENT

At the dinner on Thursday evening, with Chairman W. Lee Lewis presiding as a skillful toastmaster, the speakers epitomized the thought of the meeting, namely, the part chemistry is to play in this reconstruction period. Dr. Raymond F. Bacon urged the development of a stronger feeling of professional consciousness among chemists, and recommended the giving of more thought to the business side of chemistry. Dr. Chas. H. Herty emphasized the need of protective legislation, if the progression of the past four years is to continue, and made announcement of the plans for effective coöperation between the civilian chemists of the country and the Chemical Warfare Service through a committee of the ablest members of the AMERICAN CHEMICAL SOCIETY.

President Noyes, whose subject was "Team Work," said that with the assistance of every member we shall be carried forward into that new era, rapidly approaching, when American chemists will lead the world in manufacturing and research.

Mr. Harrison E. Howe, National Research Council sponsor of the tables of physical and chemical constants, urged support for this "tool of the trade" needed by every worker in the chemical field.

Mr. William R. Moss, lawyer and representative of the Chicago Chamber of Commerce, urged that chemists keep in closer touch with "the man on the street," and interest themselves in the daily problems of mankind outside of their own special field.

In closing the program, Dr. Otto Eisenschiml expressed in pleasing manner the gratification it had given Chicago chemists to act as hosts to the parent SOCIETY and guests.

Members of the official bodies of the SOCIETY were entertained at special luncheons by the Chicago members. It was evident that the elaborate plans for the entertainment of the members and accompanying ladies had been carefully laid out in advance, and the Chicago Section is to be congratulated upon the successful culmination of its work.

Opportunity was afforded by the meeting for the getting together of various alumni organizations of chemists, and for a well-attended dinner of Alpha Chi Sigma members. A new feature was a dinner to the professional women in attendance at the meeting, tendered by the ladies of the Chicago Section, at which Miss Ethel M. Terry acted as hostess.

PRESS REPORTS

The offices of the A. C. S. News Service were busy early and late in their efforts to get the salient points of the meeting to public attention through the press. In his report the technical director of the A. C. S. News Service says:

> The reports from the clipping agencies indicate that the publicity given to the Chicago meeting was exceptionally large. Whether it will equal in volume or surpass that received from the St. Louis meeting cannot be ascertained until the full returns are analyzed.
>
> As Chicago is one of the world's greatest news distributing centers, the wires of the Associated Press, the United Press and similar organizations sent out many dispatches to the newspapers of the country, as is shown by the sheaves of clippings now being garnered by the A. C. S. News Service. The admirable dispatch summarizing the work of the meeting, written by Mr. Richard D. Jones of the United Press, had an especially wide distribution. The daily papers throughout Illinois, Indiana, and various parts of the Middle West carried unusually full accounts.
>
> The sixtieth meeting was held in the midst of a political campaign and in a city the press of which happened to be giving more than usual attention to local affairs. The Chicago newspapers, however, printed about ten columns concerning the sessions. The most attention was given by the *Journal*, and the other leading Chicago papers are herewith given according to the space allotted by each: *Tribune*, *American*, *Daily News*, *Post*, *Herald-Examiner*.
>
> Extensive dispatches were printed in the eastern papers and some of them appeared in prominent positions. The subjects which seem the most popular to date, as far as lay journalism is concerned, are flavoring extracts without alcohol, the resolution urging Congress to pass dye legislation, hydrolyzed sawdust as cattle food, all news relating to fuel and news print, and the announcement that America now makes 800 rare chemicals, this last being featured on the front page of the *New York Times*.
>
> More trade and technical publications sent representatives than ever before in the history of the SOCIETY, because of the fact that so many periodicals of this class are either published in Chicago or have branch offices there.
>
> The A. C. S. News Service wishes to acknowledge the very efficient help of the Chicago Section's Publicity Committee, of which Mr. Chester H. Jones is the chairman.

ATTENDANCE

The following figures tell the story of the total registration:

STATE	MEMBERS	GUESTS	TOTAL
Alabama	1	...	1
Arkansas	1	...	1
California	9	...	9
Colorado	4	...	4
Connecticut	5	2	7
Delaware	12	3	15
District of Columbia	21	8	29
Florida	2	...	2
Georgia	7	2	9
Illinois	404	192	596
Indiana	43	13	56
Iowa	19	6	25
Kansas	9	3	12
Kentucky	2	1	3
Louisiana	7	...	7
Massachusetts	22	6	28
Maryland	7	...	7
Maine	1	...	1
Michigan	28	8	36
Minnesota	20	15	35
Mississippi	1	1	2
Missouri	23	3	26
Montana	1	...	1
Nebraska	10	...	10
New Hampshire	1	...	1
New Jersey	32	3	35
New York	58	7	65
North Carolina	6	2	8
North Dakota	3	...	3
Ohio	88	16	104
Pennsylvania	46	8	54
Rhode Island	1	...	1
Tennessee	3	1	4
Texas	7	2	9
Vermont	1	...	1
Virginia	6	...	6
Washington	2	1	3
West Virginia	3	1	4
Wisconsin	53	11	64
Canada	13	3	16
Cuba	1	...	1
China	...	1	1
England	1	...	1
Japan	1	...	1
	986	319	1305

THE VALUE OF TECHNICAL TRAINING IN THE RECONSTRUCTION OF INDUSTRIES

By Thomas E. Wilson

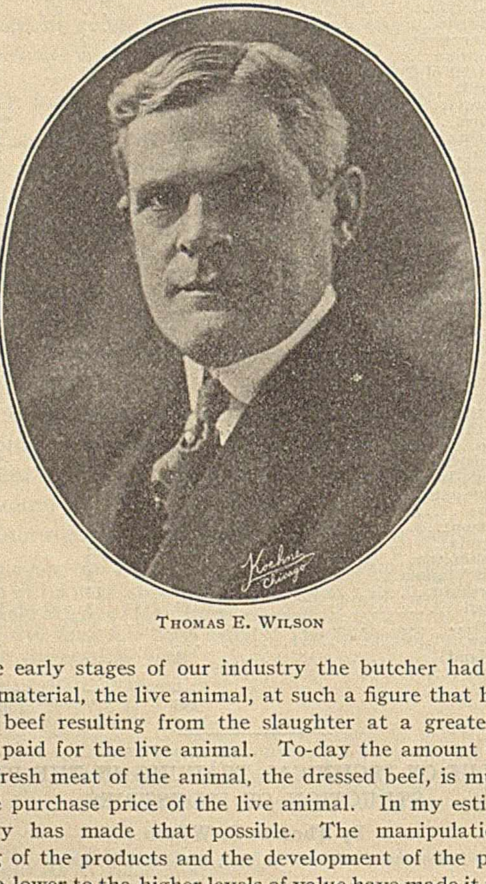
PRESIDENT, WILSON & CO., CHICAGO, ILLINOIS

I understand that I am the first business man who has been invited to address your SOCIETY. For this privilege I thank you in behalf of industry. It may not be out of place for me to express to you men and women, at this time, the appreciation of industry for the wonderful things that you have done during the past few years, and I want here to make publicly that acknowledgment, particularly to the men of your SOCIETY who have served in our industry, and who did so much to make possible its accomplishments during the war and prior to the war. A great deal has been said of the accomplishments of the men and women of your profession in the preparation of the munitions of war, but probably too little has been said about your great work in industry.

My subject can probably be best treated by outlining briefly the history of chemistry in the packing industry. It is an interesting story and it has been my privilege to have lived through it. The whole story has happened within the lifetime, I think, of every person in this room.

When I first entered the packing business there was no such thing as a chemical laboratory in the Union Stockyards. Many of you are acquainted with the man who opened the first laboratory, Mr. H. B. Schmidt, now of Cincinnati. Mr. Schmidt had his trials and tribulations, I can assure you. His department was looked upon as a luxury. He had a difficult job, but he was shrewd enough to introduce into his laboratory work a vacuum pan for the making of extract of beef. He had been criticised month after month about the expenses of his department, although they were not much, because his room was not larger than ten by ten, and he was the only person in it. When he introduced the vacuum pans he was able to put it on a dollar-and-cents basis and to show results.

As I say, that isn't so many years ago, but I think that was the turning point in the packing industry. Up to that time what were known even then as the large packers were merely butchers. They were a great deal like the cross-roads country slaughter house, improved somewhat, but not to such an extent that they would be recognized to-day.



Thomas E. Wilson

In the early stages of our industry the butcher had to buy his raw material, the live animal, at such a figure that he could sell the beef resulting from the slaughter at a greater figure than he paid for the live animal. To-day the amount realized for the fresh meat of the animal, the dressed beef, is much less than the purchase price of the live animal. In my estimation, chemistry has made that possible. The manipulation and handling of the products and the development of the products from the lower to the higher levels of value have made it possible for the packer of to-day to sell the beef for a lot less—not a little less—but a lot less than he pays for the live animal.

I am not going into the details of the development of chemistry in the packing industry, but I will show you as an example, just what the development has been in my own concern. As I have said, just a few years ago we started with chemistry in the stockyards, with one chemist. To-day our company has very close to one hundred chemists in their organization. We have the analytical chemist; we have the research chemist; we have the chemical engineering chemist; and last, but not least, the business or commercial chemist, because these men have taught us how to handle our products. They have made possible the distribution of our products all over the world. They started in with refrigeration, with the control of our curing processes, with the control of our canning, and with every step in the industry, and made it possible for this business to develop into the largest industry in the world, to develop to that stage where it was possible to do what was done during the war.

I do not want to take up your time in reciting the accomplishments of the packing industry, but in order to give you a little insight into what those accomplishments were, I am going to read from the report of Stephen Chase, of the Food Administration, which I think pretty well describes the situation.

> * * * * As a result in February 1918 extremely urgent demands were made by the allies for pork shipments to meet the immediate, absolute needs not only of our armies, but the armies of our allies and the civilian population of Europe. In fact, the further prosecution of the war was shown to be directly dependent on the immediate meat supplies being shipped from this country.
>
> At that time a program was worked out in detail, calling for 300,000,000 lbs. of pork products per month for the following three months. It was an undertaking that many people considered entirely impossible, but the program was carried out within 25,000,000 lbs., the total shipment for the three months of February, March and April amounting to 900,000,000 lbs.

That was 900,000,000 lbs. of perishable products in the months of February, March, and April 1918. If you think back you will remember that during that time, particularly when this program started in February, our country was tied up with the greatest snowstorms we have ever seen, and our railroads were practically broken down, but the program, as Mr. Chase says, was carried out.

In addition to that, the application of scientific training in the packing industry has made it possible for this industry to operate on the smallest margin of profit of any industry in the world. That is counter to the common belief, because the information that has been given out has been given out through misunderstandings on the part of many people and unfortunately on the part of some of our government bureaus.

* * * * *

We have in our industry, and I think in practically all of the fundamental industries of this country, reached a turning point. In my opinion, we have passed the point of volume. I know it is true of us, and I think it is true of many of the industries in the country, that we have striven for volume, and in doing this we have in many cases sacrificed our natural resources and our raw material. We must now conserve more than we have in the past. The packers have had credit for using everything but the "squeal," which is true, but I am willing to go on record with you here to-day. There are many fields yet undeveloped, and there are great opportunities, I think, for accomplishments in the future just as great as what have been made up to the present time. These were wonderful. They startled the whole civilized world, but I believe and feel in my heart that the future holds open to men and women of your scientific training—I know it is true in our business—a grand opportunity for further development. This development, however, can come only through close coöperation between men of your training and the business heads and the operating heads of these great concerns. This coöperation will aid not only in the development but also in the conservation of our products and of our raw material, and in the avoiding of spoilage and deterioration.

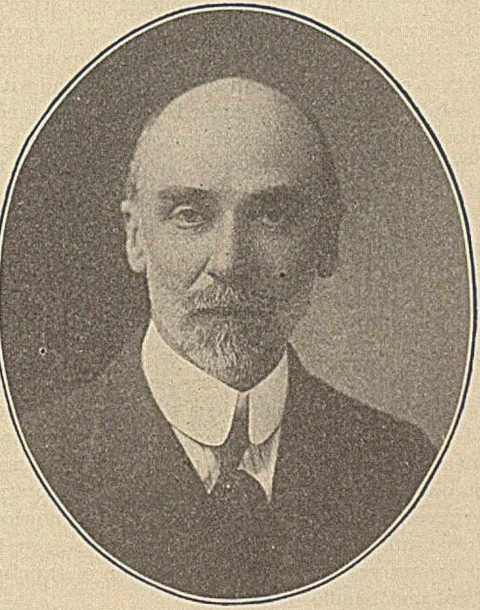
You chemists have a responsibility, I think, in this respect. I think you have failed a little in bringing your profession before the business people of industry. There has been a little hesitancy and there has also been a disposition to be a little too technical in the discussion of your branch of the work with the business men of your different organizations. In behalf of the business men I bespeak a determination on your part to translate your technical knowledge into the language of dollars and cents, and to talk to the business men in their language, not in your own, and to encourage a closer contact, which I think will be helpful both to you and to business. * * * * *

THE RELATION OF EDUCATIONAL INSTITUTIONS TO THE INDUSTRIES

By Henry P. Talbot
Massachusetts Institute of Technology, Cambridge, Mass.

The announced title of this address was necessarily hastily selected, and is obviously too extensive for the time which can be devoted to it. It is my purpose to talk to you, in homely fashion, of a few of the problems which at the moment are confronting the institutions in their attempt to supply industrial needs, with respect to both scientific productivity and man power. There will be much rehearsal of known facts, with, let us hope, an occasional approach from some new angle.

The basic situation seems to resemble closely that of producer and consumer in the commercial field. The two fundamental essentials to successful team-work are an intelligent mutual understanding and a real spirit of give-and-take coöperation. Given these, progress toward satisfactory attainment should be sure.



Henry P. Talbot

At the present time there is too little understanding. Many of us who carry the burdens, as well as the privileges, which are attached to the title "Professor," and live in neighborhoods peopled by business men, the consumers of the college product, are startled and puzzled to find how little these neighbors know of our professional responsibilities or opportunities. Business men talk to our classes and fail to render them the service which they greatly desire to give because they lack experience in exposition. Representatives of the industries attempt to lay down specifications as to the product desired from the colleges without a comprehension of the raw material with which the process begins. Alumni forget their own former crudities and ignore improvements made since their graduation. Teachers, on their side, have much to learn of industrial needs, as will be discussed presently.

Reference has been made to *real* coöperation. Experience indicates that the conception of coöperation in the minds of many is hardly distinguishable from the principle that the only comfortable location for a carbuncle is on the other fellow. It is easy to talk of coöperation, but its realization is very likely to mean some sacrifice of settled routine, with, perhaps, an outlay of energy, or even of money, the ultimate wisdom of which it requires some vision to appreciate. This is as true of the one party as of the other in the field under discussion. It is not as clearly realized as it should be, although there are notable instances of broad sympathy and keen prevision.

The community can demand of the scientific faculties of the colleges, as producers, the maintenance and advancement of work in abstract science; a ready service in all that promotes public welfare; the attack of commercial problems which are vital to industrial progress; and the adequate training of young men and women to meet the demands for workers in these various fields. The successful performance of the last-named service would automatically insure the success of the others, assuming the necessary financial support. The crucial question is: Is the present performance reasonably efficient? It is to be suspected that probably a considerable majority of my present auditors who are employers of college men would promptly answer, "No." I base this assertion upon the trend of discussion heard among groups of men, many of whom are themselves college trained, and upon the fact that Societies, Institutes, and Foundations have been, and are still, devoting much of the time of individuals and committees to the study of the general problem of engineering education, of which chemistry and chemical engineering are phases. In these discussions the indictment seems not to lie so much against the scientific training, especially in the fundamental sciences, as against the attitude of our college graduates (including always, and perhaps particularly, technical schools) toward their co-laborers and their employers. Instructional methods do not, however, escape criticism, which is frequently directed against a too academic atmosphere. It is these two types of criticism which I shall consider with you.

ESSENTIALS DEMANDED OF OUR EDUCATIONAL SYSTEMS

In the report on engineering education which Prof. C. R. Mann prepared for the Carnegie Foundation, there are incorporated the results of inquiries among some five thousand engineers as to the traits which they considered most essential for success in engineering professions. Numerical predominance was overwhelmingly in favor of such attributes as "character," "leadership," "power of initiative," and "resourcefulness," whereas "technical knowledge" occupied about the seventeenth place in a list of some twenty items. Let us recall also what has just been stated as to the apparent present demand for a knowledge of human relations. The inference seems to be that our educational systems should aim to provide these prime essentials, and there is a further implication that there is notable failure in this respect. But, while recognizing the prime significance of such attributes as are enumerated, may we not fairly question whether a charge of general failure is fair to the colleges? Is not the question closely related to that of raw materials? Character which has the elements of permanent excellence, initiative, resourcefulness, and leadership, are all essentially native attributes. The colleges cannot initiate them; they should, of course, develop them where they already exist, but in these days of crowded classrooms and lack of personal contact, the college may, perhaps, deem itself fortunate if, in some instances, it does not interfere with the designs of Providence. For those possessing the qualities of leadership, the colleges can do much toward the development of natural gifts through intelligent encouragement of so-called student activities. In such activities there is opportunity for all to acquire a coöperative spirit and to acquire the ability to present one's personal viewpoint to others. It is, however, probable that greater care should be taken to see that the fellow with real, but latent, traits of leadership, as recognized by the maturer judgment of his instructors, is not debarred from opportunity for development by others with more self-assertion than actual ability. This is a problem for our deans of students.

To meet the alleged deficiencies with respect to human relationships, many advocate a substantial increase in the time allotted to academic instruction dealing with labor problems and "human engineering." It is true that such instruction promises to be greatly vitalized, and there is a growing general recognition of the fact that the engineers of the future must be better informed in matters relating to the welfare and morale of those working with or under them, perhaps even to the exclusion of some engineering training. All this may be granted; and the remedy is good as far as it goes. However, it should not be overlooked that the undergraduate attitude toward the doctrines of the lecture room is, in spite of our best efforts, too often one of genial tolerance rather than of interest, and it should be remembered that most subjects, even professional, are so highly volatile that they seem to leave but little residue after a summer's vacation. It is, therefore, problematical how far academic discussions alone will satisfactorily meet the alleged shortcomings.

In this connection, there should be noted another type of procedure which has been adopted to meet the requirements of the industries for leaders. I refer to the various schools of Business Administration and to courses of the nature of the Course in Engineering Administration as established at the Massachusetts Institute of Technology, the object of which is to afford a systematic training of men for executive positions, giving them a sufficient knowledge of the fundamentals of engineering to enable them to make demands intelligently upon their subordinates, and to appreciate operative needs and propositions for development. This form of training is, as yet, new, but of much promise.

COÖPERATIVE COURSES OF STUDY

But it is quite certain that, do whatever we may, we cannot reproduce the atmosphere or general conditions of the works within the walls of the college or technical school. Moreover, the majority of students have passed without interruption from the primary and secondary schools to the college, and it is probably but natural that the college courses should seem to many but a continuation of the tasks imposed in childhood, to be completed in the easiest possible way. The greater the effort required on the part of the student to secure the privileges of a collegiate training, the greater, in general, and naturally, is the appreciation of the opportunity. Would that the same might be said of sacrifices on the part of the parents! The maximum increase in such appreciation has long been noted in the case of those students whom circumstances have obliged to interrupt college work to accept industrial positions. This has led to attempts to capitalize this accretion of interest by the establishment of coöperative courses in which students alternate between the classroom and an operating plant. As is well known, such courses have long been in successful operation at the University of Cincinnati. Other institutions have developed courses on the same general plan, but varying in details, and to some extent in immediate objective. Two such courses, which are in successful operation at the Massachusetts Institute of Technology, may serve as types. The first, in Electrical Engineering, is conducted in coöperation with the Lynn, Mass., works of the General Electric Company. After two years of continuous work at the Institute, the class is divided into two divisions, each of which is alternately thirteen weeks at the Lynn plant and eleven weeks at the Institute. A minimum amount of classroom instruction is carried on at Lynn coincidently with that service period. The total duration of this course is five years, and upon its successful completion, the degrees of Bachelor and Master of Science are awarded.

The second coöperative course is that including a School of Engineering Practice which immediately follows the completion of the four-year course in Chemical Engineering and covers a period of twenty-six weeks. This, in turn, is followed by twenty weeks of graduate work, including research, in the halls of the Institute. This course has been described in the JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMISTRY. At the present time the Stations of the School of Chemical Engineering Practice are established in coöperation with the Eastern Manufacturing Company and the Penobscot Chemical Fibre Company at Bangor, Maine, covering the paper and pulp industry; with the Lackawanna Steel Company and the Larkin Company at Buffalo, where the metallurgy of iron and steel, by-product coke ovens, and the manufacture of soaps are studied; and the Merrimac Chemical Company, the Revere Sugar Refinery, and the Boston Rubber Shoe Company near Cambridge, where the students become acquainted with the manufacture of rubber goods. Each Station is provided with instructional facilities and is under the charge of a resident director, a member of the Institute faculty. The degree of Master of Science is awarded upon the successful completion of this course.

Both of these coöperative courses aim to train, and I believe succeed in training, men of a superior type as engineers, for which there is the most earnest demand and urgent need. Only those men are admitted to these courses who have shown in their earlier work that they have the ability to grasp the significance of the unusual opportunities which such courses offer, and ability to attack the work in a serious spirit and with promise of successfully attaining a standard of accomplishment which may properly be given the recognition of the Master's Degree.

It seems certain that courses of the character of those just outlined must represent distinct advancement toward the satisfaction of the demands made by employers. Nothing could do more to dispel the possibly ultra-academic atmosphere of the college classroom than the atmosphere of the works; nothing can be more useful in the development of the embryonic engineer than to find himself confronted with the necessity of applying the quantitative principles acquired in the quiet classroom to the massive, pulsatory organisms of the operating plant, and to learn the limitations of such applications under the guidance of instructors; nothing could better impress upon the student the fundamental and practical importance of what he is too often prone to regard slightingly as "theoretical stuff," or better reveal to him the ramifications of the knowledge which he will need in his career. And, in these courses, we have, too, the best answer yet devised to the question of training men to understand and handle other men.

I have dwelt upon these coöperative courses mainly that I might emphasize one point in particular, namely, that although when these courses were conceived and planned, there were many who were confident in their predictions that they would not succeed because they would interfere with production, and that the foremen and workmen would tend to resent the intrusion of the students, nothing of the kind has actually happened. Indeed, the story is of a quite different sort. There has been a marked spirit of coöperation on the part of all of the higher types of employee and, so far, no difficulties have arisen when students were temporarily in charge of unskilled laborers. That which has won for them this coöperative spirit is, I think, the evidence which they have given of an honest and earnest desire to learn what the other fellow knew and they did not know. The home letters and verbal statements from students who have participated in these coöperative courses furnish abundant evidence that they have, sometimes unconsciously, acquired much insight into human engineering.

SUMMER EMPLOYMENT FOR THE ENGINEERING STUDENT

But, fine as these courses are, they present one real difficulty. They require five years for completion. It is not, of course, the added tuition, but the living expenses which make the extra year a financial burden. Ignoring now the question whether or not all engineering courses (or at least those of Chemical Engineering) should extend over five years, I desire to make a plea for coöperation on the part of the industries to help out some of our fine fellows who cannot spend this extra year in college. While it may be true that more professional opportunities in chemistry than formerly are open to college men during the summers, it still remains a fact that there is, in the aggregate, a very large body of the finest type of fellows who, each summer, are anxious to gain the same sort of insight into industrial conditions which is gained by their more fortunate associates who take such courses as those outlined above as types, but to whom those opportunities remain closed. I have presented this plea before and have been met at once with the statement that the industries are not philanthropic institutions, and that such men were a trouble and expense. I grant the temporary expense, but I question whether there can be real coöperation without a spirit which is akin to philanthropy, and I even venture to believe that it may well prove to be bread cast upon the waters which will not be so very many days in making its reappearance.

It would obviously be both impracticable and purposeless to undertake to provide for all of the men now entering chemical courses. Very many of these students utterly lack the seriousness of purpose or insight to enable them to realize or to avail themselves of such privilege or opportunity. My query is this: Are there not many of you employers who could take on for the summer a student who had completed two, or better three, years of college work and had the endorsement of his instructors as a man of high character and ability? Give him a pick and shovel, if that is the best that can be done. If he is the right kind of a chap, he will come back to college a better prospective engineer for that experience. But I venture to believe that if you place him as helper to some of your men "higher up" to enable them to undertake some of the things which such men have wanted to get at but could not find time for, you will be surprised to discover how much keen, earnest, intelligent, even if inexperienced, effort will yield. I base this assertion largely upon observations made upon what students have accomplished, when put upon commercial problems in our laboratories between their junior and senior years. It would be the finest sort of a way for you to secure competent men on the later completion of their college courses. Some of these fellows are obliged to secure during the summer the means to defray the expenses of the college year. To them, of course, the question of compensation is of great moment, even though they realize the value of the experience. There are many more to whom the opportunity is paramount to the financial return. I earnestly solicit your interest in this matter as a duty to the profession as a whole, and perhaps to yourselves as well. It is the duty of the colleges to face squarely the demand for more human engineering and to be prepared to scrap age-long habits, if need be, to meet the situation, but it seems to many of us that what is so loudly demanded can be effectively attained only by the opening of more opportunities for actual contact with industrial conditions. The chemical industries have been less responsive than others, because, in part at least, of the belief that their processes needed to be guarded from competitors. This phase should also be candidly studied if it stands in the way of coöperation in your individual case, to determine whether, as a reason, it will stand analysis.

There is still another most important phase of this question which is frequently overlooked to which I desire to call attention. Do we ask ourselves candidly, what were you and I like when we left college? Granted that there has been much improvement in the conception of the college course since our day, is it reasonable that young fellows of twenty-one to twenty-four years of age should issue from four years of training with ability to meet the ideals pictured in many discussions? I do not wish to plead excuses for the college. We can by team-work improve the output, but you of the industries cannot expect to avoid becoming graduate teachers of the men who come to you. This general principle is already admitted by a number of the larger concerns who are offering training schools for young men of college age, thereby making one of the most important contributions toward general improvement. Most plants cannot introduce such schools, but you, as individuals, can constitute yourselves as graduate teachers, and recalling your own immaturity at graduation can exhibit a sympathetic rather than too critical an attitude toward the newly fledged graduate, even going so far as to forgive him if, for the time, he seems to believe that he is the bearer of better tidings than the world has yet heard.

RELATION OF THE INDUSTRIES TO COLLEGE INSTRUCTING STAFFS

Let us now turn to a consideration of the relations to the industries which should exist with respect to the efficient use of the intellectual and physical resources of the members of the instructing staffs of our educational institutions, largely composed as they are of highly trained experts.

No argument is required before this audience in support of the importance of research in abstract science. The really important question is how to increase the output, which means, in turn, how to provide those who are naturally endowed for such research with adequate livings and with necessary equipment. Maximum productivity is probably reached through the endowment of research laboratories, with organizations which enable their members to devote time and thought uninterruptedly to investigational work. Next in order of effectiveness is a provision for essentially uninterrupted work upon the part of individuals who have marked aptitude for research in institutions where a separate research organization is not possible.

The more common, because it is apparently the necessary procedure, is the provision of some facilities for research for a considerable proportion of a teaching staff, the individual members of which vary widely in aptitude and enthusiasm, and all of whom are under a considerable burden of teaching responsibility in these days of crowded classes and a diminished supply of teachers. These research opportunities may take the form of the release of a definite portion of time to be devoted to research, or the provision of a paid research assistant, or the direction of research which is done under a fellowship grant. Obviously, the output under these conditions must be less, as measured in published papers or the magnitude of problems attacked, than in the case of isolated and selected workers in organized research laboratories, but the intangible influence upon the teaching staff which is absolutely essential for a live institution is reflected in the human output.

The industries, through corporate action or through individuals, are showing an increasing interest and generosity toward each of the plans for research just outlined, and it is a pleasure to note that the chemical industries are in the forefront of this movement. The endowments for research laboratories and the activities of the National Research Council have been increased; there is expectation that funds will be contributed to permit a limited number of men of distinction in investigational activity on college staffs to devote themselves entirely to research; and fellowships have been founded at various institutions. The Massachusetts Institute of Technology, for example, holds four of these; one from the du Pont de Nemours and Co.; one from the Monsanto Chemical Co., and two (one called a scholarship) from the Grasselli Chemical Company. Other institutions are similarly fortunate. These fellowships are given without restriction as to the character of the work undertaken, save in one instance to indicate a preference as to the division of chemical science. They have the special merit of inspiration for the holder as well as for those under whose guidance he may carry on his research.

The agencies just outlined contribute mainly to the promotion of the vitally important work in abstract science. How are the institutions helping in the solution of problems which are commonly regarded as those of applied science? The works laboratory can ordinarily provide for the control of the daily operation of the industries and for many questions arising in connection with the improvement of old and the designing of new processes, but it is a rare case in which there are not some problems of this sort, the attack of which is precluded by questions of time, space, or specialized equipment. The up-to-date manufacturer is, moreover, often confronted with questions as to the possible significance or utility of some abstract scientific development with respect to his particular industry. He has no trained specialists at his command and he is, in the words of one of my friends, much in the position of the gentleman attached to the bull's tail, in that he does not know whether he can better afford to hang on or let go. It is to problems of the two latter types that the resources of the institutions may well contribute valuable aid.

The Mellon Institute, with its Industrial Fellowships, is a leader in such industrial coöperation. Other institutions have adopted the same spirit. I will cite but one, that with which I am familiar, the Research Laboratory of Applied Chemistry at the Massachusetts Institute of Technology. In that laboratory a portion of the workers are engaged upon investigations of value to the industries at large, and a portion upon problems presented by individual concerns. The spirit of the so-called "Technology Plan" is the same, but, in that case, the industries have generously done their part first, and at present an organization of forces is being effected to meet the obligations of the Institute.

But, beside those associated with research organizations of the type just indicated, there remains a great body of specialists engaged chiefly in teaching in our various institutions, both colleges and technical schools. What should be the relation of these men to the so-called "commercial interests?" The answer is not simple. I do not know that I can give it to the satisfaction of anyone; but let us look at some of the factors involved. Is there not truth in the frequent assertion that our human product, mainly consumed by the industries, is inefficient in part because too many of us live in ignorance of the conditions which our graduates have to meet; that many have never been confronted with the application of the quantitative principles, about which we discourse fluently, to masses of machinery and materials utterly unlike our beakers and centinormal solutions; that we, perchance, know only of industrial terms as we find them on our library shelves? If there is any truth in such criticisms, may it not be worth while for us pedagogues to consider the possibility of spending an occasional summer in an industrial plant, if the industries will coöperate for our mutual benefit? I frankly confess to a regret on my own part that I did not follow this course years ago. I have, however, had sufficient experience to realize this, that all of you teachers can give a surprising additional vitality to your instruction by drawing upon even a limited personal experience, and I may add that, with discretion, you can make this experience, like your stock anecdotes, last for many years.

Again, we may ask, is it not worth something to any institution to have its instructing staff undertake worth-while commercial problems? Right here we meet divergent opinions. Admitting that dignified investigations with commercial bearings are intrinsically as well worth doing as many of those of abstract science, other factors must also be admitted. Abstract investigations can usually await leisurely solution; the business man, as some one has said, wants his results "yesterday," and this may lead to methods of expediency rather than thoroughness, and may result in encroachments upon time which should be devoted to instruction and study, or it may necessitate extra hours of labor which sap vitality. Contact with commercial work may lead to "pot-boiling" and loss of interest in abstract investigation. The results of industrial research can rarely be promptly published. There is a tradition, a relic of the days before the engineer was admitted to the learned professions, that to come into contact with things commercial is to lose professional caste.

There are, however, brighter tints in the picture. There is a tangible benefit which can come from contact with persons and conditions outside the academic circle. Good judgment will minimize or avoid interference with instructional work. A knowledge of the proper time to slight details to secure results usable for a particular purpose, is as important as a blind, academic superconscientiousness. The industries need this form of coöperation. Moreover, I feel sure that many of my brother administrators will agree with me that we cannot brush aside the importance of association with commercial interests as a means of securing living incomes for teachers and of lessening the present disturbing depletion of the college staffs. I feel that the committee recently appointed by the Council of this Society to call the attention of educational executives to the need of providing more adequately for the chemists engaged in teaching should have included in their communication some reference to greater liberality in their attitude toward industrial coöperation. The privileges which pertain to academic positions have a real value, but, unhappily, they do not pay grocers' bills, nor do they represent the equivalent of the increased emoluments offered by technical positions, even after advances in college salaries have been made on the basis of recently increased resources. It does not seem reasonable to debar college teachers from remunerative commercial research, which has its own broadening influence.

To avoid a misunderstanding of my position, I must add that I do not advocate a general substitution of industrial research for abstract research. The best interests of both the industries and education dictate that preference should, all things considered, be given to abstract research whenever conditions for such work are adequate as to men, salaries, facilities, and funds. I would, however, plead for the privilege of industrial research for the rank and file of teachers, and express my belief that every teacher is better for some of it. Let us abandon the idea that honest scientific work done for pay subjects the doer to loss of caste, while, at the same time, we honor and admire those who elect to devote mind and heart to those abstract problems which are the real agencies of advancement.

THE FINANCIAL SIDE OF THE PROBLEM

Finally, just a few words as to the financial problems of the educational institutions. It seems to be the fashion for colleges to provide a perpetual bargain counter at which goods are sold at less than cost. In the country-wide drives for endowments much emphasis has properly been laid upon the unavoidable necessity for increasing salaries. It would be easy to infer that the salary roll is the major outlay to be met, while, as a matter of fact, at least for technical instruction, this outlay is equaled or considerably exceeded by the overhead expenses. Indeed, as some one has phrased it, the teacher is in the position of a residuary legatee. Coal bills must be met; labor must be paid for at rates determined by industrial conditions and maintained by collective bargaining; supplies of all sorts must be purchased without the saving influence of the bargain counter; old lines of service must be enlarged and new lines inaugurated. What is then left from the general funds is alone available for salaries, research, old-age pensions, and annuities; that is, for those items which affect the personal status of the instructing staff. Tuition fees now probably provide less than half the actual outlay per student and cannot be raised to cover the other half. These are some of the reasons why colleges have such an insatiable thirst for general funds. Great generosity has been shown toward such institutions, but the present conditions are increasingly perplexing and call for careful consideration and the residuary legatees have their part to perform. As a class, we are prone to over-respect traditional practices. There is much room for improvement in instructional methods in such a way as to reduce the cost per student-hour, to economize space and materials, and to increase the effective use of educational plants throughout the year. Even though we recognize that educational processes cannot successfully be conducted strictly along lines which lead to industrial success, we can easily lean backward by ignoring suggestions obtainable from commercial contacts. It is an unquestionable duty, in these days of reconstruction, to attack such questions courageously—even if some of our hobbies have to go to the scrap-heap. The expedients adopted of necessity during the war to economize were oftentimes surprisingly efficient. We must also give ear to the demand that we should acquaint ourselves and our pupils with the elements of human relationships. Unless we do these things, and do them sincerely, we cannot deserve the support for which we ask.

It is to you who are in the business world that the educational institutions must look for assistance and encouragement. As I have tried to indicate, this can take the form of an increase of appreciation of the fact that the colleges cannot reproduce within their confines the atmosphere of the works, and that we need your coöperation in the development of men both before and immediately after their graduation. To say that we need money for research, for salaries, for operating expenses, for equipment and expansion is, of course, to sound a familiar note. Our corps of science teachers has been sadly depleted as the result of the efficiency shown by such men in national service which marked them as men capable of great accomplishments. You have naturally shown your appreciation of them by offers of positions of great opportunity and high emolument. In chemistry, the demand is so great that the situation is peculiarly critical. We may, I think, in fairness and until the supply of young men has more nearly equaled the demand, as it will presently do, ask you to endeavor to make use of the members of college staffs as consultants without withdrawing them wholly from their activities as teachers, without whose help the supply of capable men will speedily run out. It is not, I think, too much to assert that your financial aid and coöperation of all sorts is your insurance for the future of a most vital sort, and I have no hesitation in speaking for my colleagues, both teachers and administrators, when I say that we shall not be lacking in appreciation or in endeavor to deserve your support.

THE EDUCATION OF THE RESEARCH CHEMIST[1]

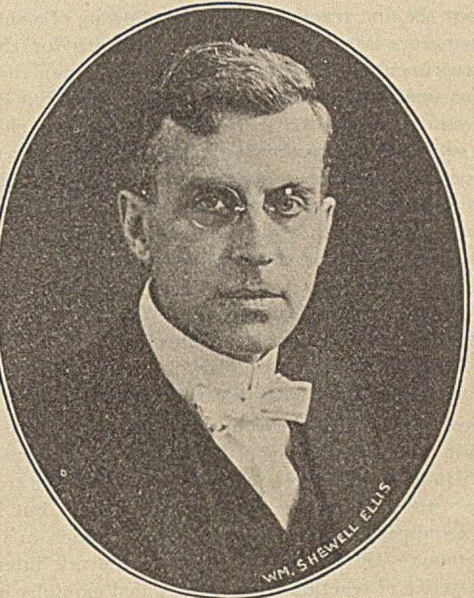
By Robert E. Rose

Chemical Department, E. I. du Pont de Nemours & Company,
Wilmington, Delaware

The education of those who are to lead the dye industry to future successes is a matter of vital interest to us. The subject is equally of interest, in its general aspects, to all who teach and to all who are concerned with commercial enterprises founded on the technical application of the results obtained by research. Its interest to the general public, though not so apparent, is no less real because the methods which are to be suggested for obtaining a sufficient supply of competent chemists are in a large measure applicable to the training of the average citizen.

As we know, the dye industry in this country was established with the aid of chemists who were not trained, except in a general way, for the special needs of the industry. They had to rely on their knowledge of chemistry as a whole in meeting the highly specialized problems of their new vocation. Their adaptability to their new duties throws a very interesting light on the educational system of which they are the products.

It is to-day quite clear to us that the research men trained in this country are competent to hold their own with those produced elsewhere; indeed, it is my own opinion that our chemists, on the average, show more individuality, more independence of thought, and greater adaptability and resourcefulness than those produced by any other educational system; their excellence is the real reason for the present success of the dye industry here. However, our satisfaction should not blind us to the fact that there is still room for improvement; the only safe way to hold a lead is to increase it.



Robert E. Rose

The thoroughness of a man's training shows when he is called upon to use his general knowledge to solve unfamiliar, highly special problems; it is then that he cannot rely on oft-repeated experience, but must think. It is then that the strong and weak points in his training show, because in a large measure clear thinking is a result of proper education. It is for this reason that I think it worth while to describe such weaknesses as were apparent, especially in the less mature men who came almost directly from the classroom. I do so only because I believe that attention to these points will show how they originate and allow of formulating definite policies for improvement.

FAILINGS OF THE AVERAGE YOUNG RESEARCH CHEMIST

Considered as a whole, the first task undertaken by the chemist engaged in founding the dye and pharmaceutical industries here was that of a systematic verification or amplification of facts already in some measure common knowledge. It was his duty to determine the very best conditions for the accomplishment of certain definite ends, the general conditions being known. Work of this kind is essentially a matter of logical experimentation; it involves no necessity for generalization except to a minor extent; it requires logical planning as a prime essential. In attacking work of this kind the research men too often failed, not in attaining the end but in reaching results rapidly enough. They conducted series of experiments, they collected data and yet more data, but they did not discriminate sufficiently between essential information and mere information. They failed quite evidently in a real comprehension of the problem in terms of research. It may be said of them that they were experimentalists

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[1] Read before the Division of Dye Chemistry.

first and thinkers second; the real research man experiments to confirm his reasoning. Not having a real grasp of the problem, the chemist too often exaggerated secondary issues and spent time on these without advancing closer to the real object of his work.

Another and a very nearly related failing was that of conducting experiments in a way that allowed of more than one variable influencing, at one time, single members of a series of experiments. I do not refer to the very evident and gross fault of introducing more than one variable intentionally—that was too common—but what I have in mind is that subtler fault of allowing variables to creep in for want of sufficient foresight. It was necessary, let us say, to take the product of a certain reaction and try a number of variants in a subsequent step. Under such circumstances the mature research man would have carried out the first reaction on a scale allowing of a subdivision of a homogeneous mass into smaller portions for the subsequent experiments. What the inexperienced man did was to prepare so small a quantity by the first reaction that he had to make several preparations in order to obtain enough material for the subsequent experiments. Of course, he observed the precaution of carrying out his preparation under what he supposed to be identical conditions, but one does not have to go very far with research to realize how difficult it is to get identical products by carrying out the same reaction twice.

These facts lead me to say, and this in the friendliest possible spirit, that the greatest failing of the chemist, as turned out by the training given him, is an insufficient ability to think logically and to use the structure obtained by thought as a basis upon which to build logical experimentation.

The experience which the young chemist brings with him has not taught him a real grasp of the experimental details of research. He is apt to forget that it is not what you are looking for, which will explain the course of a reaction, but it is frequently an apparently non-essential factor which in reality is of importance. He has not learned that every intermediate step in a series of reactions must be studied carefully and mastered thoroughly in every detail before the next step is approached; that to rush through a series of experiments without paying attention to this point will often necessitate the repetition of the experimental work and, what is worse, lead to false conclusions with regard to the last step. The physical characteristics of every portion of the material which he handles in the whole series, the reactions of the mother liquors, their color, the nature of the precipitates, all these are points he has not learned to fix definitely and exactly in mind and notebook as he goes; he is too apt to neglect them in the hope that he will get quicker results by pushing on to the end.

A great share of the blame for this slighting of detail, one of the two chief faults of the young chemist, is to be attributed to inadequate training in observation. He fails to use his eyes, nose, and fingers as he should; he does not record trifling but very essential differences simply because he never becomes aware of them.

Another cause of this fault is to be found in the impression, which is general, regarding the gross nature of industrial work. Does not industrialism strive for results of importance in the least possible time, and is not the proper method that of taking every short cut? This belief is one of the curses of industrial research. It is one likely to be fostered by technical courses. The younger men were not of a sufficiently robust independence in research matters to resist this impression; they had not learned to think for themselves, and they forgot that in treating industrial subjects, just as in confirming or refuting theoretical conceptions, it is thorough work which gives the quickest results.

The effect of industrialism was apparent in another way which, though of minor importance, still occasioned a great deal of delay. The man who in a college laboratory would have been willing to work with grams had an insatiable desire to work with pounds in a technical laboratory. He lost sight of the fact that the test tube experiment was usually quite enough to decide the majority of points and that the contents of a test tube could be handled much more quickly than quantities necessitating the use of large beakers, flasks, or even small-scale plant apparatus. It should be understood that this is not said with any intention of disparaging large-scale experiments; they are essential, but they should come only after the details of the problem have been satisfactorily solved by experiment on a small scale.

FAULTS OF OUR SECONDARY SCHOOLS

Having emphasized the chief failings of the average young chemist as made evident in the building of the dye industry, it becomes necessary, in order to give any value to these criticisms, to use them as a basis for pointing the way to improvement. First of all, the effort should be made to determine the source of these faults; having established the reason for the trouble, it will then be easier to point out where improvement might be effected.

Logic is judgment and judgment is a matter of sense; the facts which are used in forming judgments will be gaged accurately only if properly observed. The underlying requirement, then, of all research in which data are gathered first-hand, is that of accurate observation, the exercise of well-trained senses; upon this must be built a sound interpretation of the facts observed.

Our education, elementary as well as advanced, makes scarcely an effort to train the senses; instead, emphasis is placed on the development of the memory and of reasoning, though both are really capable of useful development only when there are first-hand observations to remember and conditions which call for the exercise of judgment. Efforts to develop the power of reasoning are essential, because facts in themselves lead nowhere, but it is none the less true that accurate observation is the first requirement.

For the chemist it is of the very first importance to be able to discriminate between slight variations of hue or shade, to recognize minute differences in the macroscopic and microscopic structure of precipitates, to recognize trifling changes in bodies, and to recall them; he should have a delicate sense of touch and of smell. Not only should he be able to recognize these differences absolutely, but he should have sufficient accuracy of observation to judge of them relatively, even when both are not before him at once. He should have a very keen memory for sense impressions. To have such keen senses he must have developed them during the period extending from infancy through the first years of childhood. That the chemist fails so often to observe rightly is thus an outcome of the fact that there is nothing like a concerted effort made by the community to develop the senses through the period of childhood and thus to train the faculty of observation. The evolution of the physical organs of sense is left to chance and in the majority of human beings remains in a very slightly developed condition.

Until a conscious effort is made in our primary education to meet this requirement, our advance in science will not be as speedy as it should. This statement cannot be condemned by saying that foreign men of science have had no better preparation than ours. We cannot afford to remain at the mark set for us. We must go beyond it in this essential matter just as we have in a great many other directions, and earn in this field also the right to call ourselves pioneers.

It is not stating the case too strongly to say that our present methods of primary education, taken as a whole, kill curiosity, dull the senses, and place a false emphasis on the value of information obtained from others. "I know because I have seen, or felt, or heard," that is the mental attitude which we need; not the one which is typified by the statement, "I know because teacher said so," or "because it was in the book." Fortunately, there is every evidence that a new system is coming into effect; already in many communities, especially in the larger cities, great advances have been made, and if the right teachers can be obtained our elementary education will soon be much improved.

The fault continues through all the eight years of school, where the emphasis is consistently on second-hand data. In fact, the emphasis becomes stronger as one reaches the high school years, except in laboratory courses. I have had considerable experience with students in the far West, and these men of the Coast, and women, too, are strikingly good students. To my mind that is only in part a consequence of their mental ability. To a still greater extent, it is a consequence of the fact that they are constantly dealing with nature during their childhood and adolescence. They are accustomed to spending long periods in the woods or on the water directly in contact with nature, where their powers of observation are developed as they are not developed in the city dweller.

FAULTS OF THE INSTITUTIONS OF HIGHER LEARNING

Turning to the institutions of higher learning, the criticism to be offered becomes a little more difficult to formulate. Matters are not quite so bad here, and those that are bad are largely the result of the poor previous training which the student and instructor have had. However, there can be no harm in pointing out the chief faults as I see them. Again, in this kind of work, it is my opinion that only too frequently the requirements can be met by doing routine work. There is very little necessity for reasoning and the student who succeeds best is too frequently one who appreciates just what the instructor would like to have memorized. If we take the courses in chemistry, since that is our chief concern, and analyze them, it seems that they are too much bounded and fixed by the textbook. It is true that in general chemistry, there has been reached something very like standardization in the order followed and in the subjects treated. The fact that the consensus of opinion is satisfied with the present condition seems to point to the conclusion that the subject is fairly well treated, though I cannot recognize any ground for complacency. Most of our elementary textbooks start out by giving the student the basic laws of the science. They force him to contemplate the quantitative aspect of phenomena before he has become familiar with them qualitatively. How many would like the game of bridge if they were required to learn the rules before they were at all familiar with the cards, before they ever attempted to play the game? The same applies to learning chemistry, which is something entirely different from teaching it. I feel that we emphasize logical presentation at the expense of acting in harmony with human nature. In consequence the teacher spends much too much time explaining the text. Of course this is made necessary in some measure by the student's preparation; he does not know how to handle a textbook. But granting that, I think the modern logical textbook is much too abstruse for a beginning class; elaboration is not essential to mental training; difficult problems can be presented simply. To force thinking in unfamiliar terms may be good for the best, but it is bad for the majority of students. Force has no proper place in teaching. Good thinking comes only with liking, and in the universities there is not enough emphasis placed upon kindling the interest, arousing the enthusiasm and maintaining the liking of the students for the subject, and at the same time training them in correct observation and logical thinking. However, with all its weakness, the average course in general chemistry is very much better than the beginning courses in organic chemistry. These use textbooks which are much too encyclopedic as a background for a memory training in graphic formulas, too much rote learning made necessary by too much attention to detail. There is not enough emphasis on the harmony of the whole theory of organic chemistry and not enough on the main features as distinct from the detail. The chief reactions of organic chemistry are very few, but they are made to appear many because each is treated as an individual case in connection with the particular substance being described.

The technical courses in our schools are, on the whole, lamentably inefficient. They are an attempt by those who are not in touch with the industry to prepare a student for the actual conditions to be found in the industry. As they are at present given, most of these could quite well be eliminated and replaced by fundamental subjects, such as English or mathematics. As far as I can learn all those who have the welfare of the industry at heart are very fearful of the swing toward technical courses in colleges and universities. It is the natural outcome of the emphasis on the importance of chemical industry of the past few years, also it is the consequence of the belief among those responsible for the policy of institutions of learning, presidents and governing boards, that they would be showing a willingness to meet the nation's needs by getting away from mere basic education and turning to the production of specialists. Let us hope they will learn the real feeling of those who use young chemists, their wish is that the colleges will insist more than ever that their best service is to give basic courses.

This brings me to another criticism of the university course which is much easier to make than to use as a means of correction. A good research man must have a broad training; he must be familiar with subjects other than chemistry, other than the sciences. He must be able to write his own language clearly and state his conclusions with proper emphasis. But the highest attribute of the human mind is constructive imagination; it is this which, in its greatest perfection, leads to the creation of works of art which add to the beauty of the world, and gives us our great men of science, those whose vision makes possible the formulation of new theories, new interpretations of the universe. In a lesser degree it is essential to all good research, and our educational institutions should strive to develop it. The best food for the growing imagination are the products of man's mind; more effort should then be made to interest the student in becoming familiar with the beauties of music, poetry, and the graphic arts; in his chosen field he should be led to see the grandeur of the achievements of the human mind by a study of the history of the growth of the great theories of science. He should be encouraged to learn more of the other sciences than is usually the case, more especially the biological group, and he should be given an interest in the development of human society. This may seem difficult of accomplishment, but much may be done by a concerted effort on the part of those who have the power to adjust matters, if they will view the matter not as proponents of the value of any one science or art but as champions of the best possible developments of the human mind and body.

CORRECTIVE MEASURES TO OVERCOME THESE FAILINGS

The major faults have been pointed out. What corrections can be suggested? The faults go so far back in the educational system that it seems foolhardy for any one group of men to suggest remedies, but profound modifications require longer, more earnest efforts than shallower ones, and the obvious duty of everyone who desires these changes is to do his utmost to initiate the reforms. These changes, as I see them, revolutionary though they may seem, lie in the path of the evolution and the growth of the educational system. If I am right, then all that I am seeking is to do what I can to accelerate the natural process.

It is very evident that in elementary training there is a wide divergence from that ideal which requires that the innate curiosity of childhood should be fostered and guided to attain that share in the personality of the child and adolescent which is a requisite for the subsequent attainment of the spirit of research.

However, it will only be when average parents become good teachers of observation and deduction instead of dogmatic transmitters of superstitions and half truths that the grave condition can be remedied. In the meantime, we must place every effort behind all that will tend to bring the public to a fuller realization of the enormous national importance of infant and childhood training of a different kind from that at present in vogue. We must do all that we can to introduce a greater respect for accuracy of observation and to promote a better interpretation of facts, especially in the training of the mothers of the nation, upon whom falls so large a share of the burden. Also, we must do all that we can to raise the public appreciation of the dignity and importance of the grade school teacher. We should make it clear that the teacher of childhood is actually of far more importance than the specialist who instructs in the university; of more importance because all the youth of the country passes through her hands and because she has more influence on making good citizens and profound thinkers than the university teacher has. Progress in this is a matter of many years, but let the chemist take an honorably active part in hastening the achievement. We see clearly that there is no other single factor that means so much to real world happiness as good schooling at home and by the state during the years of the developing senses. Even now we should use what influence we may to cause the adoption of policies which will give children a chance to develop their senses, their powers of observation and keep alive in them that healthy skepticism, without which there can be no real thought.

As matters stand, it will be in the institutions of higher learning that changes will commence; it is in them that any influence which we may be able to exert will first make itself felt, because the mass to be moved is smaller and the sciences form a much larger part of the whole. What do we need to make our courses in chemistry better? It is obvious that we must have the very highest grade instructors. We are very fortunate in this respect, but we might do better; and another thing that makes this subject urgent at the present time is that the circumstances connected with the war drew many of the men, who would have become our best teachers, into industrial work. One thing is certain, that we should do everything to make the calling of the teacher of science one which can be embraced without sacrifices such as must be made at present. If it is true that there are chemists in the industries whose activities entitle them to $50,000 a year because of their services to their shareholders or employers, then it is equally true that there are teachers of chemistry who are worth quite as much to the community. The great difficulty is that the teaching profession is in the unfortunate position of not being able to sell its products. It gets only what the users of its products, the community at large, feel called upon to pay. Now we all realize how soon an industry would find itself in difficulties if it allowed its income and profits to be determined by the users of its output. And in the teaching profession the matter is still worse because the users are so indirectly in contact with the teacher that they do not recognize the part he has played in making the product he turns out. I wish that some institutions might refuse to put one penny into new buildings or repairs so long as their staff is in need—it would be proper because a good teacher can get along in a barn but a poor one nullifies the value of palatial equipment. It is needless to say more on this subject here because the SOCIETY has already taken a very definite stand and pledged itself to do all that it can to promote the movement which has already set in to make the reward of the teacher more nearly commensurate with his services.

The suggestion which has been made, and in some cases acted on, that the industries should aid by retaining the services of the professors, is to my mind a very dangerous solution of the difficulty. It amounts to a subsidizing of the teachers by the industry. Research must be entirely untrammeled, and this requires that the college professor keep away from research in the interest of any commercial enterprise. There can be no objection, on the other hand, to his being called in as a consultant, that is, to the use of his wide theoretical knowledge in criticising technical research or solving difficulties, but his functions should go no further than those of a consultant. Only under very special circumstances should the teacher do any research at the direct instigation of an industrial enterprise. It is characteristic of technical research that it is spread over a wide number of subjects and the tendency which will develop if the academician is asked to aid will be simply to scatter his endeavor over so wide a field that the advance of basic knowledge will be retarded. On the other hand, I think it would be extremely advantageous if university men spent some time in direct contact with a technical enterprise in order to keep in touch with the most recent developments in the application of theory to industry. Also this would allow him to learn what demands the industry is placing on his students and would thus enable him to satisfy both sides better without sacrificing his academic freedom in any way. I venture to say that a good number of those who advocate technical courses would change their minds; after such experience they would be convinced that though specialists are essential they cannot be made during undergraduate existence.

SUGGESTED IMPROVEMENTS IN CHEMISTRY COURSES

With regard to improvements in the chemistry courses, I think the first one should be in the matter of textbooks. These should be made with less detail and more regard to the harmony of the whole structure. For example, in the case of organic chemistry, the text is expected to represent what a student should learn in the course of about a year's study, consisting of two lectures, six hours' laboratory work, and perhaps some quizzes weekly. Now, in that time, it is obvious that nothing but the high points can be touched, and the text should be constructed with this clearly in mind. Naturally, this must not be carried too far, but the treatment of a subject should be very different when it is intended only to give a general understanding from that which is required if minute knowledge is to be acquired.

Let us do all we can, then, to aid the genius who will write an elementary organic chemistry that gives little attention to matters of small moment and leaves the student with a feeling for the real meaning of this grand chapter of human knowledge, a book which will leave the student with a live understanding of the evolution of the science, of the meaning of its laws, and a real insight into the facts its symbols represent.

Given a good book, then the lecturer should make it his duty to emphasize the descriptive side of the science. It would be for him to hold the interest of his class, to make them see how tremendously important the subject is in the lives of everyone. Let the textbook explain how the constitution of formaldehyde has been determined, but let the lecturer tell of its manifold industrial uses. If he has any aptitude, he cannot help holding his class and making them anxious to learn even more about the properties of this extremely interesting substance.

In the laboratory, the work should approximate the conditions of research as nearly as possible. Given a good foundation in general chemistry, it should be possible to make each preparation a little research problem. This implies, of course, very small laboratory classes and excellent instructors with a real feeling for research.

Turning to special preparation for industrial work, it seems to me that this is best accomplished by emphasizing the applications of the theories as the theories are unfolded in the ordinary course of presentation. I do not think much emphasis should be placed on a distinction between technical chemistry and theoretical chemistry. After all, it is the latter which is essential for an understanding of the subject. The former can be acquired by experience in actual practice. It is on this account that I think most of the technical courses, as given, fail in their object, and should be improved or eliminated altogether. On the other hand, more especially in the case of the chemical engineer, I feel that a certain familiarity with the names and with the appliances in common use in the industry would be a distinct advantage, and for this purpose I would have special courses in technology given by men who would make it their business to keep in close touch with modern practice.

Surely, it would be possible to take the few chief reactions which underlie the organic chemical industry and talk of these in such a way that both theory and practice would become evident. That is really the kind of technical course which I would endorse.

The chemical industries have been asked to aid by opening their laboratories and plants to the student. The problem is no easy one. It should be remembered that the expense, direct and indirect, of having a student in the industry is very considerable; the return is not so evident. The subject must be discussed further before any general policy can be followed; the industries will certainly meet the teaching profession halfway.

With regard to the rest of the curriculum, what should be done is to introduce as far as possible those subjects which will round out a man rather than make him a specialist while yet he is an undergraduate. Water analysis may be important, but if it is to be given at the sacrifice of a good course in English, let the English take the place of the water analysis. The same treatment would apply in the case of a number of those courses which are essential applications of chemical technique, rather than intended to widen the student's horizon. This brief comment is all that is allowable here.

The teaching of research is a very high art, and this subject deserves more encouragement in our universities. The fact is that our emphasis is on the teacher rather than the research man, as it most certainly ought to be, but, at the same time, this does interfere with the development of research schools. And research schools are of the very first importance to the development of the science—they are places where the student, working with a number of others, becomes filled with the spirit of research. It was the atmosphere of such schools that made possible the ascendency of Germany in chemical matters. There are men who are much more valuable to the country as leaders of research than as teachers of any subject, and these men should be freed, in so far as possible, from any routine teaching. They will, from very love of their subject, do a great deal of work which is essentially educational. They must, in fact, in order to be leaders of research, but they should not be tied down by any rigid requirements of hours laid down by the directors of the institution in which they are. Furthermore, I should like to see help given to those men who show real ability as investigators while yet they are young, this help to be given before they lose heart and consent to relinquish their dreams of developing really important new lines of research. Let us try to remove the cause of the disheartening feeling that it is not research quality but quantity which is made the criterion of a man's ability. If two men apply for a position, the one that can say he has published ten papers is likely to get it, if the other man can lay claim to only three. Yet those three papers may show a capacity for thought and originality entirely foreign to the numerous articles of his competitor. I have thought that much might be done by the SOCIETY if they would organize some body which would have for its purpose the endorsing of particularly good research, and one which would bring meritorious investigations to the attention of the executives of the institution in which they were done. It seems to me that this would work a great betterment in conditions. To be endorsed by the SOCIETY would mean that a man was recognized, and that students would feel if they went to him that they would be in proper hands. At present, the student looking for a research problem usually drifts to the head of the department, a state of affairs which is not one to encourage the younger men unless they are glad to admit that the head of the department is really the best research man there.

When all is said and done, I feel that we might well adopt the plan which has been so successful in Germany of having institutions set aside for research alone. These should be supported by states and the industries, but should be under no obligation to do research for any special purpose. Their only restriction should be research within the widest interpretation of the science assigned to them.

After the research work is done at the university, the man enters the industry and becomes of immediate interest to us. Can we not improve our methods for handling these men? I feel that the industries are not yet willing to put the emphasis in their research laboratories on research ability as against executive capacity. Both have their place, but actually the former is more important than the latter. What is done is rather to show appreciation of a man's research ability by pushing him into an executive position which, because of its routine duties, prevents his further growth and is a direct loss to everyone.

Another suggestion that I would make is that in those cases where there are a number of technical research men in a laboratory an effort be made to consider this as a school, and a mature man chosen to instruct the less mature men, so that they may have something better than their own mistakes to lead them to improvement. This is an extremely important subject, but in itself would take more time than is available for discussion.

All that I have said of research education is far from conveying my feeling of the intense importance of the subject. I think the SOCIETY has an excellent opportunity of aiding in this matter of national interest. I should like to see, as a beginning, a section devoted to educational subjects where teachers and those who use the products turned out by the teachers could meet to discuss their different views and to formulate plans for betterment.

In concluding I should like to have it understood that I am fully cognizant of the difficulties of teaching, of the trials and disappointments of the profession. I do not wish to seem unreasonable when I say that there is room for improvement before our research men can be all that they should be. Only by having the finest workers in the field of science can we feel entirely secure of our future among the nations. No effort is too great, nothing too small, if it helps to realize the hope that chemistry may come into its own as the most important of the sciences, as a part of that sum of human knowledge which will do more than all else to make life worth living.

QUALIFICATIONS OF ORGANIC CHEMISTS[1]

By M. L. Crossley

CALCO CHEMICAL COMPANY, BOUND BROOK, N. J.

The training of chemists for the organic chemical industry has received considerable attention of late, but it seems to me that their qualifications have not been sufficiently emphasized. A university training is not and should not be considered a sufficient guaranty of the proficiency in chemistry necessary to an understanding and appreciation of the complex problems involved in the manufacture of organic chemicals. It is not the function of an educational institution to produce expert professional men, but rather to train men to think and to orientate themselves advantageously in their environment. To qualify as an industrial chemist, a man's training must be augmented by experience gained in the chemical industry.

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[1] Read before the Division of Dye Chemistry.

During the past few years it has been found necessary to employ men of limited chemical ability and experience, giving them responsibilities which some were unable to appreciate. From the experiences of the past few years we emerge with certain definite convictions concerning the qualifications of chemists for the organic industry.

DESIRABILITY OF A LIBERAL EDUCATION

The man who best understands the past is the man best prepared to evaluate the present and anticipate the needs of the future. Human progress has been slow and difficult. It is unraveled only by a diligent study of the several mediums of human expression. We must convince the public, for in the final analysis the public determines the curicula of our schools, colleges, and universities, that three essential reforms are needed to-day in our system of education—(*a*) less specialization in secondary schools and in the first two years of college work; (*b*) more thoroughness in the teaching of the fundamental studies; and (*c*) a better correlation of studies.

M. L. Crossley

Specialization at too early a period in one's training narrows his intellectual horizon and limits his perspective of world problems. By the time the boys get to college to-day, they are chronic mental dyspeptics. They have had much intellectual hash thrown at them, some of which they have picked up, but very little of which they have retained. The fundamental structure of knowledge, to which they would dovetail the superstructure, is missing. The results are not gratifying. In the future we must insist on a more thorough training in the fundamental studies, particularly in the secondary schools. The efficiency of our educational system can be enhanced by a better correlation of studies and demonstration of their unity of purpose.

The consumer of education's product is responsible for its quality. A liberal education is the best foundation, in my judgment, for scientific work. It cultivates and disciplines the imagination, and is essential in developing a critical and impartial judgment. I believe it was K. Pearson who said that "A disciplined imagination has been at the bottom of all great scientific discoveries." Observation makes possible an outline of the picture and imagination fills in the details, thus completing it, but the composite product of observation and imagination might be a mirage and must be checked by an impartial judgment.

KNOWLEDGE OF FUNDAMENTALS OF CHEMISTRY ESSENTIAL

A knowledge of the fundamentals of chemistry is absolutely essential. The chemical industry will train their chemists to do specific work, but it is imperative that the universities supply them with men who have a sound and thorough knowledge of the fundamentals of chemistry and its allied sciences. It is not sufficient that young graduates have a knowledge of chemical facts. They must also be trained in the methods of research and have an appreciation of its value. We should suggest to our colleges and university faculties that the time now given to industrial courses in chemistry can be more advantageously spent in a thorough study of fundamental organic reactions, quantitative analysis, physicochemical principles, and in a study of the relation of chemistry to world progress. The outstanding weakness of the young college graduate is not his lack of knowledge of industrial processes, but rather his inability to apply fundamental principles to a solution of the problems in hand, particularly when this involves any analytical concept. Industrial research must be thorough. All products of a reaction must be identified and quantitatively determined. The main question is not, "Has a reaction taken place," but "Is it a profitable method of making the product, and what is the mechanism of the reaction?" Can a better method be developed which is simpler and cheaper?

An organic chemist must have his powers of observation highly developed. This should be an essential part of his training. There has been too little attention paid to original and accurate observation on the part of the student. It is only by experimentation under proper guidance that a student gains self-reliance and thus strengthens his powers of initiative. By a too close study of a textbook he learns to rely on authority and neglects his own powers of observation and ability. Initiative is indispensable in an industrial chemist, who is responsible for the creation of processes which must be profitable. Initiative is that dynamic force which is necessary to compel a man to venture beyond the border line of certainty into the unknown and dare to show his individuality. Creative work is impossible without it. Of course the university cannot be expected to create either the powers of observation or initiative in students. These qualities can only be developed. The student must possess them as inheritances. I believe it was Paracelsus who first said that "The power to recognize and value truth cannot be conferred by academic degrees."

The savage was undoubtedly a keen observer, but his interpretations of his observations were not always good for those less savage than he. The university teacher must impart to his students dexterity in experimentation, accuracy, and precision in recording observations, and must cultivate in them an appreciation of the importance of facts. To see and to think are equally important. Facts are the building stones of chemistry. The university must train chemists in the method of grouping and associating facts for retention. Important facts must be memorized and the student must be trained to distinguish quickly relevant from irrelevant facts. Incoherent thinking is usually the result of careless observation and faulty grouping of facts. A chemist must be capable of reading foreign languages—at least German and French—and must have a thorough appreciation of the value of chemical literature. He must be trained to abstract scientific information from the technical journals; to arrange his information systematically in an orderly report; to make a critical study of it; to interpret its meaning, and to apply the results either in shaping the course of research or in interpreting experimental results. No intelligent research can be conducted on any problem until the investigator is familiar with all the work previously done by other investigators on the same or allied subjects.

CHARACTER AN INDISPENSABLE QUALIFICATION

Character is one of the most essential qualifications of a chemist. However much chemistry a man knows, if he is dishonest, particularly in his thinking, selfish, jealous, untruthful, immoral, lacking in ambition and in other essential attributes of character, he will find no place in the chemical industry. If he has character, he may overcome other limitations. He must also be ambitious, for without ambition he is like a candle without a wick. Both fall down under fire. Loyalty to ideals is also essential. Without loyalty a man gives up at the first sign of discouragement. In research, one must have ability to recover from the shock of discouragement and will to try again with undaunted spirit. Of course the young chemist does not ever consider the possibility of failure, and when failure comes he is taken by surprise. The valuable man in an organization is he who recognizes that it is not necessarily a mistake which leads to failure, but rather inability to profit by the mistake. An error in judgment places one man on guard against a similar occurrence, while it unnerves another. It is essentially the function of the institutions of learning to eliminate the undesirable in the process of education. An academic degree should be an endorsement of a man's character as well as an affidavit of the amount of training he has had.

GRADING BASED UPON EXPERIENCE DESIRABLE

The industries must grade chemists in accordance with their experience. Men who have had the required training and who meet the other qualifications should be appointed first as junior chemists to serve at least two years before being promoted to the grade of assistant chemists, and at least three years' experience should be required before promotion to the grade of chemist. The title of chemist should mean something and should not be indiscriminately applied to all men, irrespective of their training and experience, who are employed in any way in connection with chemical activities. This or a similar system of grading chemists is essential if the profession is to receive the recognition which it deserves from the industries. The principle herein emphasized is in operation, I believe, in the Bureau of Chemistry, and in at least one laboratory connected with a chemical manufacturing plant. To be effective, however, any system must be general. Coöperation is needed among the employers of chemists to bring this about. No great achievement is possible in any department of human endeavor unless all the forces working toward a common end are coördinated and made one in purpose and action.

SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES

"The Best Yet"—This phrase expressed the unanimous opinion of those who attended the Sixth National Exposition of Chemical Industries, at the Grand Central Palace, New York City, during the week September 20 to 25, 1920.

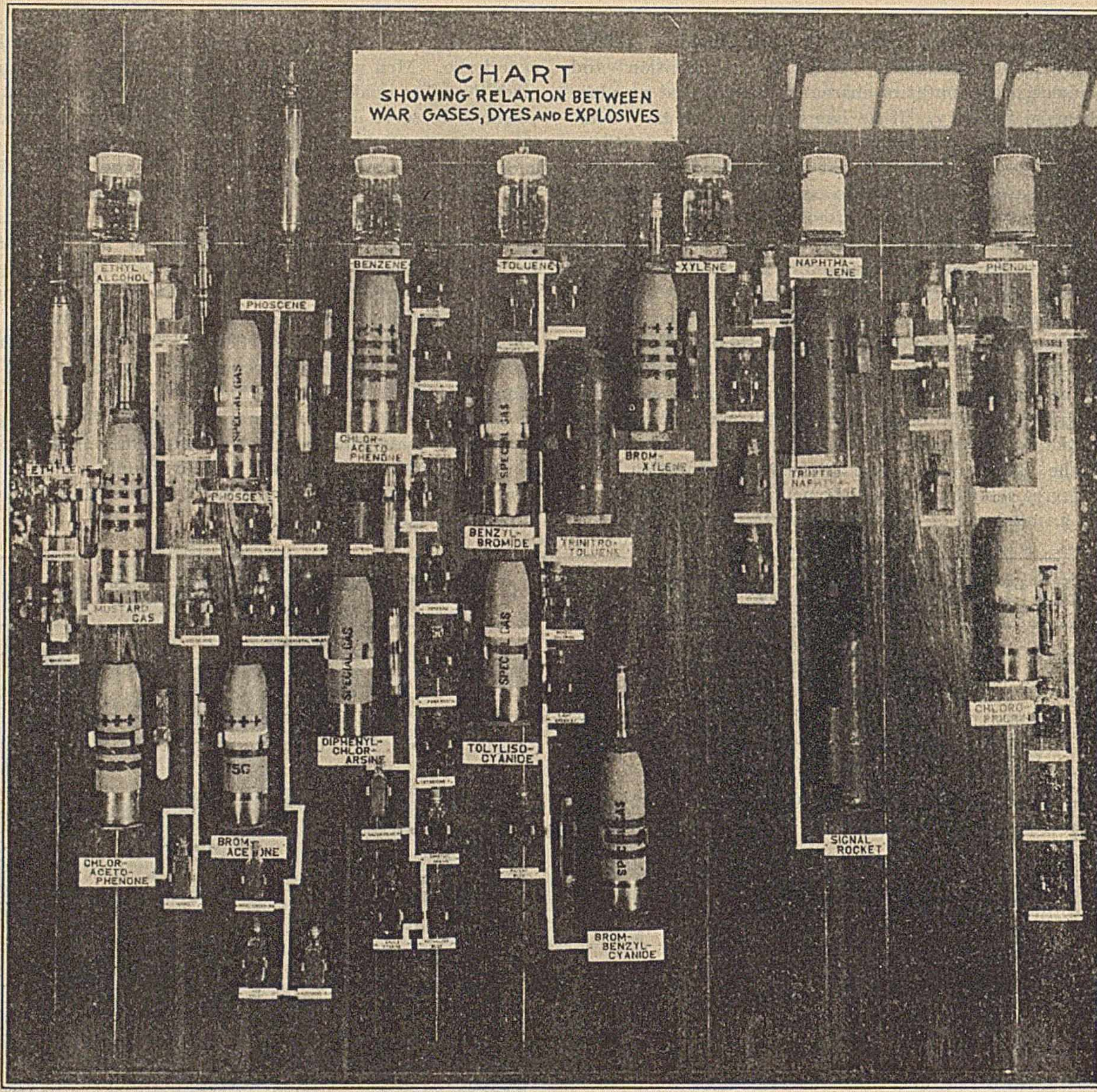
Many factors contributed to that enthusiastically favorable verdict. First and foremost was the total number of exhibitors, 457 as compared with a maximum of approximately 300 in previous years, a ratio which typifies the increasing magnitude and diversification of the American chemical industry. An attendance of over 125,000 thoughtful citizens clearly evidenced the constantly increasing popular interest in the work of our chemists. More thought had been given to the question of appropriate display, and more funds had been expended in transforming these thoughts into concrete form. So, too, the stenographer type of booth attendant, all too mistakenly prevalent in the past, was replaced by technically trained representatives of the exhibiting organizations, the result necessarily being an improved standard of "dope," to which in turn appreciative visitors listened with earnest attention. "The Show" is certainly a great educator.

The auditorium on the fourth floor was filled not only during the attractive "movies" depicting the intricacies of chemical industries, but also during the delivery of addresses at the symposiums on timely topics. Evidently the spoken word firmly holds its place in the Exposition program, despite the noise of nearby machinery in operation and the temptation to mingle with the crowd in the inspection of exhibits.

PUBLIC EDUCATION

If we were asked "What is the most striking outcome of the Sixth Exposition?" we would unhesitatingly answer—the education of the public on the subject of the intimate relation between dyes, synthetic medicinals, explosives, and toxic gases. There were a number of exhibits which brought this out clearly. The most effective were those of the Chemical Warfare Service, about which hung a constant throng, and of E. I. du Pont de Nemours & Co., where Dr. and Mrs. R. E. Rose, Dr. H. A. Lubs, Mr. E. W. Pierce, and Dr. West explained this relationship by means of formula models of the variety exhibited formerly only on the lecture tables of organic chemistry. It was a daring conception, and had we been asked to play the role of prophet, we would have predicted failure—

Models Showing Relationship between Dyes and Explosives



Chemical Warfare Service Chart Showing Relationship between Dyes and Explosives

but the public "ate it up." Dr. Rose used both his voice and his facile pen. The latter found expression in a fascinating booklet, "Molecules and Man," which was eagerly read.

The booklet distributed by the Texas Gulf Sulphur Company contained an interesting story of sulfur in the Southwest, but an equal number of pages was devoted to the physicochemical properties of sulfur. Highbrow stuff? Not at all, but a clear indication that the Exposition idea is developing a broader and sounder basis.

Another development of this year's Exposition was the increased use of models by those whose equipment is too bulky for display under booth restrictions of space. Among the many models were the working model of a rotary dryer exhibited by the Ruggles-Coles Engineering Co., a complete water softening outfit by the Permutit Co., an acid tank car by the General Chemical Co., a hydrochloric acid plant in operation at the General Ceramics Company's booth, and a new form of still for destructive distillation shown by the Fuel Products Corporation.

NATURAL RESOURCES

Accustomed thoughts of Florida as the home of citrus fruits and early truck gardens were displaced at the booth of Buckman, Pritchard and Co., where we gained for the first time an impression of Florida as a source of minerals. Titanium and zirconium ores are now being gathered in large quantities and of high purity from the sands of the East Coast.

The mineral exhibits from the South were not confined to Florida. The city of Knoxville again displayed the resources of those portions of Tennessee adjacent to that enterprising city; while the Southern Railway System and the Mobile and Ohio Railroad Co., through an elaborate exhibit prepared in coöperation with A. D. Little, Inc., and explained by talented representatives of that organization, showed a great field awaiting the chemist's hand for its development.

Natural resources again came to the fore in the group of Canadian exhibits. The Ontario Bureau of Mines, the Canadian Pacific Railway, and the Dominion Water Power Branch set forth these resources with attractive displays of charts and minerals, while the industries using the power at Shawinigan Falls showed the utilization of natural power in the conversion of raw material into useful chemical products.

Tremendous strides have been made in the number of applications of stellite since the first public inspection of that alloy afforded by Mr. Haynes just ten years ago during a journey of chemists to the San Francisco meeting of the American Chemical Society.

The Semet-Solvay Co., the Solvay Process Co., the General Chemical Co., the Barrett Co., and the National Aniline and Chemical Co., Inc., staged what was practically a joint exhibit, typical of the organic relationship into which these companies are now entering. Included in the exhibit was a living room completely outfitted with National dyes, from rugs, curtains, and clothing on the wax figures to the smallest toy among a child's playthings, and the food on the table.

The Newport Chemical Works, Inc., showing "Newport all the way" products on living models, failed to cover the subjects as completely as had been done in an adjacent aisle; nevertheless its exhibit was an attractive feature of the first floor.

At every turn one saw exhibits of dryers, evidencing the growth of the dye industry.

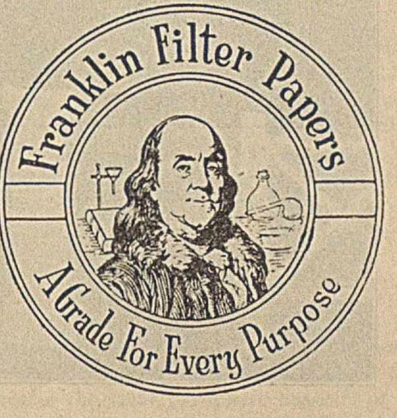
Peace application of a war development was easily recognizable in the number of exhibits of industrial gas masks. It is very clear that here a long-felt industrial need has been filled.

In the 1920 display of the Buffalo Foundry and Machine Co., each piece of apparatus represented either a new development or an improvement over apparatus shown at former Expositions.

NEW DEVELOPMENTS

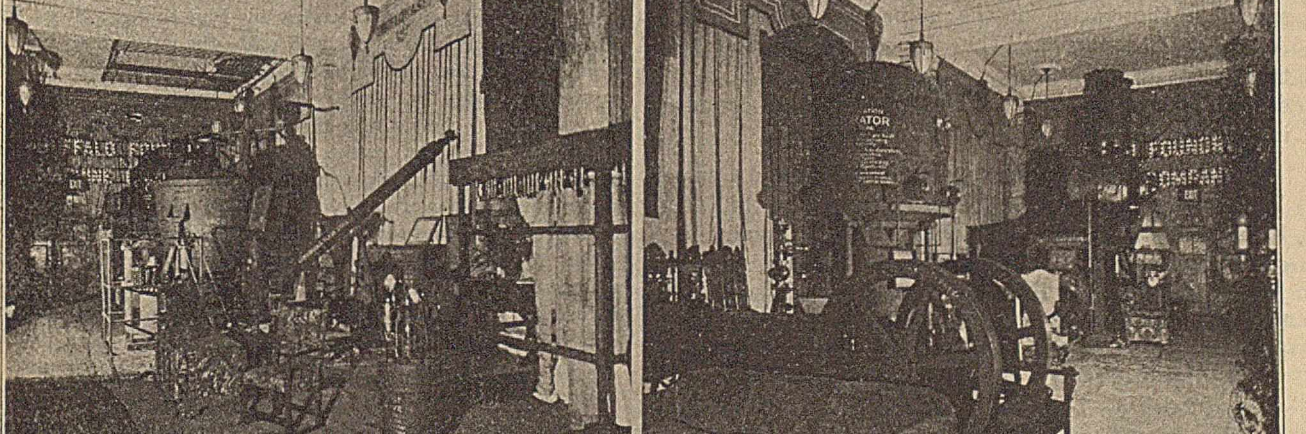
Two very recently developed combinations of chemistry and art were shown. The Dow Chemical Company exhibited a number of oil paintings and water colors showing exterior and interior views of the plant. These were done by the British artist, Mr. A. H. Knighton Hammond, who seems to be a pioneer who has seen in a chemical plant fit subjects for the best work of an artist. On the other hand, the Eastman Kodak Company exhibited a series of paintings in which the application of chemical and physical principles gives a new power to the artist. For instance, an exquisite landscape scene, to the eye of the casual observer, when viewed through a ray filter became an equally artistic painting of the American national emblem. The artist, Mr. Charles Bittinger, in his choice of pigments had made application of the principle of invisible spectral differences of color and practically hidden one picture in the other, to be disclosed when viewed through properly filtered light.

The only unfortunate incident of the week was the masquerading of a lot of filter paper of indefinite but undoubted German origin. No marking indicative of German origin was visible, but in reply to direct questioning by two exhibitors the attendant at the booth admitted that the "Franklin Filter Paper," exhibited by the Rohde Laboratory Supply Co., was made in Germany.

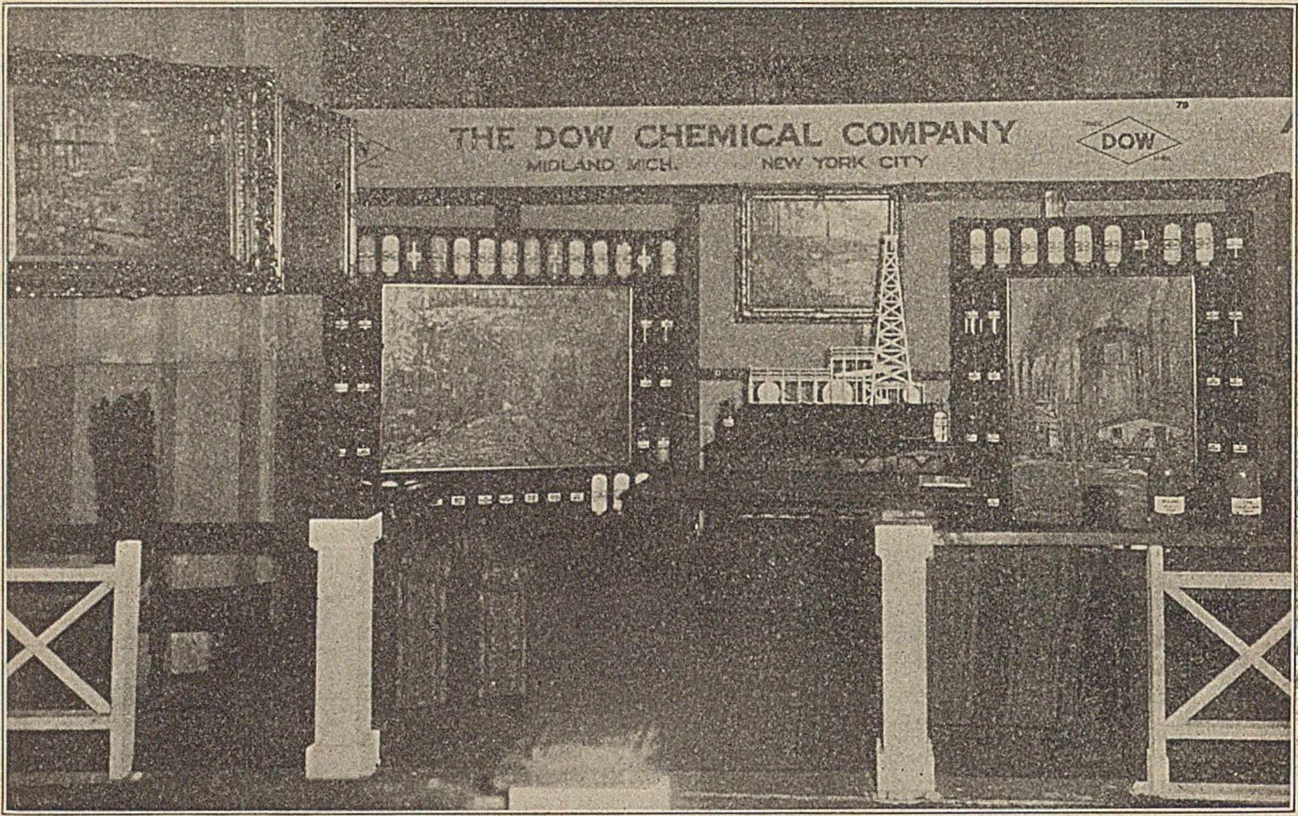


This use of a good American's name to exploit a German product in a *National* Exposition of Chemical Industries bore out faithfully the prediction of the German engineer Herzog, who in 1918 in his book on "The Future of German Industrial Exports" wrote:

> "The German makeup is to be avoided wherever at all feasible out of regard for the rehabilitation of trade with formerly hostile countries. The German garb of manufactured articles must be put away."



Sections of the Buffalo Foundry and Machine Company Exhibit



THE DOW CHEMICAL COMPANY

[This extract is taken from the widely circulated translation of the book.] When the attention of the management was called to the display it was at once ordered removed. It was being shown in the booth of another exhibitor without the permission of the management.

FUTURE POLICY

This incident led to the formation of a definite future policy at the annual dinner given by the managers to the Advisory Committee on the last night of Exposition week. No exhibits of other than American origin will be permitted in the future except upon special authorization of the management and of the Advisory Committee. The Exposition will be held true to its original ideals, a setting forth to America of what her chemists are doing for American chemical independence.

It is a matter of regret to all that the Grand Central Palace is soon to be converted into an office building. It is fortunate, however, that there is available a great building, the Eighth Coast Artillery Armory, Jerome Avenue and Kingsbridge Road, easily accessible by the subway and elevated lines, and having much more space on one floor than was occupied by the entire Exposition just held. In this new location the "first floorers" will no longer hold the advantage over those who have had to be content with the higher tiers. Without this new building the Exposition would have had to be abandoned or a great many exhibitors excluded, for it was found that Madison Square Garden with all of its balconies the restaurant, etc., equaled in surface area only the first two floors of the Grand Central Palace, while the two next largest armories in the city contained less square feet for exhibition purposes than the main floor of the Palace.

"On with the Show!" Its stimulating effect upon the American chemical industry increases yearly, while its value as a public educator is inestimable.

OPENING ADDRESS

By Chas. H. Herty

CHAIRMAN OF THE ADVISORY COMMITTEE

The alchemist sought in secrecy his Philosopher's Stone with which to convert base metals into gold—the iatro (drug) chemist who followed the alchemist purposely shrouded his work in mystery, thinking that thereby he could practice best his fancied wizardry. The chemist of to-day, however, casts aside these false standards, takes the public frankly into his confidence and applies in his daily work common sense of the most thoroughgoing quality to every problem in which his talents can benefit humanity. The outward expression of this modern policy, in which America leads the world, is this annual display of the raw materials, the machinery, and the products of our chemical industries. That the story has its popular appeal is attested not only by the thousands who thoughtfully inspect these exhibits, but by the constantly increasing space given by our press to matters chemical.

It is a matter of special interest at the present time to note the amount of space devoted to preliminary accounts of this Exposition by the press of our neighbors in Central and South America. This is clearly indicative of a conviction on the part of the people of these countries that instead of looking to Germany as in the past, they must now look to America for the products of the chemical industries. This great field for export trade can be made permanently ours if we show constant good faith, high quality of products, attention to local desires, and care in shipments. These are better assets than the most elaborate programs of propaganda and subserviency to unrighteous political purposes which once permeated these markets.

PARTICIPATION OF RAILROADS

The most striking feature of the present Exposition is the reappearance of the exhibits by railroads of the natural resources along their lines. These displays locate for the chemist hitherto unknown sources of raw materials or set forth undeveloped resources which singly or in combination under the guiding sense of the chemists can be utilized to increase the national wealth. We are recovering from the blow dealt our industrial development by the absurd policy of the recent Railroad Administration which decreed a cessation of such exhibits. Fortunately, private ownership of railroads takes a more intelligent and progressive view of this important matter. Congratulations to those progressive railroads which have reinaugurated these exhibits! Their example will no doubt be followed by many others at the next Exposition.

AUTHORIZED CAPITAL AND EXPORTS

The possibilities for development of the chemical, drug, and dye industries are indicated by the authorized capital of the new companies organized during the past six years. These amounts, according to the *Journal of Commerce*, September 4, 1920, were as follows:

1915	$ 65,565,000
1916	99,244,000
1917	146,160,000
1918	73,403,000
1919	112,173,000
1920 (8 mo.)	167,992,000

In addition to supplying domestic needs, government statistics show that during the past fiscal year our exports of chemicals have been distributed in all of the principal countries of the world. The total value of these exports was $1,250,000,000. It is of particular interest that the products of our young dye industry were shipped in quantities whose valuation totaled $24,000,000.

NEED OF LEGISLATION

We must not be misled, however, by the foregoing figures. Those referring to capitalization represent *authorized* capital, not actual capital invested; they represent the confidence of American citizens in the great future of the American chemical industry. The magnitude of our dye exports is not indicative of a complete, self-sustained and well-rounded dye industry, but rather it is the concrete expression of the innate ability of the American to do on a large scale that which he has learned to do. Many gaps are yet to be filled before that industry is complete. We must candidly face the fact that during the past six months there has been a decided slowing up in our chemical development. The execution of many completed plans for expansion has been postponed because actual capital has been timid. Why? Because Congress adjourned in June last without enacting into law any one of those several measures whose purpose was the protection and safeguarding of those industries which had sprung into being to fill the nation's obvious needs as affected by the exigencies of war.

A damaging blow has been dealt by our legislative representatives through their inaction. It is not difficult to imagine the satisfaction which this situation gives to those who formerly boasted of their domination of us in matters chemical and who now openly avow their determination to recover their lost markets. To all who have read the revelations of the base use to which that former domination was put through corruption of our industrial life and through the establishment of a complete system of espionage which for a long time in a critical period misled public opinion and crippled our effectiveness by sabotage made easy, this prospect of a recovery of markets can be looked upon only as an impending national curse. The warding off of this peril, however, is not difficult. The case has been fully presented to the Congress, a great majority opinion, absolutely non-partisan in its character, has been developed, the House of Representatives has already acted favorably, but the Senate has failed to act. Public opinion should make itself felt—for the vital interests of the public are at stake—and insist that at the approaching winter session of the Congress this legislation be completed. If this be done, I prophesy a new era in our chemical development, which will make the successes of the past five years pale into insignificance and guarantee forever the economic independence of this country in all lines of chemical industry.

These thoughts apply particularly to our dye industry. Here much has been accomplished, progress has been phenomenal, yet much remains to be done. We cannot afford to delay the completion of this industry, for it is too intimately bound up with a vast number of our other industries and stands too closely knit with that latest development of warfare upon which our country's future safety may depend. It is a short-sighted and ill-informed American who is impatient and complains because our dye industry is not yet completely rounded out.

THE FOOD OF THE NATION

Of the three essential constituents of plant food, phosphorus, nitrogen, and potassium, nature has abundantly blessed us with phosphorus in the form of the great phosphate deposits of our southeastern and northwestern states, but our efforts to provide domestic sources of nitrogen and potassium have proved ineffectual.

Whatever mistakes may have been made in our past efforts on fixation of atmospheric nitrogen, that industry must be established. The use of nitrogenous compounds in peace as a fertilizer and in war as an explosive points clearly to the fact that we cannot afford to continue dependent for such supplies on ship transport from outside our borders. The submarine has demonstrated its ability to destroy selected ship-commerce, and submarines can ply in the Pacific as well as in the Atlantic Ocean.

In potash matters we have played a losing game. In the false hope of a return to the cheap foreign potash of pre-war days, we have withheld that encouragement and stimulation of our domestic potash industry which would have assured the full development of our own resources, and now we are paying tribute to the extent of millions on millions of dollars. Where thousands of dollars have been spent on research on potash and its development, millions could have been spent whose total amount would not be a tithe of the millions we seem destined to pay as tribute unless our policies be quickly changed.

INDUSTRIAL RESEARCH

In other lines, however, the progress of industrial research has been phenomenal. Conservative estimates place the amount to be expended this year on industrial research laboratories, personnel, housing, and equipment, at $25,000,000. Evidently our industries as a whole are passing out of the empirical stage and are realizing that the greatest progress is to be made through scientific development and accurate control. On the journey of the American Chemical Society to San Francisco in 1910 I was shown a new alloy which at that time had found no industrial application. To-day, however, that alloy and similar ones have increased the output of our machine shops threefold, because with the same number of men and the same amount of equipment, machines can be run three times as fast. It is not difficult to understand how great a role this one development played in the rapid equipment of our armies during the war.

And this bit of history suggests the possibility of overcoming the present inefficiency of labor through research on improved methods of operation of all lines of industry. Increased production through greater utilization of chemistry is a phrase which America should take deep to heart.

ALCOHOL EXCISE TAX

In this survey of present-day conditions, may I direct your attention to one anomalous situation? Alcohol is one of the most important reagents used by chemists. Congress recognized this fact in the enactment of the National Prohibition Act, which, while providing for the abolition of alcohol as a beverage, nevertheless made distinct provision for stimulating the production and facilitating the distribution of tax-free alcohol as a chemical reagent. And yet a recently enacted law in the state of New York, the very heart of chemistry in America, imposes an excise tax of thirty cents per gallon on that alcohol which the Congress provided should be, from the federal standpoint, tax-free. No other chemical reagent bears a similar tax. That law constitutes a hardship upon our industries and our universities, and it is sincerely to be hoped that the State Assembly will promptly repeal such a crippling and unjustifiable measure.

COÖPERATION WITH THE CHEMICAL WARFARE SERVICE

Now let me make an announcement of greatest import to our country. The Congress, during its last session, in framing the Army Reorganization bill, constituted by an overwhelming vote the Chemical Warfare Service a separate and independent unit of the Army, in the conviction that it could thus be developed most effectively. At its head the President has placed that brilliant soldier, Brigadier General Amos A. Fries, who led the field forces of that Service with the American Expeditionary Forces. Upon invitation of General Fries, the AMERICAN CHEMICAL SOCIETY has pledged the active aid of its 15,000 civilian members in the successful development and prosecution of the work of the Chemical Warfare Service. The connecting link between that army of 15,000 silent workers in the laboratories of America and the official service in the War Department will be a committee consisting of:

W. D. BANCROFT, Dept. of Chemistry, Cornell University, Ithaca, N. Y.

E. P. KOHLER, Dept. of Organic Chemistry, Harvard University, Cambridge, Mass.

A. B. LAMB, Dept. of Chemistry, Harvard University, Cambridge, Mass.

R. C. TOLMAN, Fixed Nitrogen Research Laboratory, Washington, D. C.

F. M. DORSEY, Nela Research Laboratory, Cleveland, Ohio

W. K. LEWIS, Dept. of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

L. T. SUTHERLAND, Sutherland Industrial Research Co., New York City

BRADLEY DEWEY, Dewey & Almy Chemical Co., Cambridge, Mass.

L. C. JONES, National Aniline & Chemical Co., Inc., New York City

C. L. REESE, E. I. du Pont de Nemours & Co., Wilmington, Del.

W. H. WALKER, Division of Industrial Coöperation and Research, Massachusetts Institute of Technology, Cambridge, Mass.

REID HUNT, Dept. of Pharmacology, Harvard Medical School, Boston, Mass.

A. S. LOEVENHART, Dept. of Pharmacology, University of Wisconsin, Madison, Wis.

JULIUS STIEGLITZ, Dept. of Chemistry, University of Chicago, Chicago, Ill.

CHAS. H. HERTY, Journal of Industrial and Engineering Chemistry, New York City.

In this list are men whose brilliant work accomplished such wonders in the manufacture of gas masks for defense and gases for offense. The laboratories of our universities and of our industries are both represented. So, too, are the representatives of our dye plants included. I count it the highest honor of my life that I am to be permitted to serve my country through the chairmanship of this committee. I feel no hesitation in pledging to General Fries not only the united coöperation of the chemistry personnel of the country but also that of our industrial chemical plants.

Chemical warfare has come to stay. The effectiveness of gas in warfare has been proved by the fact that one-third of the total hospital cases in our Army were due to gas; its inhumanity has not proved itself in the light of history, for of this third our medical records show that the very great majority completely recovered, a far greater proportion than of those who were wounded by shot and shell. The fear of tuberculosis development among our gassed wounded has been proved baseless.

This happy outcome as to recovery removes in no wise the stigma which will always attach to Germany as the introducer of gas warfare. The heinousness of her offense against civilization lay in the breach of good faith in international agreement that gases would not be used in warfare. By this treacherous initiative she was enabled to destroy thousands of men of those nations who in good faith had provided no means of defense against such a means of warfare. America proposes to see to it that should her armies ever be called upon to take the field again, which God grant may never come to pass, those armies will be furnished immediately with the best means of defense which American ingenuity can in the meanwhile devise, and with an abundance of gases which will be immediately forthcoming, limited only by the resources of our land. These steps will constitute no tax upon our people in time of peace, but preparedness along this line of warfare will be thorough.

The *New York Times* of to-day discusses the subject of chemical warfare in an editorial entitled "A Chemists' War." In this editorial there are two noteworthy errors; one as to fact, the other as to national policy as I see it.

As to the question of fact, the *Times* states: "It was difficult to interest Congress in the establishment of a permanent Chemical Warfare Service Bureau, to be attached to the War Department." The fact is, as the public records show, there was no difficulty in convincing Congress on this point. The difficulty lay, however, in the objections by the Secretary of War and the Chief of Staff in statements made before the Senate Committee on Military Affairs. The action of Congress in establishing the Chemical Warfare Service as a separate unit of the Army was taken in spite of these objections.

As to the question of policy, the *Times* at the conclusion of its editorial says:

> It cannot be impressed upon civilized peoples too much that a chemists' war would be incalculably more disastrous to the nations engaged in it than the struggle of 1914–18. The American people must ask themselves whether they can afford to disregard the conviction of the thirty-nine countries now forming the League of Nations that it offers the best safeguards against the horrors and waste of modern war.

This recalls an interesting colloquy which took place between General March and Senators Chamberlain and Sutherland in the Hearings on S 2715, pages 95 and 96.

> GENERAL MARCH—Here they are, sir. That is my best thought on that subject. If the provision in the so-called league of nations, which prohibits the use of poison gas is carried out, all of that will disappear.
>
> SENATOR CHAMBERLAIN—If the provisions of the league of nations were carried out, we would not need any Army.
>
> GENERAL MARCH—I do not see that.
>
> SENATOR CHAMBERLAIN—We are going to have peace; the millenium is going to be here. I have not any idea it will all be carried out.
>
> SENATOR SUTHERLAND—We have already had some agreements about humane warfare, but none of them were carried out.
>
> GENERAL MARCH—That is true, but this provision specifically says that, the use of poison gas having been prohibited, Germany is forbidden to import into her territory any of the elements

which make for poison gas or liquid gas, which is forbidden, the thought being that Germany was the only nation in the world that would start any such thing.

SENATOR CHAMBERLAIN—Well, I think there are others, if they had had the chance.

The provision in the Peace Treaty by which, according to General March, "Germany is forbidden to import into her territory any of the elements which make for poison gas or liquid gas" doubtless gives to the Germans the same sense of despair that America would feel if, at the conclusion of an unsuccessful war, it were forbidden "to import" cotton for use in the manufacture of guncotton or iron ores for making steel for guns.

COÖPERATION IN CITY DISASTERS

Coöperation should, however, not be confined to national affairs. Within the last few days a terrible disaster has occurred in New York City. As a result of the work of perverted minds, many citizens were instantly killed and many more horribly mangled. The evidence which would determine the cause of such a disaster and trace its perpetrators is largely chemical. The time to utilize the chemist in such a situation is immediately after the disaster takes place. In the New York Section of the AMERICAN CHEMICAL SOCIETY more than two thousand chemists are numbered, among them men who are specialists in explosives, in metallurgy, and in cement. No one of these men, no matter how prominent or how immersed in his own laboratory, could as a patriotic citizen decline an invitation to serve on a committee advisory to the city authorities in such cases of great disaster. Provided with official passes through the police lines they could be of invaluable service through their special knowledge and acumen. For such public service they would desire no pay. There is a civic asset here which is lying neglected and which can be quickened into dynamic aid by a simple request from the municipal authorities.

COÖPERATION IN THE ALLEVIATION OF HUMAN SUFFERING

Fortunately the future energies of our chemists are not to be confined to increasing the wealth of the country and providing means for its defense. There is a higher goal ahead for American chemistry, it is the alleviation of human suffering. The normal, healthy, vigorous human being is a mass of chemical reactions which can be called normal. When these become abnormal we speak of disease, and disease entails suffering. About many of these subtle changes we know little. In our blind efforts to restore normality we try this and that drug, sometimes with success, many times with utter failure. Eminent authorities inform me that of the many synthetic medicinals sold by Germany to this country only from three to five per cent have proved of real value. We know in general terms the results from the use of drugs, but of the fundamental reactions induced by their use we know but little. These changes in the body effected by drugs are chemical changes, but in their study in the past the chemist has played but a minor part, and we have been content to continue the "cut and try" process in our efforts to heal. It is now proposed to give the chemist the leadership in this his own line of research. But he is not qualified to work out the problem alone, for the conditions are very complex. He must be associated with the pharmacologist and the experimental biologist With the focusing of these three types of mind upon the problems of health, under conditions of constant association and adequate experimental facilities, real progress can be made, even though slowly, in the alleviation of suffering. It is a task worthy of the best efforts of our very ablest men. Funds will be required for its prosecution. Fortunately the Chemical Foundation, Inc., which under its charter must spend all above six per cent of its earnings on scientific research, sees in this direction the channel through which it can best perform its mission. It has therefore pledged a sufficient amount for immediate use to insure the inauguration of this work. It is confidently believed that as the work takes definite shape and progresses it will make its own appeal to those generous Americans who have never yet failed to respond to the cause of humanity when convinced that the right way to aid has been shown them.

PROGRESS OF THE AMERICAN COAL-TAR CHEMICAL INDUSTRY DURING 1919

By Grinnell Jones

CHIEF CHEMIST OF THE U. S. TARIFF COMMISSION

A year ago, the annual census of dyes and other coal-tar chemicals, prepared by the Tariff Commission, was published on June 11. This year it has been unavoidably delayed owing to the fact that a general census of manufactures of all kinds is being taken by the Bureau of the Census. In order to avoid having two different branches of the Government each send its questionnaire to every manufacturer, it was arranged that the collection of the reports should be undertaken by the Census Bureau, whereas the tabulation and interpretation of the reports on dyes and coal-tar chemicals would be done by the Tariff Commission. The Census Bureau has secured reports from a number of small manufacturers who were unknown to us. However, the collection of the reports has been much delayed by the coöperative arrangement, and the reports of over a dozen firms have not yet been turned over to the Tariff Commission. However, the missing reports are all believed to be of small firms. I am confident that our records are sufficiently complete to show clearly the progress made during the year, but any figures given are subject to revision upward.

The Geological Survey has recently reported that the production of by-product coke and the by-products obtained therefrom during the year 1919 shows a slight decrease, as compared with 1918. This was due to labor troubles in the steel and coal-mining industries and to railroad congestion. There appears to have been a small decrease in the amount of tar distilled and a large decrease in the output of pure benzene, and especially of pure toluene. This means that a much larger proportion of the output was sold as mixtures for solvent purposes or as motor spirit, instead of in the purified condition. Of more significance in considering the future of the coal-tar chemical industry is the fact that the productive capacity of the by-product coke ovens in the United States increased 17.2 per cent during 1919. There is no question that, with the possible exception of anthracene, adequate supplies of the fundamental raw materials of coal-tar origin will be available from American sources for the growth of the industry.

THE PROBLEM OF ANTHRACENE SUPPLY

In the case of anthracene considerable progress has been made during the past year, but the problem of securing adequate supplies is still unsolved. In 1918, the anthracene content of the crude anthracene produced was about a quarter million pounds, but very little of this was refined. In 1919 the output of crude anthracene was about three times the 1918 record, and a much larger fraction of it was refined. Although this shows great and encouraging progress, a much greater increase in output must be secured before there will be enough American anthracene available to supply the American demand for alizarin and vat dyes. It may be roughly estimated that the 1919 production of crude anthracene contained less than one-fifth of the amount of anthracene which would be required to supply the American needs. The difficulty is not primarily an actual lack of anthracene in the tar or purely technical difficulties in its recovery, but rather the fact that its removal leaves the pitch so hard that it does not find a ready market under American conditions. In England and Germany large amounts of hard pitch were used for the briqueting of coal dust and coke breeze, but this industry is very little developed in the United States. Any method of recovering anthracene which seriously disturbs the marketability of the other larger fractions of the tar, especially the pitch, would make the anthracene so expensive that the dyes derived therefrom could not be made on a competitive basis.

This problem of securing supplies of anthracene adequate in amount and at a cost which is not prohibitive is perhaps the most important and most fundamental problem still awaiting solution in this industry. Whether it will be solved by the tar distillers or by the development of a synthetic process for making anthracene or anthraquinone cannot be determined at the present time. Active work along both lines is now under way and the progress already made is encouraging.

THE PRODUCTION OF INTERMEDIATES

As was to have been expected, there was a large decrease in the output of several intermediates needed primarily for explosives. This is most noticeable in the case of phenol, which showed an enormous production—106,000,000 lbs.—in 1918, but fell to less than 1,500,000 lbs. in 1919, nearly all of this being obtained from coal tar. A less conspicuous case is the decrease in the output of monochlorobenzene from 20,500,000 lbs., in 1918, to a little more than 4,000,000 lbs. in 1919. There was also a considerable decrease in the output of several intermediates required for making dyes used for army uniforms; for example, there was a 25 per cent decrease in the output of *m*-toluylenediamine, which was used for making a khaki dye for cotton uniforms, and a 90 per cent decrease in *m*-nitroaniline, which was used for making a khaki dye for wool uniforms. It is my purpose to-day to give some typical examples of the progress of the American coal-tar chemical industry under peace conditions.

A comparison of the intermediates produced in 1918 and 1919 shows a considerable increase in the number of intermediates and substantial increase in amount in many cases. In 1919 there were about 225 different intermediates produced, against about 140 in 1918. The new intermediates are, of course, comparatively difficult to make, but were needed for dyes and medicinals of the better class. Among these new intermediates may be mentioned bromobenzene, dibenzylaniline, dichloroaniline, nine new sulfonic acid derivatives of naphthol or naphthylamine, β-oxynaphthoic acid, and five new anthraquinone derivatives.

As a rule, the intermediates for which there is the largest demand, and whose manufacture had been well established by 1918, show comparatively little change in 1919. Thus, nitrobenzene gained 11 per cent, the 1919 output amounting to about 42,500,000 lbs.; the output of aniline was about 24,500,000 lbs., a gain of 1 per cent; *p*-nitroaniline, with an output of about 1,300,000 lbs., lost 1 per cent; and β-naphthol, with an output of about 5,000,000 lbs., dropped 6 per cent. The output of H acid increased from a little less than 3,000,000 lbs., in 1918, to about 4,000,000 in 1919; on the other hand, the output of dimethylaniline fell off about 15 per cent, amounting to 3,500,000 lbs.

There are many notable increases in the output of individual intermediates, especially noticeable in the case of those derived from toluene or from anthracene. The output of U. S. P. benzoic acid increased from about 173,000 lbs., in 1918, to over 600,000 lbs. in 1919, with a drop in valuation from $3.07 to 74 cents per lb. *o*-Toluidine increased from 639,000 lbs. to a little over 1,000,000 lbs., and *p*-toluidine from about 200,000 lbs. to over 575,000 lbs., with a drop in valuation per pound to nearly half the 1918 figures. The general increase in the output of intermediates derived from toluene is, of course, due to the relaxation of the restriction on the use of toluene during war times.

There are also many examples of a big increase in the production of intermediates which are difficult to make, but are required for dyes of the best quality. A good example of this kind is amidonaphthol sulfonic acid, 2:8:6 (gamma acid), which was made in 1918 by a single firm, but in 1919 by five firms, with an output of over 155,000 lbs. valued at $667,000, which is many times the 1918 output. These five firms used this gamma acid to make nearly a half million pounds of Oxamine Black—an important direct black which can be developed. Moreover, gamma acid also went into Diamine Fast Red F, Neutral Gray G, and Columbia Black F B—all of them important direct cotton dyes of faster type.

Other intermediates, whose output increased substantially, include metanilic acid, with an output during 1919 of 450,000 lbs.; ethybenzylaniline, which served for the manufacture of Acid Violet; Michler's ketone (280,000 lbs.) used mainly for the important dye Auramine; thiocarbanilide (2,250,000 lbs.) used as an accelerator for vulcanizing rubber; naphthylamine sulfonic acids 1:5 and 1:8; and amidonaphthol sulfonic acid 1:2:4 (about 900,000 lbs.), important naphthaline derivatives.

The progress among the anthracene derivatives is of especial interest. Here, unfortunately, definite figures cannot be given without revealing confidential information. In 1919, there were ten intermediates derived from anthracene, against only five in 1918. The output of anthraquinone, which is the most important because it serves as raw material for the manufacture of nearly all other intermediates derived from anthracene, was about ten times as great in 1919 as in 1918.

THE PRODUCTION OF DYES

The total output of all dyes increased about 8 per cent over 1918, or to a little more than 63,000,000 lbs., valued at about $67,000,000. The average value per pound was $1.07, which is just the same as shown by the 1918 census. The average quality of the dyes has, however, improved considerably, owing to a partial replacement of many of the cheaper dyes by others of a more satisfactory character. The consumer, accordingly, received better value for his money in 1919 than in 1918.

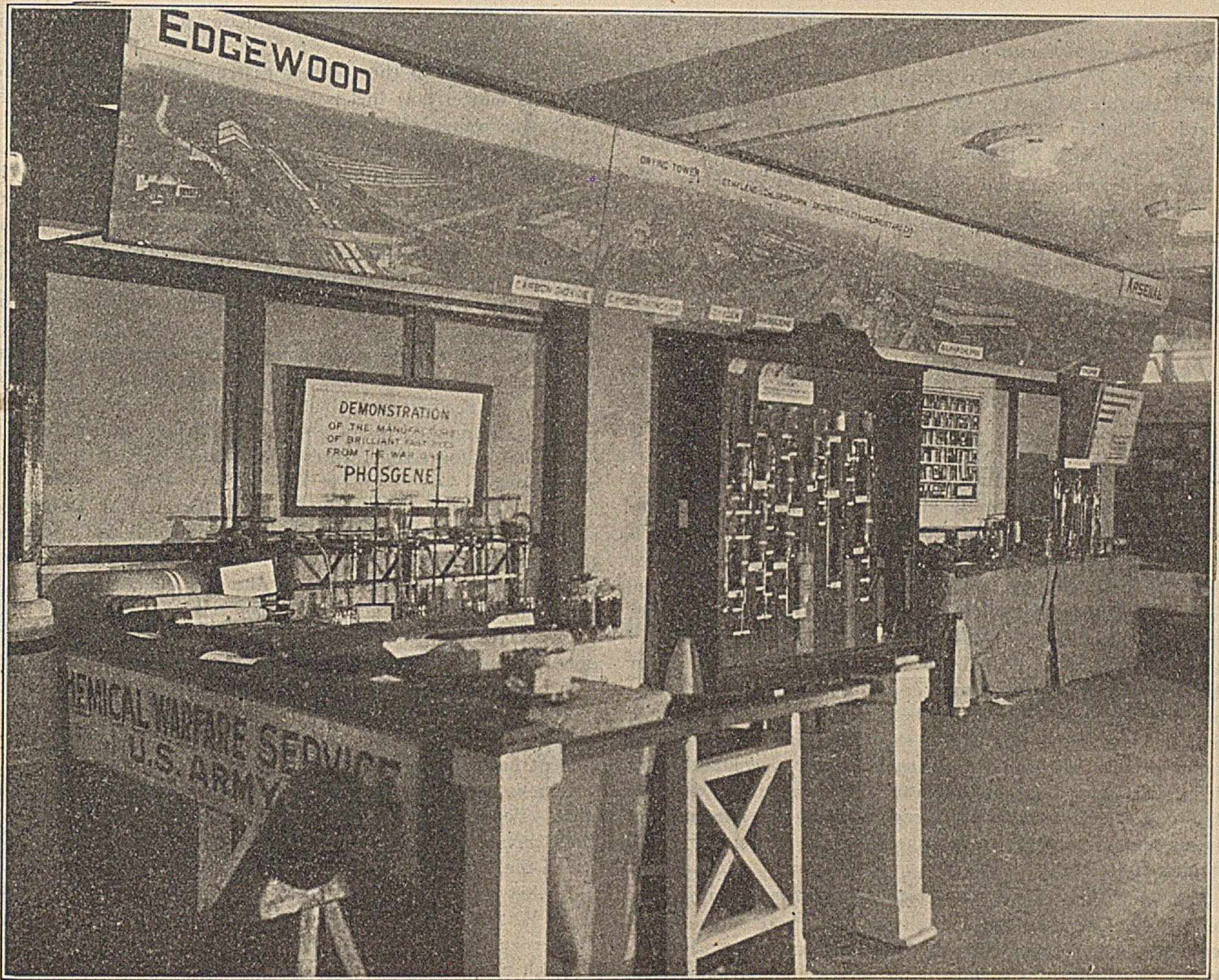
The production of basic dyes for 1919 was over 4,000,000 lbs., an increase of more than 1,000,000 lbs., as compared with 1918. The production of Magenta, Victoria Blue, Malachite Green, and Bismarck Brown more than doubled, while Auramine nearly trebled. There has been a conspicuous increase in the production of Rhodamine B.

The production of direct dyes was about 14,500,000 lbs., an increase of 2,000,000 lbs., as compared with 1918. About half of this total was direct Deep Black E W. Conspicuous changes include large increases in the output of Chrysophenine, Primuline, Oxamine Black, Diamine Rose, and the first appearance of Diamine Fast Red F.

The production of mordant dyes during 1919 was over 3,100,000 lbs., which is about 2,300,000 lbs. less than the output of mordant dyes in 1918. This decrease is due principally to a diminished production of Alizarin Yellow G G and R of more than 2,000,000 lbs. Mordant dyes available in 1919 in considerable, although inadequate, amounts, included alizarin, Alizarin Saphirole, and other alizarin derivatives, as well as a considerable number of fast mordant dyes for wool dyeing and mordant printing.

The production of acid dyes for 1919 was over 14,000,000 lbs., an increase of about 6,000,000 lbs. over 1918.

The production of indigo, 20 per cent paste, reached 8,863,824 lbs., valued at $5,233,719. This exceeded the 1914 importation



Chemical Warfare Service Exhibit

by 356,465 lbs., and the 1918 production by 5,779,936 lbs. Several indigo derivatives were placed on the market. Four other vat dyes were made on a commercial scale during 1919, but the output was only a small fraction of the pre-war consumption. However, fundamental progress has been made in this important field.

The total production of sulfur colors for 1919 was over 17,000,000 lbs. This was about 6,000,000 lbs. less than that for 1918. This was largely due to a decrease of about 8,000,000 lbs. of sulfur olive and khaki dyes required in the war period for cotton uniform cloths. Sulfur black production in 1919 (14,250,000 lbs.) was about 2,000,000 lbs. more than that for 1918.

COAL-TAR MEDICINALS AND PHOTOGRAPHIC DEVELOPERS

Among the coal-tar medicinals there has been a substantial increase in the output of many items already well established in 1918, including aspirin, acetphenetidin, arsphenamine, guiacol, and methyl salicylate. Moreover, a considerable number of new products have been introduced on a small scale.

In the case of photographic developers of coal-tar origin, there was a decrease of 30 per cent in the output of hydroquinol—to about 200,000 lbs. valued at nearly half a million dollars. On the other hand, the output of metol increased more than five times—to nearly 60,000 lbs., and *p*-aminophenol increased about 7 per cent, or to over 130,000 lbs.

The many difficult problems in readjustment from war conditions to peace conditions have been met with encouraging success. The achievements of American chemists in these industries furnish an excellent basis for optimism as to the future.

REORGANIZATION OF THE CHEMICAL WARFARE POST OF THE AMERICAN LEGION

Major L. T. Sutherland presided at the reorganization meeting of the Chemical Warfare Post of the American Legion, and introduced Brigadier General Amos A. Fries, the present head of the Chemical Warfare Service, who outlined the plans of the Service and made an earnest plea for the coöperation of civilian chemists with the military organization.

General Fries pointed out the difficulty of educating, in times of peace, to the necessity of preparing for chemical warfare, both in the offensive and defensive sense. He cited statistics recently given out by the Army to the effect that three out of every ten casualties in the World War were due to gas and one-third of the wounds inflicted were also due to gas attacks.

General Fries voiced the appreciation of the Chemical Warfare Service for the aid that has been given by civilian chemists to obtain proper recognition for the Service.

Civilian chemists and particularly former officers of the Chemical Warfare Service will be called upon frequently, said General Fries, to aid in the work of the Army, and a reserve corps will be organized in the near future through which active coöperation with civilian chemists can be established. National guard units as well as regular army divisions will be trained in gas warfare.

Following remarks, voicing the willingness of civilian chemists, and particularly former service men, to coöperate with General Fries in every way, by Colonels Burrell, Bogert, and

Walker, the election of officers for the Post was held. The new officers are: Commander, Major L. T. Sutherland; Vice Commander, Lt. Col. Mayo Smith; Adjutant, Capt. E. Caldwell; Treasurer, Major Fred C. Zinnser; Members of Executive Board: Colonels W. H. Walker, F. M. Dorsey, Bradley Dewey, R. F. Bacon, G. A. Burrell, and W. S. Bacon.

Before adjournment the Post passed a resolution to be sent to Congress endorsing the dye bill and urging its speedy passage.

All former members of the Chemical Warfare Service are urged to affiliate themselves with this Post, and to send the necessary dues to the treasurer, Major Fred C. Zinnser, Hastings-on-Hudson, N. Y.

ABSTRACTS FROM THE MEETINGS

OPENING MEETING

The opening address, by the chairman of the Advisory Committee, is printed on pages 956 to 959.

Dr. Chas. L. Reese, president of the Manufacturing Chemists' Association of America, pointed out the ways in which the Exposition had furthered coöperation between the producer of chemicals and the manufacturer of apparatus. American manufacturers, according to Dr. Reese, are furnishing better glassware and porcelain than ever was obtainable from foreign sources. There is still work to be done; present needs include improved autoclaves for use in the dye industry, and better standardization of laboratory apparatus. A committee of chemists is coöperating with the manufacturers in an effort to eliminate a large number of pieces and have the remainder of the apparatus conform to the specifications of the Bureau of Standards.

Following Dr. Reese, Col. J. S. Dennis, assistant to the president of the Canadian Pacific Railway Co., spoke as the representative of our Canadian neighbors. He said that Canada's future development depends upon increasing her population and developing those natural resources which can better Canada's financial position only through effective expansion.

In a discussion of the "Problems Confronting the American Exporter," Erasmus Hopkins, of Gaston, Williams and Wigmore, Inc., pointed out the weaknesses of American foreign selling methods, as compared with those of the English and German exporter. The American manufacturer must realize that, in foreign even more than in domestic trade, shipments must meet requirements as to quality and time of delivery. Materials should be packed in units conforming to the system of the country to which they are to be sent. The manufacturer must coöperate with the exporting house in regard to the financial side of its foreign business.

FUEL ECONOMY SYMPOSIUM

In opening the Fuel Economy Symposium, Chairman R. C. Beadle, managing editor of *Combustion*, said in part:

> The Chemical Exposition has this year for the first time recognized the tremendous importance of all those things which go to make for better efficiency, by setting aside a day of this week when matters may be discussed which relate to that brother of the chemical engineer, known as the combustion engineer, in its fuel economy conference, discussing carefully with eminent authorities all phases of industrial activity that relate in any way to economy in the production of that underlying force which drives the wheels of all our industries.

Mr. W. O. Rankin, of the Quigley Furnace Specialties Company, stated that powdered coal has met the demand for a highly efficient fuel in the metallurgical industries, and is now coming into the field in power plant operation. With furnaces of proper design, a 20 to 40 per cent increase in efficiency and a fuel consumption reduction of 25 to 60 per cent are easily possible.

F. F. Uehling, of the Uehling Instrument Company, stated that "no matter how fuel is burned, and no matter what fuel are used, whether solid, powdered, liquid or gaseous, the biggest loss is always due to the heat energy wasted up the chimney." The loss depends upon three factors: namely, excess air in the products of combustion, the temperature of the products of combustion, and the amount of unconsumed fuel in the products of combustion. These three points, respectively, may be controlled by the continuous automatic determination of CO_2, the use of an ordinary flue-gas thermometer, and the determination of CO.

In modern heating systems using oil as a circulating medium, said Alexander Mackechnie of the Parks-Cramer Company, difficulty on account of carbonization of the oil has been eliminated. The method is not a substitute for steam heating, but is adaptable for temperatures to which dry saturated steam cannot reach.

W. B. Chapman, of the Chapman Engineering Company, showed a large and complete series of lantern slides illustrating the development of the gas producer up to the modern type, with its important accessories in the line of gas-cleaning and regulating devices. The present-day tendency is toward simplicity of design, the use of accessories which will show the operator just what he is doing, and the employment of better men in charge of the process.

F. L. Reisman, also of the Quigley Furnace Specialties Company, discussed the application of plastic high temperature cement in the place of fire clay. The extra initial cost of the cement is more than balanced by the increased life of the furnace. For instance, a wall which, laid in fire clay, would last three months can be made to last three and a half years by the use of the cement.

In his paper on "Preventing Conduction and Radiation Heat Waste," S. L. Barnes, of the Armstrong Cork Company, emphasized the necessity of reducing the heat losses which occur through conduction and radiation from boiler settings, furnaces, kilns, etc. The reduction of heat loss by insulation increases the capacity of the equipment without increase in fuel consumption, makes temperatures more constant and uniform throughout the apparatus, decreases the time required to bring equipment to working temperature, lengthens the life of refractories by eliminating the necessity for overheating, and provides more comfortable working conditions for operatives.

W. R. Van Nortwick, of the Roto Company, pointed out the loss in boiler efficiency due to soot and boiler scale. In one case cited, with a new and perfectly clean horizontal tube boiler of 600 h. p. capacity, the uptake temperatures increased 100° in four days, an increase in fuel consumption of 5 per cent, due to failure to blow the soot from the tubes. Service tests indicate that boilers blown every 6 hrs. show an increased efficiency of 4 to 5 per cent over those blown every 24 hrs. Mr. Van Nortwick advocated mechanical removal of boiler scale in preference to the use of boiler compounds, as more practical and more economical.

Conrad Dressler, of the American Dressler Tunnel Kilns, Inc., outlined the process employed in the Dressler kiln, and pointed out the various ways in which the kiln construction contributed to fuel economy.

INDUSTRIAL MANAGEMENT SYMPOSIUM

Harrington Emerson, first speaker in the Industrial Management Symposium, emphasized the value of ultra analysis of costs in factory operations in order that concentration of supervision may be effectually focused on those items showing the widest deviations from standard efficiency. He brought out the point that the cost accountant needs the coöperation of the technical man who knows the operation of a particular plant

Mr. Emerson said that the chemical industries operate with the fundamental elements of cost accounting, namely, materials, personnel, and equipment, and that it is probable that the chemical industries set up standard costs more rigidly than most other industries.

In discussing the part played by research in industrial conservation, H. E. Howe, of the National Research Council, gave numerous concrete illustrations of increased economic production effected through the application of scientific principles. A striking illustration in point is the results achieved through the coöperation of engineers, chemists, physicists, and metallurgists on the problem of more efficient illumination of industrial plants. In conclusion Mr. Howe said:

> While much has been accomplished, it is apparent that there is much more yet to be done and scientists are continually endeavoring to have the public at large understand its pressing needs and to have industry avail itself of what science is now able to offer. Industry must support science in its effort to establish an increasing number of fundamental principles which can be applied to the further solution of industrial problems. There are a number of the natural sciences which have not been introduced to industry in the same way as has chemistry. Oftentimes industry is unfortunate in placing its problem before a particular science when another is better able to be of real assistance. In the past too often the sciences themselves have remained apart and have not contributed each to the other's work in as great a degree as is desirable. Wherever sciences have been cross-fertilized, the results have been remarkable and the achievements to be accredited to physical chemistry to-day are an illustration of the point I would make. * * * *
>
> Often when such arguments as I have presented are laid before a man in the industry he assents as to their soundness and may often appear bored at a repetition of an old story, but in too many cases he remains unconvinced and feels that his own industry is so peculiar that no lessons can be drawn from the experience of others and that he is doing so well that the assistance of science is not required. It is in a change of this attitude that we are particularly interested, and our effort is to change a passive agreement with our viewpoint into an active application of the principles which we know from experience to be sound.

The report of Grinnell Jones, chief chemist of the U. S. Tariff Commission, upon the "Progress of the American Coal-tar Chemical Industry during 1919" is printed on pages 959 to 961.

MATERIALS HANDLING SYMPOSIUM

In his opening address, Roy V. Wright, editor of the "Material Handling Cyclopedia," declared that the present problem of speeding up the transportation of raw materials and finished articles is dependent upon the improvement of facilities for handling at freight terminals.

The next speaker, J. H. Leonard, editor of *Freight and Terminal Engineering*, emphasized the fact that the "proper handling of materials is an engineering function from beginning to end," and that "every branch of engineering science must aid in the solution of the problem."

Ramsey W. Scott, of the Technical Advisory Corporation, likewise discussed transportation facilities, from the standpoint of handling the country's food supply.

Willis T. Spivey, material handling engineer, asserted that "the keynote of successful conveyor installation is *right application*," and "that no type of production equipment depends more upon surrounding plant conditions." The sales-engineer must therefore carefully analyze the problem, including the existing routing methods with their probable changes, a comparison of the cost in time and labor of the present handling method with that after the proposed installation is made, special conditions which may effect its economical operation, and probable plant changes or additions.

Everett W. Morgan, of the Pneumatic Scale Corporation, displayed and discussed the advantages of a metal shipping container. As one illustration, he quoted from the Underwood resolution before the Senate last spring, to the effect that "the wooden packing cases and containers made of soft wood" (in the United States in 1919) "consumed enough material to manufacture 4,000,000 tons of paper, or, in round numbers, double the quantity manufactured by all the newsprint mills of Canada and the United States combined." The use of steel containers would release this enormous amount of material for the paper industry.

CHEMICAL ENGINEERING SYMPOSIUM

The Chemical Engineering Symposium was conducted by the American Institute of Chemical Engineers. Chairman David Wesson pointed out the every-day duties of the chemical engineer. As a citizen, it is his duty, Dr. Wesson said, to show his interest in various patent laws and tariff bills now pending, by giving to the congressman the benefit of his knowledge and experience.

Thomas W. Pritchard, of the Fuel Products Corporation, presented a new method by which destructive distillation may be carried on under more definite temperature control, thus reducing the time of operation by one-third, and at the same time improving yield and quality of product. In brief, the change consists in conducting the uncondensed vapors from the condenser through a thirty-eight blower and superheater back through the retort, thus distributing the heat units throughout the mass, as well as sweeping out the vapors formed.

Robert G. Guthrie, of the Widney Test Laboratories, declared that the question of the relation of recoverance to fatigue is of vital importance to the engineer. On three tests of pieces taken from the same cast iron bar, for instance, the variations in recovery were as great as 50 per cent.

C. Price-Green, of the Canadian National Railways, and B. F. Haanel, of the Canada Department of Mines, both told of the unlimited mineral resources and chances for development that their country offered to chemical engineers and to manufacturers. Mr. Price-Green discussed the phenomenal development of the Canadian chemical industry during the war. In speaking of the paper industry, he said:

> To-day the United States is mainly dependent upon Canada for its supply of paper and paper-making material, and the demand is a heavy one, as you use one-half the world's annual production of white paper. Canada is supplying 55 per cent of this demand. In 1890, Canada only exported to the extent of $120; to-day there are $250,000,000 invested in pulp and paper, and our annual production is valued at $120,000,000, and our exports $100,000,000, of which you receive 8 per cent.

After describing the method of peat formation and its physical and chemical properties, Mr. Haanel described methods of preparation of peat fuel, and gave statistics as to its heat value and industrial application.

W. D. Richardson, of Swift & Company, discussed the "Corrosion of Iron and Steel as Affecting the Industries," A. Hough and W. Savage spoke on the "Nitration of Hydrocarbons," and C. R. Bellamy pointed out some of the technical details in the operation of a modern by-product coke oven plant.

CERAMIC SYMPOSIUM

The Ceramic Symposium took the form of a meeting of the American Ceramic Society at which Chairman R. H. Minton read an abstracted committee report on "The Significance Attached to the Term Ceramics in Ancient and Modern Usage."

Charles F. Binns, in an address on "Ceramics and the People," pointed out the part the ceramic industries are playing in modern civilization, listing among their products cement, windows, drains, bricks, tile, wall tile, bathroom fixtures, sanitary fittings, electric light bulbs, glass screens for indirect lighting, sinks, and laundry trays.

ORIGINAL PAPERS

THE DETERMINATION OF CARBON MONOXIDE IN AIR CONTAMINATED WITH MOTOR EXHAUST GAS[1]

By M. C. Teague

Tunnel Gas Investigations, U. S. Bureau of Mines, Pittsburgh, Pa.

Received August 12, 1920

In connection with the joint investigation of the Bureau of Mines and the New York-New Jersey State Bridge and Tunnel Commission with reference to the physiological effects of motor exhaust gas, it was of first importance to find a method for determining carbon monoxide in low concentrations and in the presence of other oxidizable gases.

The analytical determination of this gas in the concentrations here encountered (0.01 to 0.10 per cent) offers a much more difficult problem than the usual determination. The Orsat method, using ammoniacal cuprous chloride solution as the solvent for carbon monoxide, does not remove the last traces of the gas; 0.2 or more may not be absorbed.[2] The Haldane analyzer as modified by Burrell and Seibert,[3] when operated by an expert, does not exceed a precision of 0.01 per cent. The Haldane blood method,[4] although applicable to small concentrations, is subject to many variations, which do not always give concordant results.

The method which offered the greatest possibilities for the present work was that of iodine pentoxide, which consists in oxidizing the gas with iodine pentoxide and determining the amount either of carbon dioxide formed or of iodine liberated.

Considerable study of this method has been made since its first use in 1888.[5] A portable apparatus described by Graham[6] makes use of bromine in potassium bromide solution to remove any unsaturated hydrocarbons, and dries the gas with calcium chloride and phosphorus pentoxide before it enters the iodine pentoxide tube, which is held at temperatures between 90° and 150° C., there being no observed difference in results over this range, except in the presence of relatively large amounts of hydrogen. Under carefully controlled conditions, an accuracy to within 0.005 per cent carbon monoxide is claimed.

Lt. Col. A. B. Lamb[7] and his coworkers made use of the iodine pentoxide method in connection with their work on carbon monoxide absorbents for gas masks. At that time there was developed by A. T. Larson and E. C. White[1] a 6-unit multiple apparatus. This was designed for use with carbon monoxide-air mixtures only, although they experimented and found an interference by hydrogen. The purifying train included a tower of sodium hydroxide solution, another containing hot concentrated sulfuric acid, and finally a tube of dry alkali. The attempted accuracy was 0.01 per cent carbon monoxide.

There has been a difference of opinion among earlier investigators as to the advantages of determining the amount of carbon dioxide formed or that of the iodine liberated. Upon first inspection of the equation

$$I_2O_5 + 5CO \longrightarrow 5CO_2 + 2I$$

it would seem preferable to determine the carbon dioxide, since a relatively large amount of it is formed. At these very low concentrations, however, the complete absorption of carbon dioxide is an exceedingly difficult operation. For most types of absorption tubes there would be the inconvenience of using several such tubes or of passing the gas through the apparatus at a slower rate. Furthermore, it has been found undesirable to work with baryta solution much weaker than 0.02 *N*, whereas in determining the iodine liberated by the reaction 0.001 *N* sodium thiosulfate can be used, a difference which offsets the advantage of the greater amount of carbon dioxide formed.

APPARATUS—TYPE I

An apparatus practically the same as that of Larson and White was constructed with the view of adapting it for carbon monoxide determinations in dilute exhaust gases.

The iodine pentoxide tubes were made of about three-quarter inch pyrex tubing, with the U about 10 in. long. They were filled with alternate layers of glass wool and iodine pentoxide (each tube containing 30 to 40 g. of the latter). The arm on the exit side of the U-tube was somewhat longer than the other and tapered to make an interlock glass joint with the guard tube. A similar joint was made with the absorption bulb, thus removing the possibility of error due to rubber connections.

PREPARATION OF PENTOXIDE

After the apparatus was assembled it was necessary that the iodine pentoxide be conditioned before making any determinations. This was accomplished by raising the temperature to 220° to 230° C. for several hours, while air was drawn through. (Iodic acid begins to decompose at 170° C. to form water and iodine pentoxide.) With the water, considerable iodine was at first driven off. Two varieties of iodine pentoxide were tried: one, the ordinary commercial variety, prepared by the oxidation of iodine with fuming nitric acid, required about 25 hrs. heating; while the other variety, prepared by the chloric acid method,[2] required only about 15 hrs. heating. The tubes con-

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[1] Published by permission of the Director of the Bureau of Mines and the Chief Engineer of the New York-New Jersey State Bridge and Tunnel Commission.

[2] G. A. Burrell and F. M. Seibert, "The Sampling and Examination of Mine Gases and Natural Gas," Bureau of Mines, *Bulletin* **42**, 48.

[3] *Loc. cit.*, p. 17.

[4] Forthcoming Bureau of Mines Bulletin on "Physiological Effects of Motor Exhaust Gases."

[5] C. de la Harfe and F. Reverdin, *Chem. Ztg.*, **12** (1888), 1726; Maurice Nicloux, *Compt. rend.*, **126** (1898), 746; Armand Gautier, *Ibid.*, **126** (1898), 1299; **128** (1899), 487; L. R. Kinnicutt and G. R. Sanford, *J. Am. Chem. Soc.*, **22** (1900), 14; E. H. Weiskoff, *J. Chem. Met. Soc. S. Africa*, **9** (1909), 258; G. A. Burrell and F. M. Seibert, Bureau of Mines, *Bulletin* **42** (1913), 60.

[6] J. Ivon Graham, *J. Soc. Chem. Ind.*, **38** (1919), 10.

[7] In charge of the Defense Research Section, C. W. S., U. S. A.

[1] Appreciation is here expressed for the use of unpublished data relative to Larson and White's iodine pentoxide apparatus.

[2] This method will be described later by A. B. Lamb and W. C. Bray.

taining the latter variety gave lower blanks and seemed more active and therefore less sensitive to temperature changes than did the other tubes.

In making the determinations, the iodine pentoxide tube was usually maintained at a temperature of 150° C. One-liter samples were drawn through the apparatus and then displaced with outside air. The rate of flow was about 1 liter in 15 min. The liberated iodine was absorbed in one Bowen's absorption tube containing a 10 per cent potassium iodide solution, and titrated with sodium thiosulfate (0.002387 *N*) (1 cc. thio $\approx$ 0.15 cc. carbon monoxide at 25° C. and 760 mm. pressure, or 1.5 parts in 10,000 for a 1-liter sample).

EXPERIMENTS UPON CARBON MONOXIDE-AIR MIXTURES

The determinations made on carbon monoxide-air mixtures are summarized in Tables I and II. It is apparent that the temperature of the iodine pentoxide is not a sensitive factor when working with carbon monoxide-air mixtures. Table II shows the increased precision obtained by sweeping out the train more thoroughly.

TABLE I—EFFECT OF I_2O_5 TEMPERATURE

	Parts CO in 10,000		
	100° C.	150° C.	175° C.
	6.0	6.1	5.7
	5.6	5.7	5.7
	5.4	5.7	5.5
	5.8	5.9	5.7
	5.8	6.0	5.7
	6.2	6.2	6.1
MEAN,	5.8	5.9	5.7

TABLE II—VARIATIONS OF PRECISION WITH TIME OF SWEEPING THE TRAIN

Series No.	Procedure	No. of Determinations	Parts CO (Mean Value)	Maximum Variation from Mean (Parts CO)
1	Total time, 30 min. (15 min. for sample, and 15 min. for sweeping the train)	6	8.8	±0.4
2	Total time, 45 min. (15 min. for sample, and 30 min. for sweeping the train)	6	4.1	±0.2
3	Total time, 60 min. (15 min. for sample, and 45 min. for sweeping the train)	6	4.9	±0.2
4	Total time, 60 min. (30 min. for the (1 liter) sample, and 30 min. (2 liter) for sweeping the train)	6	5.5	±0.3
5	Total time, 75 min. (15 min. for sample, and 60 min. for sweeping the train)	6	4.0	±0.1

EXPERIMENTS UPON EXHAUST GAS

Attention was next turned to the use of exhaust gases. Analysis showed the following constituents: carbon dioxide, carbon monoxide, oxygen, hydrogen, methane and perhaps other low saturated hydrocarbons, traces of unsaturated hydrocarbons, and some unburned gasoline.[1] Obviously, there were also water and varying amounts of oil-smoke particles.

The carbon dioxide was sufficiently removed by the sodium hydroxide. The concentrated sulfuric acid was heated to 160° C. that it might absorb any traces of unsaturated hydrocarbons, in addition to drying the gas.[2]

As noted above, several investigators had found hydrogen to be partly oxidized by the hot iodine pentoxide. In each case, however, the amount of hydrogen was relatively large, while in exhaust gases the hydrogen content varies up to about one-half that of carbon monoxide. The effect of such low concentrations had therefore to be determined.

While methane and ethane do not interfere with the iodine pentoxide reaction, Graham observed that normal pentane when present in large concentrations was slightly affected at the temperatures used (90° to 150° C.). If that was true, it was to be expected that gasoline (hexane and heptane) would undergo oxidation even more readily.

There were, therefore, three possible sources of difficulty in applying this apparatus to the determination of carbon monoxide in these mixtures, namely, the presence of hydrogen, smoke particles, and gasoline vapor.

The following determinations were made to compare the iodine pentoxide method with the Orsat and similar methods.

TABLE III—COMPARISON OF METHODS

Expt. No.	Method of Determining CO Concentration	CO Concentration (Calculated)	CO Found by I_2O_5 Method	I_2O_5 Value / (Calc. Value)
1	CO from formic acid (not analyzed)	In gassing chamber 1.98 parts	1.82	0.92
2	95 per cent CO, Henderson analyzer	In gassing chamber 3.9	3.86	1.00
3	Exhaust gas, Orsat method 6.7 per cent CO	In gassing chamber 3.0	3.90	1.30
4	Exhaust gas, Orsat method 6.5 per cent CO	In gassing chamber, approximately 2.8	3.50	1.25
5	Exhaust gas, Orsat method 8.4 per cent CO	In gassing chamber 1.0	1.34	1.34
6	Exhaust gas, Orsat method	In gassing chamber 13.5	17.8	1.32
7	Exhaust gas, Orsat method 6.3 per cent CO	Orsat buret to sampling tube, then diluted to 1 liter 10.29	13.77	1.34
8	Exhaust gas, 6.3 per cent CO	Orsat buret to sampling tube, then diluted to 1 liter 9.59	13.62	1.42

In Expts. 1 and 2 the pure carbon monoxide was measured in a graduated cylinder and displaced by water. In others, using the gassing chamber, the exhaust gas was displaced from a large graduated gasometer. In the last two experiments the exhaust gas was measured out of the Orsat buret directly into the sampling tube, and then diluted to about one liter.

The methods of diluting in the chamber were probably accurate to ± 10 per cent. Nevertheless, when exhaust gas was used, consistently higher results were obtained by the iodine pentoxide method. This increase varied with gas from different cars; on the car used for the above tests it was 30 to 40 per cent, while for another car it was 60 to 80 per cent. It was true that the cuprous chloride solution of the Orsat apparatus did not absorb the last traces of carbon monoxide, yet that unabsorbed could not account for the observed high results. It was evident that some one or more of the other constituents of the exhaust gas were also being oxidized by the iodine pentoxide.

EFFECT OF HYDROGEN—A mixture of carbon monoxide and air was prepared and analyzed. A known volume of hydrogen was then added to the remaining gas and the carbon monoxide again determined.

These experiments justify the conclusion that such quantities of hydrogen as occur in exhaust gases (about one-half the carbon monoxide concentration) are not sufficient at these low concentrations to influence the

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[1] Analyses made by G. W. Jones, Pittsburgh Station, Bureau of Mines.

[2] E. H. Weiskoff, *J. Chem. Met. Soc. S. Africa*, **9** (1909), 258.

carbon monoxide determinations as obtained by the iodine pentoxide method. It was not until hydrogen was present in about twice the volume of carbon monoxide that any effect was observed in the above determinations, and even then the results were not conclusive.

EXPT. A: PARTS CO IN MIXTURE

	Without Hydrogen	With Hydrogen = 0.5 Volume of CO		With Hydrogen = 1 Volume of CO
	150° C.	100° C.	150° C.	150° C.
	4.7	4.9	4.8	4.9
	4.8	4.9	4.9	...
MEAN,	4.8	4.9	4.9	4.9

EXPT. B: PARTS CO BY I_2O_5 METHOD (Temperature 150° C.)

	SERIES I Without Hydrogen	SERIES II 1.2 Parts CO and Approximately 2.2 Parts Hydrogen	SERIES III 1.2 Parts CO and Approximately 4.5 Parts Hydrogen
	1.3	1.5	1.9
	1.2	1.5	1.5
	1.3	1.6	1.5
	1.2	1.7	1.8
	1.1	1.6	1.9
	...	...	1.9
MEAN,	1.2	1.6	1.8

EFFECT OF SMOKE PARTICLES FROM THE OIL—Although a pad of glass wool was used in the sodium hydroxide tube just before the iodine pentoxide, it was possible for small smoke particles to pass through this and perhaps increase the iodine liberated. To determine whether or not this caused the observed high results from exhaust gas, a paper filter was inserted into the train. The filter was made by clamping two 11-cm. "quantitative filter papers" of good quality between two ground-edge funnels, permitting a filtering area of about 90 sq. cm.

The use of this filter made no difference in the determinations on exhaust gas, *i. e.*, the carbon monoxide determinations were the same as those when the filter was not used (60 to 80 per cent higher than the value calculated from the Orsat analysis).

EFFECT OF GASOLINE—Three determinations were made upon a mixture of carbon monoxide and air containing about 4 parts of carbon monoxide. Motor gasoline was placed in an Erlenmeyer flask, and the flask stoppered. After standing for several hours, a small portion of the flask atmosphere (equal to about 1 part gasoline in 10,000) was withdrawn by a Luer syringe and inserted into the above carbon monoxide-air mixture. The carbon monoxide equivalent in two samples of this mixture was determined on the same apparatus as used above.

PARTS CO OR EQUIVALENT

EXPT. No.	Air + CO Mixtures	Air + CO + Gasoline Mixtures
1	4.1	7.0
2	4.3	7.2
3	4.0	...
MEAN,	4.1	7.1

It is evident from the above experiments that whereas the concentrations of hydrogen and smoke particles encountered in exhaust gases do not interfere in the I_2O_5 method of determining carbon monoxide, the unburned gasoline vapor does interfere to a considerable extent.

Several absorbents were tried for the removal of the gasoline vapor without affecting the carbon monoxide concentration.

(1) Cold concentrated sulfuric acid inserted in the train before the heated acid had no effect upon the results.

(2) Dry, activated coconut charcoal was known to be a good absorbent for gasoline vapor and at the same time useless for absorbing carbon monoxide. A tube of this absorbent was, therefore, inserted before the I_2O_5 tube in the place of the solid sodium hydroxide. With this arrangement the high results on exhaust gas were reduced to very nearly the calculated value. When determinations were made upon carbon monoxide-air mixtures, however, the carbon monoxide was appreciably absorbed by the charcoal.

(3) Many heavy mineral oils are also good absorbents of gasoline vapor at higher concentrations. A bead tower containing such an oil (Albolene) was therefore inserted in the train in front of the sulfuric acid tower. It was found that the vapor pressure of this oil was sufficiently high to cause an undesirable and somewhat variable blank due to its reaction with the I_2O_5. This was true at both room and freezing temperatures, and therefore prevented its use, even though it completely removed the gasoline vapor from exhaust gases.

(4) Shaved paraffin had no effect upon the results with exhaust gas or carbon monoxide-air mixtures. The average of three determinations on exhaust gas using the usual train showed an increase of 74 per cent over the calculated carbon monoxide value, whereas with the paraffin in the train an average of the same number of determinations showed an increase of 70 per cent. On the two procedures with carbon monoxide-air mixtures, the determinations checked.

(5) It was thought possible that by chilling the dried entering gases to —80° C., the gasoline would be condensed to droplets capable of being filtered out. The gas was led through a small U-tube containing glass wool and about which was packed carbon dioxide snow. With the failure of this to give the desired result, the tube containing the glass wool was replaced by one containing an alundum cylinder (Norton, medium porosity). The chilled gas was thus drawn through this porous cup. The results on exhaust gas were still unaffected.

(6) The next lower convenient temperature was that of liquid air. A similar U-tube containing glass wool was employed. While liquid gasoline cooled to this temperature (—190° C.) becomes a glass-like solid, it was realized that its vapor at such exceedingly low partial pressures might still prove difficult to completely remove.

A twenty-liter carbon monoxide-air mixture was prepared; three samples were withdrawn; and air containing gasoline vapor was injected into the remainder, and six samples taken. The carbon monoxide values of three of the latter samples were determined on the apparatus previously used (Type I) and three on the train with the liquid-air cooled tube.

	CO + Air Mixtures Old Apparatus Parts CO	CO + Gasoline + Air Old Apparatus Parts CO Equivalent	CO + Gasoline + Air "Liquid Air Tube" in Train Parts CO Equivalent
	8.3	48.0	7.8
	8.0	46.7	7.6
	7.5	46.0	7.8
MEAN,	7.9	46.9	7.7

Thus, at this temperature, the gasoline vapor was completely removed even under greatly exaggerated conditions. The liquid air temperature also condensed the water, carbon dioxide, and probably all of the unsaturated hydrocarbons.

APPARATUS—TYPE II

All of the members of the former purifying train were therefore removed, leaving only the liquid-air cooled tube (Type II apparatus, see Fig. 1). Repeated determinations showed the same results.

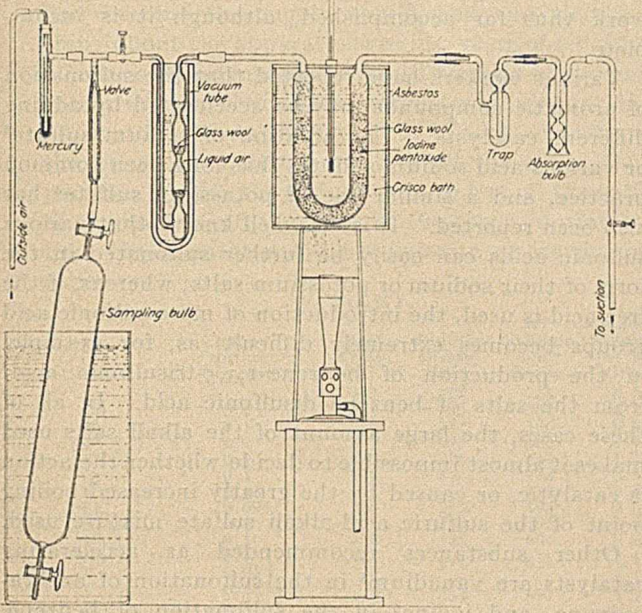

FIG. 1

CARBON MONOXIDE-AIR MIXTURES

	Type I Apparatus Parts CO	Type II Apparatus Parts CO
	5.8	5.2
	5.9	5.7
	5.7	5.4
	4.9	5.0
MEAN,	5.6	5.3
	16.1	16.4
	16.2	16.3
MEAN,	16.2	16.4

In the following tables are found the results of numerous determinations on exhaust gases. From the results it is noted that at liquid air temperature all of the gases in dilute exhaust gas which interfere with the accurate carbon monoxide determination by the I_2O_5 method are removed.

EXHAUST GAS CONTAINING 3.8 PER CENT CO FROM MACHINE IN APPARENTLY GOOD CONDITION

Measured from Gas Buret	Type I Apparatus		Type II Apparatus	
Cc. CO Taken	Cc. CO Found	Per cent of CO Calculated	Cc. CO Found	Per cent of CO Calculated
1.16	..	...	1.12	97
1.05	..	...	1.08	103
0.80	0.87	111	..	...

EXHAUST GAS CONTAINING 4.0 PER CENT CO FROM ARMY TRUCK WITH ONE CYLINDER NOT FUNCTIONING

Measured from Gas Buret	Type I Apparatus		Type II Apparatus	
Cc. CO Taken	Cc. CO Found	Per cent of CO Calculated	Cc. CO Found	Per cent of CO Calculated
0.99	..	...	1.06	107
1.04	1.73	166	..	...
0.63	..	...	0.59	94
0.57	0.94	170	..	...
0.65	..	...	0.64	99
0.64	1.03	161	..	...
	MEAN,	166		100

EXHAUST GAS CONTAINING 9.6 PER CENT CO FROM ARMY TRUCK (ENGINE RACING)

Measured from Gas Buret	Type II Apparatus	
Cc. CO Taken	Cc. CO Found	Per cent of CO Calculated
0.78	0.79	101
1.03	1.04	101
1.16	1.19	103
	MEAN,	102

In Type II the Dewar vacuum tube has replaced four members of the Type I purifying train. This simplified apparatus will probably reduce the time per determination by 50 per cent, owing to the shorter time necessary to clear the train completely. The elimination of liquid seals also facilitates the manipulation. Blank determinations on Type II were constantly at zero. About 300 cc. of liquid air were used per train per day.

PORTABLE APPARATUS

A convenient method for accurately determining carbon monoxide in such mixtures as dilute exhaust gas having been developed, it was further modified into a portable apparatus for use in exploring vehicular tunnels, garages, and other enclosed places where it is desired to determine low carbon monoxide concentrations, in the absence of relatively large amounts of hydrogen.

The apparatus is shown in Fig. 2. The gas sample, which has been reduced to 500 cc., is drawn into tube *f* by use of the leveling bulb *e*, and through 3-way cock *g*. *b* and *a* are stoppered vacuum cylinders (8 to 10 in. tall) containing U-tubes immersed in liquid air and hot Crisco oil, respectively. In the cold U-tube are condensed the water vapor, carbon dioxide, gasoline vapor, and traces of other saturated and unsaturated hydrocarbons. The hydrogen, methane, and carbon monoxide pass on into the iodine pentoxide U-tube immersed in the oil bath *a* heated to 100° to 175° C. Only the carbon monoxide is oxidized by the iodine pentoxide (the concentration of hydrogen in dilute exhaust gas being too low to be affected). The liberated iodine is absorbed in potassium iodide solution in test tube *c*, using the bubbler as shown in the sketch, and titrated with sodium thiosulfate from buret *n*. Buret *m* is used for the starch solution.

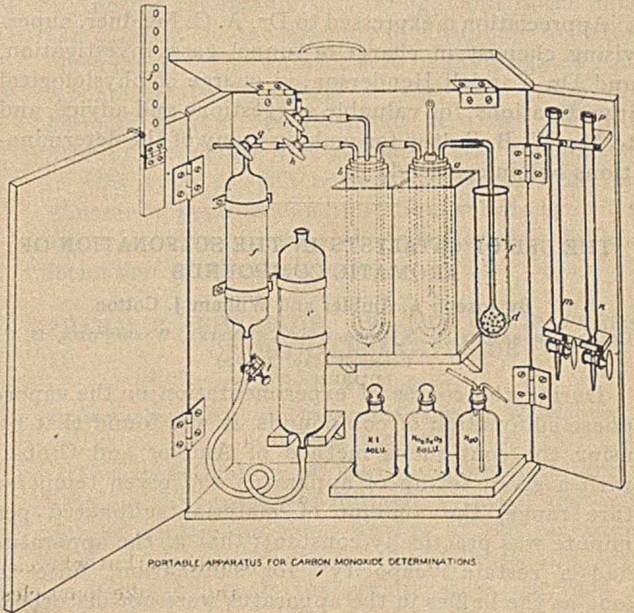

FIG. 2

By filling the Dewar tubes before starting to work, they will be found quite sufficient for a day's work, which will be much too long for the operator to remain in most atmospheres containing carbon monoxide.

In making a determination, a sample is drawn into *f* by means of *e* (filled with water), and slowly passed through the apparatus. The rate of flow is regulated by placing tube *e* on rack *j* and adjusting the pinchcock *l*. From 6 to 7 min. is the best rate for a 500-cc.

sample. During this procedure, stopcock *i* is turned to permit the evaporating liquid air to escape into the atmosphere. Since the apparatus must be cleared with fresh air and the determination is being made in the gas to be tested, stopcocks *i* and *h* are now turned to place the liquid air chamber in communication with *f* and the tube thus filled with "pure air" for sweeping the train.

The apparatus is contained in a cabinet 24 in. × 20 in. × 7 in.

A determination should take about 15 min. and should be accurate to from 0.003 to 0.005 per cent carbon monoxide (0.3 to 0.5 part in 10,000).

SUMMARY

The iodine pentoxide method for determining low concentrations of carbon monoxide has been investigated with reference to its use with dilute motor exhaust gas. The type of apparatus heretofore used was found to give appreciably high results owing to the presence of small amounts of unburned gasoline. A new iodine pentoxide apparatus (Type II) has therefore been developed. All of the interfering gases are first removed at the temperature of liquid air. This method has been found quite satisfactory for determining carbon monoxide in small quantities in the presence of gasoline vapor.

A portable iodine pentoxide apparatus has been designed which should permit a determination to be made in 15 min. with an accuracy of from 0.003 to 0.005 per cent carbon monoxide (0.3 to 0.5 part in 10,000).

ACKNOWLEDGMENT

Appreciation is expressed to Dr. A. C. Fieldner, supervising chemist in charge of tunnel gases investigation, and Dr. Yandell Henderson, in charge of physiological investigations, for valuable suggestions and advice, and to Mr. W. B. Fulton for making many of the determinations herein reported.

THE USE OF CATALYSTS IN THE SULFONATION OF AROMATIC COMPOUNDS

By Joseph A. Ambler and William J. Cotton

COLOR LABORATORY, U. S. BUREAU OF CHEMISTRY, WASHINGTON, D. C.

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During the course of experimentation on the vapor-phase sulfonation of compounds, it was found that by using the continuous method of Ambler and Gibbs,[1] with a given set-up of apparatus and given temperature range, the amount of material sulfonated per minute was practically constant; that is, the apparatus had a certain "capacity" for sulfonation, since so long as the baffles in the apparatus were not disturbed, the free space for vapors and the absorbing or sulfonating surface were constant. The method, therefore, provided a good means of studying the effect of various substances introduced with the reacting materials, and of ascertaining which were catalyzers of the sulfonation reaction. This work is intended as introductory to a much more complete study of sulfonation catalysts. Inasmuch as the study will be unavoidably delayed for some time, it seems best to publish the work thus far accomplished, although it is incomplete.

Various workers have reported that the sulfonation of aromatic compounds may be accelerated by adding different catalysts. The addition of sodium sulfate[1] or various acid sodium sulfates[2] has long been common practice, and a similar use of potassium sulfate[3] has also been reported. It is also well known that various sulfonic acids can easily be further sulfonated in the form of their sodium or potassium salts; whereas, if the free acid is used, the introduction of more sulfonic acid groups becomes extremely difficult, as, for example, in the production of benzene-1,3,5-trisulfonic acid[4] from the salts of benzene disulfonic acid. In all of these cases, the large amount of the alkali salts used makes it almost impossible to decide whether the action is catalytic, or caused by the greatly increased boiling point of the sulfuric acid-alkali sulfate mixture used.

Other substances recommended as accelerating catalysts are vanadium[5] in the sulfonation of anthraquinone, and iodine[6] in the sulfonation of benzene. Compounds of mercury, aluminium, iron, lead, arsenic, bismuth, cadmium, and manganese[7] have also been studied from the standpoint of their effect upon the position in the molecule taken by the entering sulfonic acid group.

EXPERIMENTAL DETAILS

In the present work some of the compounds mentioned above have been studied to ascertain whether they exert any accelerating (catalytic) effect on the sulfonation of benzene, and all so far examined have shown some catalytic action. These substances are copper sulfate, mercuric sulfate, vanadium pentoxide, sodium sulfate, chromic acid, potassium sulfate, lithium sulfate, and mixtures of sodium sulfate and vanadium pentoxide. In every case the substance was dissolved in 70 per cent sulfuric acid, thus insuring a constant concentration of the catalyst in the reaction tower. The concentration of catalyst is expressed as the percentage of the characteristic element, although in making the solutions the above-mentioned compounds were actually added to the sulfuric acid. For example, 0.1 per cent copper means that the amount of copper sulfate used was chemically equivalent to that weight of copper which was 0.1 per cent of the weight of the sulfuric acid.

In each case the experiment was carried on for from an hour to an hour and a half, after which time the products of the reaction were discarded, at the same time "cutting in" with weighed quantities of acid and benzene. The experiment was considered as starting

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[1] U. S. Patents 1,292,950; 1,300,227; 1,300,228. A description of this process will be published in subsequent papers.

[1] Girard, *Bull. soc. chim.*, **25** (1876), 333; Mühlhäuser, *Dingler's polytech. J.*, **263** (1887), 154.

[2] Lambert, D. R. P. 113,784 (1899); Kendall, U. S. Patent 1,217,462 (1917).

[3] Jackson and Wing, *Am. Chem. J.*, **9** (1887), 325.

[4] Jackson and Wing, *Loc. cit.*; Behrend and Murtelsmann, *Ann.*, **378** (1911), 352.

[5] Thümmber, D. R. P. 214,156 (1909).

[6] Hinemann, Brit. Patent 12,260 (1915).

[7] Iljinsky, *Ber.*, **36** (1903), 4194; Schmidt, *Ibid.*, **37** (1904), 66; Dünschmann, *Ibid.*, **37** (1904), 331; Holdermann, *Ibid.*, **39** (1906), 1250; Dimroth and Schmaedel, *Ibid.*, **40** (1907), 2411; Behrend and Mertelsmann, *Loc. cit.*; Mohrmann, *Ann.*, **410** (1915), 373.

from this point in order to be sure that the reaction had become thoroughly established and that everything about the apparatus was in a state of equilibrium which could be maintained until the end of the experiment; and to obviate the large error inherent in the apparatus, due to the fact that it took some time for the benzene vapors to displace all the air in the apparatus, and for the sulfuric acid to wet all the surfaces of the baffles and the walls of the tower, during which time the apparatus did not operate at its maximum capacity.

TABLE I

Catalyst	Concentration Per cent	Mean Temp. ° C.	Duration of Expt. Min.	Wt. Sulfonic Acids Grams	Wt. Benzene Sulfonated per Min. Grams
...	...	243	580	734	0.63
Cu	0.1	251	185	301	0.80
Hg	0.1	243	232	386	0.82
V	0.1	249	249	356	0.71
Na(I)	0.1	252	291	649	1.10
Cr	0.1	249	202	278	0.67
K	0.17	257	292	479	0.82
Li	0.094	246	283	405	0.61
Na(II)	0.5	255	300	492	0.83
Na(III)	0.1	259	355	601	0.84
Na V	0.1 0.05	242	274	626	1.13
V Na	0.223 0.025	249	232	592	1.26

Tables I and II give the critical data so far as the catalysts are concerned. The "weight of sulfonic acids" in Table I was found as follows: Total acidity, expressed in terms of sulfuric acid, was determined by titration with standard alkali, using phenolphthalein or thymolsulfophthalein for indicator. Actual sulfuric acid was determined with barium chloride as usual. The difference of these two determinations represented sulfuric acid equivalent to the sulfonic acid present. The latter was temporarily assumed to be benzene monosulfonic acid, and its amount calculated according to the ratio $H_2SO_4 : 2HSO_3.C_6H_5$. From this value it was a simple matter to calculate the amount of benzene sulfonated per minute.

TABLE II

Catalyst	Concentration, Per cent	Mean Temp., ° C.	Duration of Expt., Min.	Wt. Sulfonic Acids Grams (Corr.)	Wt. Disulfonic Acid Grams	Wt. Benzene Sulfonated per Min. Grams	Wt. Disulfonic Acid Produced per Min. Grams
..	...	243	580	705	147	0.56	0.25
Cu	0.1	251	185	294	28	0.76	0.15
Hg	0.1	243	232	377	36	0.78	0.16
V	0.1	249	249	355	6	0.66	0.03
Cr	0.1	249	202	274	13	0.66	0.06
Li	0.094	246	283	380	95	0.61	0.34
Na(II)	0.5	255	300	463	111	0.70	0.37
Na(III)	0.1	259	356	574	101	0.75	0.29
Na V	0.1 0.05	242	274	595	121	1.00	0.44
V Na	0.223 0.025	249	232	569	88	1.15	0.39

These figures, however, were subject to error, inasmuch as some benzene disulfonic acid was always formed. Table II contains corrected values, based on the following calculation: The amount of disulfonic acid was determined by analysis of the barium salt of the sulfonic acids, making necessary corrections for the catalyst itself when it was found in the barium salt. The weight of sulfonic acids was then corrected and, by using the two ratios $C_6H_6 : C_6H_5SO_3H$ and $C_6H_6 : C_6H_4(SO_3H)_2$, the amount of benzene actually sulfonated per minute was calculated.

It should be noted here that two experiments given in Table I do not appear in the second, *viz.*, Na(I) and K. Through an unfortunate oversight the amount of benzene disulfonic acid was not correctly determined, because no determination of the amount of catalyst contained in the barium salt was made.

The experiment with no catalyst is typical of many in which the amount of benzene sulfonated per minute was always approximately 0.5 g. This figure represents the normal capacity of the apparatus.

DISCUSSION OF RESULTS

A study of Table I shows that all the substances used increased the amount of benzene sulfonated per minute, and that these catalysts are divided into two general groups, *viz.*, those which have a slight catalytic action, copper, mercury, vanadium, chromium, potassium, lithium, and two of the experiments with sodium; and those which have a marked catalytic action, the first experiment with sodium, and the two experiments using both sodium and vanadium. The more marked effect in the first experiment with sodium was caused by a small amount of vanadium, which had been used in the experiment just preceding it, and which had not been completely removed from the tower.

The most active catalyzer is obviously a mixture of sodium and vanadium in any reasonable proportion. The results also clearly show that the sodium and potassium sulfates in sulfonation mixtures have a distinct catalytic effect, and that the advantages gained by their use are not entirely due to the increased boiling point of the sulfuric acid.

Another interesting fact brought out is the effect of the catalyst on the amount of disulfonic acid formed per minute. This subject is to be investigated further. Apparently the members of the first group of the periodic system, represented here by sodium and lithium, accelerate the formation of disulfonic acid in this type of sulfonation, while the mixture of vanadium pentoxide with sodium sulfate is still more effective. The other catalysts apparently inhibit the formation of disulfonic acid.

PHTHALIC ANHYDRIDE. IV—THE VAPOR PRESSURE OF PHTHALIC ANHYDRIDE

By K. P. Monroe

Color Laboratory, U. S. Bureau of Chemistry, Washington, D. C.

Received June 1, 1920

The investigation of the vapor-pressure curve of phthalic anhydride was initiated to assist in the solution of certain problems arising in the air-oxidation process recently developed by Gibbs[1] and his coworkers. Although the results were obtained in a preliminary series of measurements, and are not of the order of accuracy which it was hoped to obtain by repetition with a more refined mercury gage, they are presented, since it appears unlikely that the author will resume the investigation.

Phthalic anhydride, purified by a method previously described,[2] was placed in a static isoteniscope of the

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[1] See the previous articles of this series: "Phthalic Anhydride," I, by H. D. Gibbs, This Journal, 11 (1919), 1031; "Phthalic Anhydride," II and III, by K. P. Monroe, *Ibid.*, 11 (1919), 1116 and 1119.

[2] Part II, *Loc. cit.*

type designed by Smith and Menzies,[1] which was clamped vertically in a paraffin bath and connected, after the fashion described by these authors, to a vacuum pump, mercury gage, and a large iron cylinder which served as low pressure reservoir. The bath was a large unsilvered Dewar flask supported by felt-covered rings and filled nearly to the brim with paraffin which was stirred violently by a turbine. Constant temperature was maintained by an electrical heating device consisting of a nichrome coil wound on a glass tube snugly fitted into an outer glass tube sealed at one end. By means of a lamp-board connected to the 110-volt lighting circuit the current passing through the coil was accurately adjusted to maintain the temperature, which was measured by a calibrated Reichsanstalt thermometer completely immersed in the bath. After constant temperature (within ±0.05°) had been maintained for 15 min., the anhydride contained in the isoteniscope was boiled by maintaining a pressure somewhat less than the vapor tension. Air was then admitted cautiously in the reservoir until the levels of liquid anhydride became equal, and the gage was read. The boiling-out process was then repeated and another reading taken. This procedure was continued until the gage readings became constant and all dissolved gases had been expelled. The gage readings were corrected to 0° C.

TABLE I—VAPOR PRESSURE OF PHTHALIC ANHYDRIDE

p (Mm. of Hg)	t (° C.)
130.5	212.0
172.1	222.0
241.2	234.6
287.1	241.5
369.4	252.4
759.3	284.6[1]

[1] Compare 276°, Lossen, *Ann.*, **144** (1867), 76; 284.5°, Graeke, *Ber.*, **17** (1884), 1176.

The following interpolation formula was found to fit these data:

$$\log_{10} p = 7.94234 - \frac{2823.5}{T} \qquad (1)$$

when p = vapor pressure in millimeters of mercury, and T = absolute temperature.

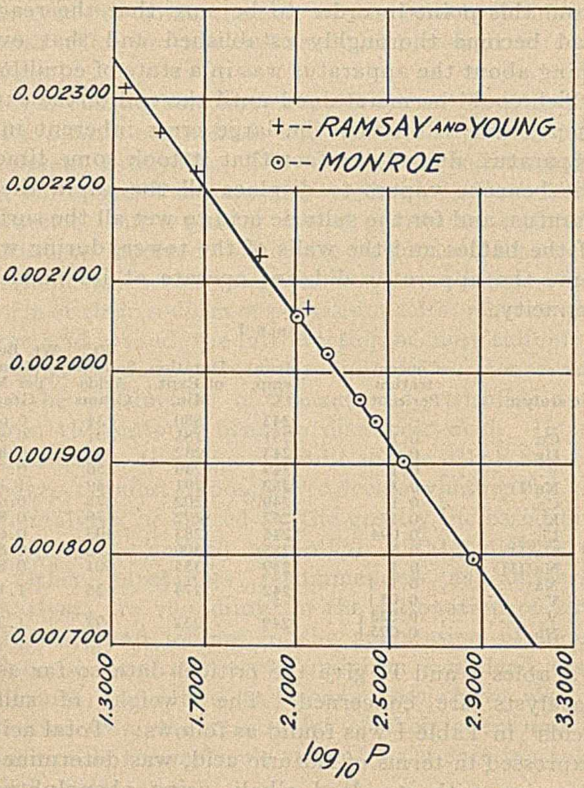
TABLE II—COMPARISON OF OBSERVED AND CALCULATED TEMPERATURES

p	T (Observed)	T (Calculated)
130.5	485.0	484.6
172.1	495.0	494.8
241.2	507.6	507.8
287.1	514.5	514.8
369.4	525.4	525.3
759.3	557.6	557.8

Since Ramsay and Young[2] have carried out a series of measurements of the vapor pressure of phthalic anhydride over a different temperature range than the one explored in this investigation, and with a different type of apparatus, it is of interest to compare the vapor tensions found by these investigators with the values calculated by Equation 1.

TABLE III—COMPARISON OF CALCULATED VAPOR PRESSURES WITH DATA OF RAMSAY AND YOUNG

t (° C.)	p (Observed)	p (Calculated by Equation 1)
159.5	22.8	26.0
168.6	32.2	35.3
177.1	46.9	46.7
196.9	87.3	85.8
210.1	142.0	125.3



The molar latent heat of vaporization of phthalic anhydride may also be calculated by Equation 1, for this equation is of the simple type obtained by integrating the Clausius-Clapeyron equation:[1]

$$\frac{dp}{dT} = \frac{L}{(V - v)T} \qquad (2)$$

where L = molar heat of vaporization, V = volume of mole of gaseous phase, v = volume of mole of liquid phase, T = absolute temperature, with the assumptions: (1) that the volume of a mole of liquid phase is negligible compared with that of a mole of gaseous phase; (2) that the gaseous phase obeys the perfect gas law; and (3) that the heat of vaporization does not vary with temperature.[2] Integrating and introducing Napierian logarithms:

$$\log_{10} p = C - \frac{0.4343\ L}{RT} \qquad (3)$$

when R = the gas constant, and C is a constant of integration.

Since

$$\frac{0.4343\ L}{R} = 2823.5 \qquad (4)$$

the molar heat of vaporization of phthalic anhydride is calculated to be 12,910 calories.

According to the criterion suggested recently by Hildebrand,[3] phthalic anhydride is shown by the data of this investigation to behave as a *normal* liquid, for the value 13.6 is obtained for the entropy of vaporiza-

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[1] *J. Am. Chem. Soc.*, **32** (1910), 1412, 1434, 1448.

[2] *Trans. Roy. Soc. London*, **1886**, I, 102.

[1] Washburn, "Principles of Physical Chemistry," McGraw-Hill Book Co., New York, **1915**, p. 123.

[2] None of these assumptions is, of course, strictly valid. The accompanying figure, however, reveals their justification by the experimental data over the somewhat limited temperature range, which is probably far below the unknown critical temperature of phthalic anhydride.

[3] *J. Am. Chem. Soc.*, **37** (1915), 970.

tion divided by R at the temperature (near 218°) at which the concentration of vapor is 0.00507 mole per liter. This value coincides with the average obtained from Hildebrand's table, based upon the vapor pressure curves of fifteen normal liquids.

THE EFFECT OF CERTAIN ACCELERATORS UPON THE PROPERTIES OF VULCANIZED RUBBER—II[1]

By G. D. Kratz and A. H. Flower

THE FALLS RUBBER CO., CUYAHOGA FALLS, OHIO

In a recent paper,[2] H. P. Stevens has given new figures, and from them made a number of deductions in regard to certain discrepancies between results obtained by the present authors[3] and earlier results obtained by him.[4] We do not entirely agree that these latest deductions will suffice for the complete coördination of his former results with ours. This view is confirmed by the repetition and amplification of our former experiments, including work with extra light instead of heavy calcined magnesia.

This work was carried out with a sample of the rubber previously employed and also with another rubber of similar physical appearance. Entirely different results were obtained with the two rubbers. In neither instance, however, was extra light magnesia found to develop greater activity than Accelerator A, and, in one case, it was markedly inferior to the latter. In both cases where Accelerator A was employed, the load required to effect a given extension led to erroneous conclusions, if used as a criterion of the rate of cure.

As these results were obtained with accelerators of definite composition and purity, the differences may be attributed to variations existing in the rubbers themselves, and most probably in the nature, amount, or condition of the extraneous materials present. As a considerable portion of this extraneous matter was extractable with acetone, an investigation was made of the relative effect of the two accelerators upon the two rubbers after extraction. Since the nature of the substances removed by the extraction[5] was not studied, no attempt can be made to correlate the effect of the extra light magnesia with any definite one of the extraneous substances originally present in the rubber. Certain facts, however, have been well enough established to deserve brief consideration.

It was noted by Spence[6] that the nitrogen in rubber was not entirely of protein origin, and that nitrogenous bodies of well-defined alkaloidal character could be detected in the acetone extract of Para rubber. This was subsequently confirmed by Spence and Kratz[7] for plantation crepe (Hevea), although a difference in the character of the protein material in the two rubbers was found. Further, certain of their results indicated that in plantation Hevea the non-protein nitrogenous substance was not easily extractable with acetone. Dekkar[1] also noted the presence of nitrogen in the acetone extract, and gave figures for nitrogen distribution in the extracted rubber and its acetone extract which closely confirmed those originally obtained by Spence. Prior to Dekkar's observations, Beadle and Stevens[2] noted that the rate of vulcanization of certain rubbers decreased if the rubbers were previously extracted with acetone. After vulcanization the physical properties of the acetone-extracted samples were so greatly impaired, due either to the loss of the resin or the physical effect of the solvent upon the rubber, that the decrease in the rate of cure was considered of secondary importance.

It would therefore appear that the removal of the acetone-soluble nitrogenous constituent is responsible for the decrease in the rate of cure of the rubbers, rather than either of the causes originally assigned by Beadle and Stevens.[3] This is also in accordance with the later results of Eaton, Grantham and Day,[4] and of Stevens,[5] wherein the accelerating substance of plantation Hevea rubber was found to be an organic base or mixture of bases, probably formed by the degradation of the protein portion of the nitrogenous material originally present in the rubber.[6]

The possibility that magnesia may hasten this degradation, with the formation of an accelerator similar to that produced by the biological decomposition of the proteins, has already been pointed out by Eaton[7] in commenting upon the patent of Esch.[8]

In view of the well-known action of many synthetic organic accelerators in the presence of certain mineral oxides, such as that obtained by Cranor[9] with zinc oxide, we are led to the conclusion that the effect of small amounts of magnesia in accelerating the vulcanization of rubber is of a secondary or contributory, rather than a primary nature, and consists largely in effecting a response from the natural accelerator in the rubber. This finds further confirmation in the observation of Stevens in his previous paper, wherein he pointed out that the accelerating effect of extra light magnesia decreases when a sulfur coefficient of

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[1] Presented at the 59th Meeting of the American Chemical Society, St. Louis, Mo., April 12 to 16, 1920.

[2] *India Rubber J.*, **58** (1919), 527.

[3] *Chem. and Met. Eng.*, **20** (1919), 417.

[4] *J. Soc. Chem. Ind.*, **37** (1918), 156*t*.

[5] A qualitative determination showed the presence of nitrogen in the extracts of both rubbers.

[6] Herbert Wright, "*Hevea Bras.*, or Para Rubber," **1912**, p. 439. London.

[7] *Kolloid-Z.*, **14** (1914), 268.

[1] Comm. of the Neth. Govt. Inst. for Advising the Rubber Trade and Rubber Industry, Part II, p. 55.

[2] *Intern. Congr. Appl. Chem.*, **25** (1912), 581.

[3] In a previous paper [THIS JOURNAL, **12** (1920), 317], we have mentioned that results obtained with certain synthetic organic substances indicate, in some cases, that the accelerator may be closely bound to the rubber. Should this also be found true in the case of the natural accelerator, the removal of this substance by extraction would markedly impair the physical properties of the sample after vulcanization, as well as slow down the rate of cure. (Compare with footnote, p. 974.)

[4] "Variability in Plantation Rubber," *J. Soc. Chem. Ind.*, **35** (1916), 715.

[5] *J. Soc. Chem Ind.*, **36** (1917), 365.

[6] The protein portion of this nitrogenous material which is insoluble in acetone and benzene has been shown to act as an accelerator (Beadle and Stevens, *Kolloid-Z.*, **11** (1912), 61; **12** (1913), 46; **14** (1914), 91). It has the further advantage of being present in relatively large amount as compared with the acetone-soluble constituent. As it does not, however, respond to magnesia to the same extent as the latter substance, and, as certain results (not included in this paper) indicate that the extraction with acetone does not cause a marked degradation of this protein material into the soluble variety, we have not made reference to it.

[7] *Agr. Bull. Federated Malay States*, **5** (1915), 38.

[8] Ger. Patent 273,482 (Nov. 22, 1912)

[9] *India Rubber World*, **61** (1919), 137

2.0 to 2.5 has been attained. At this point, increased amounts of magnesia would have no effect, as they would be in excess of the amount required by the natural accelerator, which is present in the same definite and limited amount in all of the mixtures.[1]

The same would not be true for Accelerator A, which is regarded as a primary accelerator and is present in the various mixtures in increasing amounts up to 1 per cent of the rubber.

In conclusion, we wish to draw a distinction between the terms "effect of accelerators" and "action of accelerators." This paper deals primarily with the effect produced by certain accelerators upon the sulfur coefficient and the physical properties of the rubber after vulcanization. The action of these accelerators, *per se*, is another problem entirely. We are convinced, however, that in many instances both the action and effect of organic accelerators is dependent in great extent upon the presence of certain mineral substances in the mixture.

EXPERIMENTAL PART[2]

The experimental procedure was similar in all respects to that of our former experiments. Essentially it differs from that of Stevens only in the method of vulcanizing, and in the substitution of straight pieces for physical tests in place of the rings employed by him. The relative effects of vulcanization in steam and in a platen press are commented upon later.

Two samples of thin, pale, first latex crepe (Hevea) were used. Sample 408 was from the lot of rubber that was used in our former experiments, while Sample 444 was chosen from another lot of equally good appearance, which was found to have different chemical and physical characteristics when employed in factory mixtures.

A partial analysis of the two rubbers gave the following results. No great importance, however, is attached to the figures for total nitrogen.

	No. 408 Per cent	No. 444 Per cent
Total Ash	0.26	0.29
Acetone Extract	2.62	2.99
Total Nitrogen	0.19	0.20

The extra light magnesia (sp. gr. 3.45) was the best grade obtainable. It lost 4.00 per cent on ignition, after which it contained 93.67 per cent MgO. Accelerator A was prepared by the condensation of an amine with formaldehyde and was C. P. grade.

The conditions of milling and making physical tests were identical with those previously employed, but, as comparisons were made after the method of Stevens, the physical properties of the different mixtures at break have been omitted.

Sulfur determinations were made by our method[3] in place of that of Rosenstein-Davies.[4] The coefficients represent the combined sulfur of vulcanization expressed as a percentage of the rubber in the mixture.

Throughout the work all cures were made in a platen press of the usual type. Stevens' samples were wrapped with cloth and vulcanized in steam.[1]

EXPT. I—This work consisted virtually of a repetition of the previous work, using the sample of rubber (No. 408) previously employed, but substituting extra light magnesia for the heavy calcined material used in our former experiments. The results are given in detail in Table I,[2] and the relation between sulfur coefficients and amount of accelerator is shown graphically in Fig. 1. The relation between the amount of accelerator and the load required to effect a given extension is also shown in Fig. 1. In both cases these results confirm previous ones, even to the shape of the curves themselves. As has already been stated, if accelerators (such as our Accelerator A) are present in the mixture even in small amount, it is evident that the load required to effect a given extension is not a measure of the physical properties of the mixture, nor is it a reliable criterion of the rate of cure of the vulcanized mixtures.

TABLE I—TESTS ON RUBBER No. 408

Accelerator	Accelerator Per cent	Sulfur Coefficient Actual	Sulfur Coefficient Excess	Load in Hectograms per Sq. Mm. to Effect Extension 1 to 7 Actual	1 to 7 Excess	1 to 8 Actual	1 to 8 Excess	1 to 9 Actual	1 to 9 Excess
Extra Light Magnesia	Control	0.580	...	0.34	....	0.42	....	0.50	....
	0.10	0.704	0.124	0.58	0.24	0.74	0.32	0.94	0.44
	0.25	0.916	0.336	1.03	0.69	1.37	0.95	1.98	1.48
	0.50	1.874	1.294	2.09	1.65	3.20	2.78	5.11	4.61
	0.75	2.553	1.973	3.03	2.69	4.84	4.42	8.17	7.65
	1.00	2.599	2.019	3.21	2.87	5.17	4.75	8.92	8.42
Accelerator A	Control	0.580	...	0.34	....	0.42	....	0.50	....
	0.10	1.356	0.776	0.88	0.54	1.10	0.68	1.61	1.11
	0.25	1.987	1.407	1.70	1.36	2.25	1.83	3.57	3.07
	0.50	2.925	2.345	2.14	1.80	2.77	2.35	4.23	3.73
	0.75	3.309	2.729	2.16	1.82	2.72	2.30	4.32	3.82
	1.00	3.603	3.023	2.30	1.96	2.98	2.56	4.81	4.31

EXPT. II—This consisted of a repetition of Expt. I upon Sample 444. The results are given in Table II, and the relation between sulfur coefficients and the amount of accelerator, and between the amount of accelerator and the load required to effect a given extension are shown in Fig. 1. On the basis of the sulfur coefficients, Accelerator A and extra light magnesia appear to be of almost equal activity; or, conversely, Sample 444 vulcanizes at the same rate with either accelerator. When judged by the load required to effect a given extension, however, extra light magnesia appears to be much the more active. As it is now almost generally conceded that sulfur coefficients

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[1] It is interesting to note that Dekkar's figures for the nitrogen in the acetone extract of Hevea crepe (when calculated on a protein basis) are very close to the amounts of the accelerators employed in these experiments.

[2] In collaboration with Bernard J. Shapiro.

[3] *India Rubber World*, **61** (1920), 356.

[4] *Chemist-Analyst*, **15** (1916), 4.

[1] Stevens in his first paper on this subject has mentioned the possibility of a difference in the rate of cure of accelerated mixtures when vulcanized in dry heat. We have found similar mixtures which contained magnesia to show increasingly large sulfur coefficients when vulcanized, respectively, in dry heat, platen press, and open steam. This was not found to be true, however, for mixtures which contained organic accelerators. With the latter, results obtained in a platen press were frequently higher than those obtained in open steam. Evidently many organic accelerators are partially soluble in, or volatile with steam and, consequently, results obtained with these substances in open steam are apt to be low. This point is of considerable importance, and accounts in large part for the difference in the results obtained by Stevens and ourselves. We have found that most uniform results are obtained with samples encased in molds and vulcanized in open steam.

[2] The results obtained and shown in this table are somewhat higher than those originally found, and which were given in Table I of our former paper. This discrepancy may be attributed to a change in the rubber itself, as the sample used in the present instance had aged for over one year in roll form in a partially broken-down condition before the experiment was repeated. Also, the method previously employed for the estimation of combined sulfur was found to give slightly low results for mixtures which contained but small amounts of mineral substances.

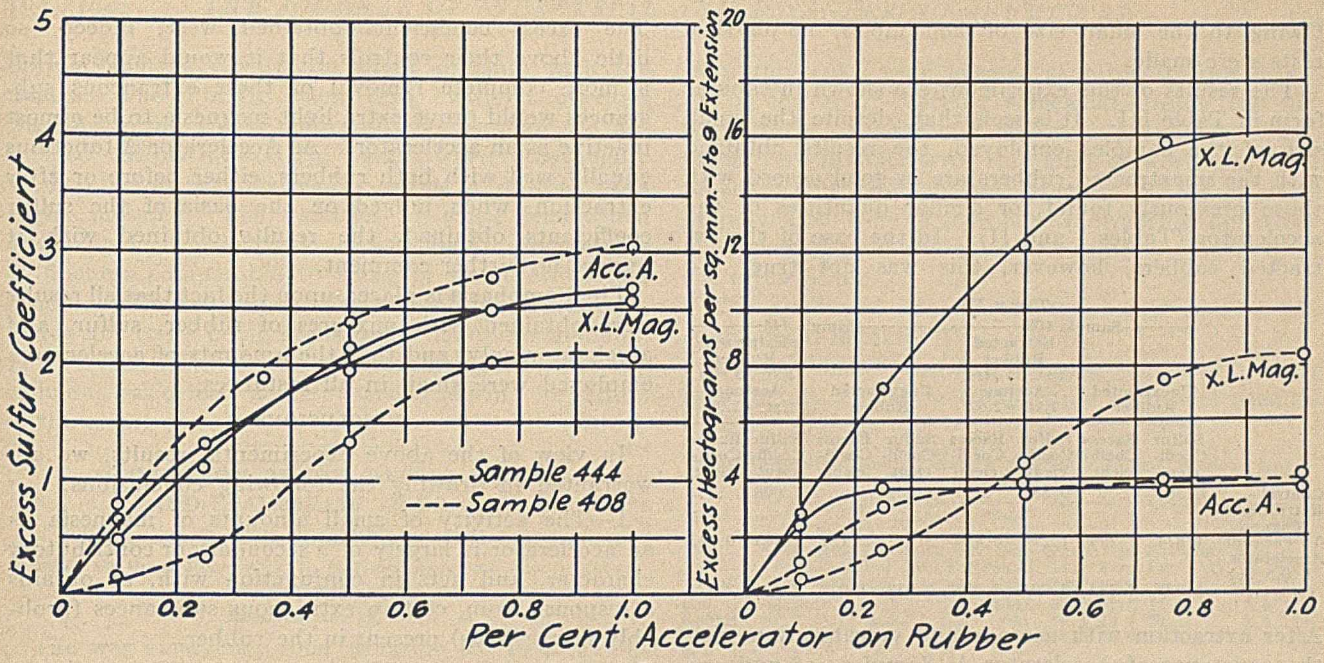

FIG. 1

afford the most reliable indication of the state of cure, the load required to effect a given extension is again seen to be unreliable as an indication of the rate of cure of accelerated mixtures. These results have strengthened our former opinion that, unless a complete series of stress-strain measurements are made, when the results of physical tests are taken as measure of the rate or state of cure of accelerated mixtures, such measurements must be made at or near the point of break of the respective mixtures. The effect of such small amounts of accelerators on the elongation of vulcanized mixtures has already been commented upon in our previous article. In contradistinction to Stevens' view, we do not regard the composition of a mixture as fixed when different accelerators are used, even if they are employed in amount less than 1 per cent on the rubber.

TABLE II—TESTS ON RUBBER No. 444

Accelerator	Accelerator Per cent	Sulfur Coefficient		Load in Hectograms per Sq. Mm. to Effect Extension					
				1 to 7		1 to 8		1 to 9	
		Actual	Excess	Actual	Excess	Actual	Excess	Actual	Excess
Extra Light Magnesia	Control	1.009	...	0.53	....	0.67	....	0.78	....
	0.10	1.482	0.473	1.55	1.02	2.08	1.41	3.44	2.66
	0.25	2.117	1.108	2.75	2.22	4.42	3.75	8.01	7.23
	0.50	3.132	2.123	3.88	3.35	7.09	6.42	13.08	12.30
	0.75	3.440	2.431	5.11	4.58	8.97	8.30	16.65	15.87
	1.00	3.552	2.543	5.14	4.61	8.37	7.70	16.69	15.91
Accelerator A	Control	1.009	...	0.53	....	0.67	....	0.78	....
	0.10	1.678	0.669	1.49	0.96	2.04	1.37	3.21	2.43
	0.25	2.317	1.308	1.95	1.42	2.53	1.86	4.41	3.63
	0.50	2.938	1.929	2.20	1.67	3.05	2.38	4.62	3.84
	0.75	3.437	2.428	2.16	1.63	2.83	2.16	4.33	3.55
	1.00	3.685	2.676	2.40	1.87	3.19	2.52	4.64	3.86

In his second communication,[1] Stevens has drawn attention to the relationship between the coefficient of vulcanization and the load at a given extension. Our present results, for Samples 408 and 444, expressed in the same manner, are shown graphically in Fig. 2. It is at once evident in both cases that they differ markedly from the results obtained by Stevens. In the case of the mixtures which contained magnesia, the curves for both rubbers are practically straight lines up to coefficients of about 2.0 to 2.5, and, as Stevens has already noted, the excess load required to effect a given extension affords a fair measure of the rate of cure. In the case of Accelerator A, however, these curves are not straight lines, which shows that the load required to effect a given extension is not a measure of the rate of cure, as indicated by sulfur coefficients. Evidently, both rubbers vulcanize at almost the same rate when this accelerator is employed.

Both Stevens' and our own results are subject to the same interpretation. Our Accelerator A has been shown to decrease the load required to effect a given extension, *i. e.*, has increased the elongation as compared with extra light magnesia. It is quite possible, however, that Stevens' Accelerator I induced a greater resistance to extension under a given load than our Accelerator A. Furthermore, it is not entirely out of the question to select an organic accelerator which would actually increase the resistance to extension to more than that obtained with a similar quantity of extra light magnesia.

EXPT. III—A comparison was made of the results obtained with the two rubbers before and after extraction with acetone.

A 10-g. sample of the rubber was sheeted thin and extracted with acetone in a Soxhlet apparatus for 36 hrs. At the end of this time, the sample was dried *in vacuo* to constant weight and re-sheeted. The mixture was made by carefully sieving the required amount of sulfur and accelerator into the sheeted rubber and then rolling into a cylinder. The sample thus prepared was squeezed between the rolls of the mill to press the ingredients into the rubber without loss of either sulfur or accelerator. Subsequently, it was thoroughly mixed by re-sheeting and re-rolling until a homogeneous mix was obtained. After the samples had been allowed to age for 24 hrs. they were vulcanized in a button mold in the platen press and the combined sulfur estimated in the usual manner.

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[1] *Loc. cit.*, Fig. 3.

Owing to the small size of the samples,[1] no physical tests were made.

The results of this experiment are shown in tabular form in Table III. It is seen that, despite the small size of the samples employed, the results obtained with the unextracted rubbers are in good accord with those previously found for similar quantities of the accelerator (Tables I and II). In the case of the extracted rubbers, however, this was not true.

TABLE III

	Sample 408				Sample 444			
	Unextracted Rubber		Extracted Rubber (Ext. 36 Hrs.) Acetone Ext. = 2.62		Unextracted Rubber		Extracted Rubber (Ext. 36 Hrs.) Acetone Ext. = 2.99	
	Sulfur Coefficient	Excess Coefficient	Sulfur Coefficient	Excess Coefficient	Sulfur Coefficient	Excess Coefficient	Sulfur Coefficient	Excess Coefficient
Control....	0.580	...	0.831	...	1.009	...	1.000	...
Extra Light Magnesia, 0.5 Per cent	1.874	1.294	1.290	0.459	3.132	2.123	1.343	0.343
Accelerator A 0.5 Per cent......	2.925	2.345	3.204	2.373	2.938	1.929	3.424	2.424

After extraction with acetone and vulcanization with the assistance of Accelerator A, Samples 408 and 444 were both found to have approximately (slightly higher) the same sulfur coefficients as were obtained with the unextracted rubbers, which have already been shown to be almost equal to each other. The extracted samples which were vulcanized with the assistance of extra light magnesia, however, gave entirely different results. Although the unextracted samples had sulfur coefficients of 1.874 and 3.132, respectively, the same mixtures, when prepared with acetone-extracted rubbers, had approximately the same sulfur coefficient, 1.3.

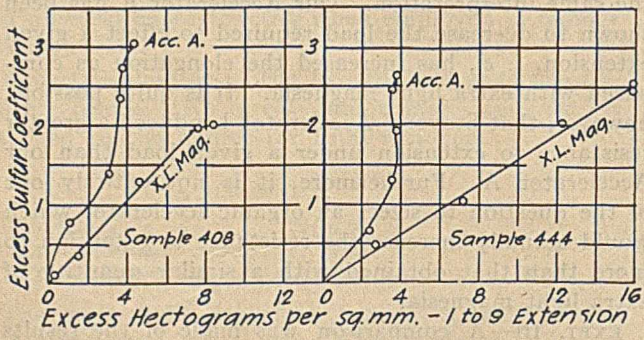

FIG. 2

It would appear that Sample 444 differed from Sample 408 quite markedly in the nature or condition of its acetone-extractable components. Although we recognize that the extraction with acetone may not be without effect upon the rubber or upon the extraneous substances left in the rubber, it would appear that, if the acetone-soluble substances are removed, not only is the response of the two rubbers to the accelerating influence of extra light magnesia decreased in both instances, but also the excess sulfur coefficients obtained are small and almost equal. The excess coefficients obtained were, indeed, so little above their controls that it would appear that a more complete removal of these extraneous substances would prove extra light magnesia to be almost inactive as an accelerator. As Accelerator A functions equally well with both rubbers, either before or after extraction, when judged on the basis of the sulfur coefficients obtained, the results obtained with it require no further comment.

Final emphasis is placed upon the fact that all results were obtained with mixtures of rubber, sulfur, and accelerator only, and that the amounts of accelerators employed were small in all instances.

CONCLUSIONS

In view of the above experimental results, we are warranted in drawing the following conclusions:

I—The activity of small amounts of magnesia as an accelerator is largely of a secondary or contributory character, and acts in conjunction with, or obtains a response from, certain extraneous substances (probably nitrogenous) present in the rubber.

II—The activity of small amounts of magnesia is limited by the amount and nature of these extraneous substances originally present in the rubber.

"PORCELAIN" WHITE LEAD

By Edwin Euston

EUSTON PROCESS COMPANY, SCRANTON, PA.

Received June 10, 1920

In the stack process of corrosion for the manufacture of white lead, two extreme results are noticed. Under properly balanced stack conditions the product is a dense "porcelain-like" crust, approximately $2PbCO_3.Pb(OH)_2$, but under less controlled conditions, such as occasionally exist in the top layer of a stack, the product is a light, fluffy powder, approximating $PbCO_3$. The characteristic appearance of the dense product has been assumed[1] as evidence that white lead is a definite compound, $2PbCO_3.Pb(OH)_2$, but this assumption does not account for the lack of coherence of the other compound.

An explanation is found in the relative cementing effect of the residual colloidal basic lead acetate in the "porcelain-like" crust, and of the residual normal lead acetate in the fluffy product. Probably because of the coarseness of particles, samples of commercial pulverized white lead, treated, respectively, with basic and slightly acid solutions of lead acetate and dried, do not demonstrate this difference in cementing effect; but the precipitation process for the manufacture of white lead affords full opportunity for the preparation of $2PbCO_3.Pb(OH)_2$ or $PbCO_3$ in very much smaller particles than the dried pulverized product. The cementing effect is then clearly shown, as the settled or filter-pressed $2PbCO_3.Pb(OH)_2$, when dried without previous washing, forms a hard "porcelain-like" mass extremely difficult to pulverize, the degree of hardness being proportional to the concentration of the basic lead acetate; but, when thoroughly washed before

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[1] It was obvious that the physical properties of the control mixture and the mixture which contained magnesia were very inferior to similar mixtures of unextracted rubber. This was not true, however, for the mixture which contained Accelerator A; the physical properties of this mixture were good and not greatly below a similar mixture prepared from unextracted rubber.

[1] Pp. 360, 361, and 364 of "Manual of Industrial Chemistry," edited by Allen Rogers. D. Van Nostrand Co., **1920**.

drying, forms a powder on slight pressure with the fingers. The $PbCO_3$ when dried without previous washing forms a cake noticeably softer than the unwashed $2PbCO_3.Pb(OH)_2$, and when thoroughly washed before drying readily forms a powder at a slight pressure. The particles of white lead when originally formed in the stack process are precipitates of fineness comparable to those of the precipitation process. The hardness of "porcelain" lead, therefore, is due not to its being an assumed definite compound, $2PbCO_3.Pb(OH)_2$, but to the cementing effect of the colloidal basic lead acetate present during formation of the crust.

UTILIZATION OF KID, RABBIT, HORSE, AND SEAL MEATS AS FOOD[1] [2]

By Arthur D. Holmes and Harry J. Deuel, Jr.

Office of Home Economics, U. S. Department of Agriculture, Washington, D. C.

Received May 12, 1920

The war emergency food situation led to a revaluation of foods with respect to nutritive value and use, including many which were not commonly known in the United States. This was true of meat products as well as of fats, cereal products, and other food staples.

The present experiments supply data regarding the digestibility of kid, rabbit, horse, and seal meats. Rabbit, both wild and domesticated, is a well-known food, used to considerable extent in some localities, particularly when the wild rabbit is in season. Kid is used in some localities in the United States, and horse meat is sold in some markets, particularly in large cities—a necessary requirement being that it be properly labeled. On the other hand, seal meat is unfamiliar to most Americans, although it is very commonly used as a food in the Pribilof Islands, the seat of the government seal fisheries. Although these meats are used only in a limited way in this country and its island possessions, large quantities could be made available for human consumption if there should be a demand for them.

EXPERIMENTAL PART

The methods followed in these experiments were essentially the same as those in previous ones of a similar nature conducted by this office.[3] The most satisfactory method of cooking the meat for this purpose was found to be in the form of small cakes, because this gave a uniform product that was easily sampled by cutting small sectors out of representative cakes. Very little difference in taste was noted in the cakes prepared from the different meats.

The purpose of these experiments was to determine the digestibility of the meat proteins, and the basal diet was so chosen as to supply a minimum of this food constituent. It consisted of bread, butter, fruit (orange), and sugar, with tea or coffee, if desired.

Young men, 20 to 40 years of age, students of a local university, were selected as subjects, the make-up of the group varying somewhat during the different tests. All the men who took part in the experiment were familiar with this kind of work and were regarded as thoroughly trustworthy. So far as could be judged, all were in good health, of normal appetites, and fairly typical examples of normal young men in the prime of life.

The results of analyses of the meats studied are summarized in Table I.

As is evident from these figures, the several kinds of meat are similar in composition to others used as food.

TABLE I—COMPOSITION OF EDIBLE PORTION OF KID, RABBIT, HORSE, AND SEAL MEATS

	UNCOOKED						COOKED					
KIND OF MEAT	Water Per cent	Protein Per cent	Fat Per cent	Carbohydrate Per cent	Ash Per cent	Fuel Value per Pound Cal.	Water Per cent	Protein Per cent	Fat Per cent	Carbohydrate Per cent	Ash Per cent	Fuel Value per Pound Cal.
Kid	57.8	17.6	26.1	..	0.9	1342	44.8	38.8	11.5	...	3.8	1175
Rabbit	67.9	25.6	4.3	..	2.1	641	49.4	28.1	20.1	...	2.4	1330
Horse	....	....	....	..	...	....	64.5	28.6	4.1	1.3[1]	1.5	711
Seal shoulder (corned)	....	....	....	..	...	....	62.3	30.0	3.1	....	4.6	671

[1] Glycogen.

KID MEAT—The use of goat meat as a food is very old, and kid flesh has long been recognized as a desirable food by many races. However, contrasted with the results of studies by Sherman and Lohnes,[1] Bosworth and Van Slyke,[2] Jordan and Smith,[3] Hall,[4] and Hill,[5] to determine the dietetic value of goat's milk or some of its constituents, one finds in the literature little experimental evidence concerning the nutritive value of goat and kid flesh. In this country this is due, at least in part, to the relatively small consumption of these foods, which is largely limited to those of foreign birth or food habits.

Since it seems to be generally conceded that kid meat is preferable to goat meat, just as lamb is preferred to mutton, the digestibility of the flesh of a young animal was studied, such meat being obtained through the coöperation of the Bureau of Animal Industry. The entire fleshy portion of one-half of the carcass of a 6-month-old kid was removed from the bones, passed through a meat chopper, seasoned, thoroughly mixed, fried in the form of small cakes in a pan greased with a little lard, and served as a part of a simple mixed diet, in such quantity that it supplied the major part of the protein eaten.

The coefficients of digestibility for the entire ration, which on the average supplied 108 g. of protein, 111 g. of fat, 347 g. of carbohydrate, and 2,820 cal. of energy daily, were found to be 91.7 per cent for protein, 95.5 for fat, and 98.6 for carbohydrate. These values are in close agreement with those reported for the digestibility of the ordinary simple mixed diet, which are 92 per cent for protein, 95 for fat, and 97 for carbohydrate.[6] The digestibility of kid meat protein alone was estimated to be 94.4 per cent.

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[1] Prepared under the direction of C. F. Langworthy, Chief of the Office of Home Economics.

[2] Published with permission of the Secretary of Agriculture.

[3] U. S. Dept. Agr., *Bulletin* **310** (1915); *J. Agr. Res.*, **6** (1916), No. 16; *Ibid.*, **6** (1916), No. 17; U. S. Dept. Agr., *Bulletin* **649** (1918); **717** (1918); **751** (1919); **781** (1919).

[1] *J. Am. Med. Assoc.*, **62** (1914), 1806.

[2] N. Y. State Agricultural Experiment Station, *Techn. Bulletin* **46** (1915), 3; *J. Biol. Chem.*, **24** (1916), 173–175, 177–185, 187–189.

[3] N. Y. State Agricultural Experiment Station, *Bulletin* **429** (1917), 4

[4] *Ibid.*, **429** (1917), 7, Pop. Ed.

[5] *J. Biol. Chem.*, **33** (1918), 392.

[6] Connecticut Storrs Station, *Report* **1901**, 245.

No attempt was made to obtain data regarding the digestibility of kid fat because that occurring in the meat was very thoroughly removed from the muscle tissue during the cooking process, and also because kid muscle fat mixed with kidney fat has been studied in another series of experiments and found to be 95.3 per cent digested.[1] On the basis of our results kid meat is apparently a very satisfactory source of protein that is well digested.

RABBIT MEAT[2]—For the purpose of these experiments rabbits (Belgian hare) believed to be representative of those procured by the average customer were purchased in the open market. The meat of wild rabbits was not available for study, but the digestibility should be about the same as that of the tame, because the two have practically identical chemical compositions, although they differ in appearance, the flesh of tame rabbits being lighter in color. The meat was prepared for serving by removing all the tissue from the bones, cutting in an ordinary household meat cutter, mixing uniformly, and frying into small cakes in a pan greased with a little lard. The rabbit meat contained very little fat and that present in the cakes was largely absorbed during frying.

On an average, the diet supplied 92 g. of protein, 114 g. of fat, 320 g. of carbohydrate, and 2,685 cal. of energy per man per day. The digestibility of the entire ration was found to be 90 per cent for protein, 95.8 for fat, and 97.9 for carbohydrate. Applying the usual corrections for the undigested protein present in the basal diet, it has been estimated that the digestibility of rabbit meat protein is 91.8 per cent. The subjects made no comment concerning their physical condition during the experimental period other than to state that they were in their usual normal health. The general conclusion obtained from these experiments was that rabbit meat is well assimilated and tolerated by the body.

HORSE MEAT—In this country relatively little horse flesh is used for human food. In Europe, however, it is a common article in the diet.[3] There is apparently little doubt that the supply of these animals will be sufficient to meet any probable demand in this country, for it is reported[4] that horses of "good flesh and health" but unsatisfactory for draft purposes on account of "wire cut," "over age," "inbred," and "under size" may be had from Montana ranches in carload lots.

A brief summary of information on horse meat as food, its qualities and identification, is included in a manual[5] prepared during the war for mess officers' use.

For the purpose of the experiments reported here a supply of meat was obtained through the courtesy of Mr. N. Hollister, superintendent of the National Zoölogical Park, from a normal healthy animal that passed rigid ante- and post-mortem inspections. In physical appearance the uncooked meat, though a deeper red in color, resembled beef very closely. To prepare it for serving it was passed through a meat cutter, seasoned, mixed uniformly, molded into cakes, and fried in a pan greased with a little lard.

On an average the diet supplied 126 g. of protein, 70 g. of fat, 349 g. of carbohydrate, and 2,700 cal. per man per day. Of the 126 g. of protein, 92 g. were derived from the horse meat, and this was found to be 96.4 per cent digested. No attempt was made at this time to determine the digestibility of horse fat, but in previous experiments the coefficient of digestibility was found to be 93.9 per cent.[1] In the reports of their physical condition during the experimental period, none of the subjects referred to any physiological disturbances resulting from the ingestion of a daily average of 306 g. of horse meat. It would accordingly appear that the protein of horse meat was both well tolerated and well utilized by the body.

SEAL MEAT—Under the supervision of the U. S. Bureau of Fisheries from 30,000 to 40,000 fur-bearing seals are slaughtered yearly. Though seal meat (seal shoulder) is used locally in the Pribilof Islands and is a well-known food of natives and explorers in the Arctic region, only a very limited portion of the amount furnished by the fur-seal fisheries has as yet been utilized, and as far as could be learned there is no experimental evidence on record concerning its digestibility. Records of Arctic travel, as for instance the observations of Stéfansson,[2] give much general information regarding seal meat and its uses, and from such data one can readily see that even if unknown elsewhere it has proved to be for uncounted time a valuable food of a very hardy people.

The seal meat used in these experiments was obtained through the courtesy of Mr. H. C. Fassett, specialist in charge of the fur-seal fisheries, and consisted of seal shoulders that had been packed in dry salt and later in brine. In preparing the meat for serving, it was soaked for 18 hrs. to remove salt, and boiled until tender. During both the soaking and the boiling, the water was changed two or three times. The cooked meat was removed from the bone, cut in an ordinary household meat chopper, seasoned, and cooked in the form of small cakes in a pan greased with a small amount of lard. In appearance and flavor the cooked meat very closely resembled corned beef.

Six digestion experiments were made with seal meat, but in two of them the data are not complete, since the tare for butter eaten as a part of the basal ration was overlooked. However, since the digestibility of protein was the primary interest, the experiments are reported without any allowance being made for the very small amount of protein supplied by the butter.

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[1] U. S. Dept. Agr., *Bulletin* **613** (1919), 7.

[2] A recent publication of the Department of Agriculture [*Farmers' Bulletin* **1090** (1920)] on "Rabbit Raising," summarizes some work of the Office of Home Economics on the composition of rabbit (Belgian hare) meat and the preparation and use of rabbits as food. Data are also given regarding the relation of live to dressed weight, the loss of weight in cooking, and the weight of bones and cooked meat.

[3] *Lancet* (London), **1** (1918), 189; *J. Am. Vet. Med. Assoc., n. s.*, **4** (1917), 681.

[4] *Nat. Provisioner*, **58** (1918), 17.

[5] "Mess Officers' Manual," prepared by several officers of the Division of Food and Nutrition of the Medical Department, U. S. Army. Lea & Febiger, Philadelphia and New York, **1919**, p. 31.

[1] U. S. Dept. Agr., *Bulletin* **613** (1919), 12.

[2] Stéfansson, "My Life among the Eskimo," **1913**.

The subjects ate an average of 104 g. of protein, 79 g. of fat, and 338 g. of carbohydrate daily, an amount of food sufficient to supply 2,455 cal. of energy. Of the 98 g. protein consumed daily, the 69 g. derived from the seal meat were found to be 94.6 per cent digested. All the subjects except one reported that they were in normal physical condition during the experimental period; the one exception reported a tendency towards constipation at the termination of the period, a condition not infrequently resulting from diets that are very completely digested. The general conclusion to be drawn from these experiments is that seal-meat protein like that of other meats is well digested.

As is always the case in this experimental work, discussion of the food and ration is always avoided with the subjects. However, from conversation which was overheard, it was apparent that they did not note any unusual flavor and thought these meat cakes were "Hamburg steak."

SUMMARY

The results obtained in the digestion experiments with kid, rabbit, horse, and seal meats are summarized in Table II. The coefficients of digestibility there given for the protein, the fat, and the carbohydrate of the entire ration and for the protein of the meats alone are the averages of the coefficients of the digestibility obtained in the individual experiments with the different meats. The amounts of meat eaten are included as a matter of dietary interest.

TABLE II—SUMMARY OF DIGESTION EXPERIMENTS WITH MEATS

		DIGESTIBILITY OF ENTIRE RATION				AMOUNT OF MEAT EATEN		
KIND OF MEAT	No. of Expts.	Protein Per cent	Fat Per cent	Carbohydrate Per cent	Ash	Aver. per Man per Day Grams	Max. per Man per Day Grams	Digestibility of Meat Protein Alone Per cent
Kid......	3	91.7	95.5	98.6	87.9	163	166	94.4
Rabbit...	5	90.0	95.8	97.9	80.1	205	217	91.8
Horse....	7	94.3	94.5	98.5	83.2	306	414	96.4
Seal.....	6	91.9	92.9[1]	98.0[1]	88.2[1]	230	281	94.6

[1] Average of four experiments.

The total ration in all the tests was very well utilized —the carbohydrates, especially, being very completely absorbed, from which it is apparent that these meats did not decrease the digestibility of the other constituents of the diet. In every case the average amount of meat eaten daily was in excess of that included in the ordinary diet of the average person, and in no instance were any physiological disturbances noted. The digestibility of the protein of the four kinds of meat studied was essentially the same as that of other and better-known meats.

A CHEMICAL METHOD FOR THE DETECTION IN FRUIT OF A PRIOR FROZEN CONDITION

By William M. Dehn and M. C. Taylor

CHEMICAL LABORATORY, UNIVERSITY OF WASHINGTON, SEATTLE, WASH.

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Modern methods of cold storage of fruits sometimes raise the question whether too low temperatures have been employed, resulting in abnormal deterioration when the fruit is removed from storage. For example, pears are held at a lower temperature than peaches, and, if both are held at the same temperature, the peaches may be injured. The question arises whether fruit which has been frozen or only partly frozen can be distinguished from fruit not subjected to these low temperatures.

Extreme cases of frozen fruit can, of course, always be recognized after thawing by the mushiness and darkening of the pulp, by the modified taste, and by the rapidity of rot. Between the extreme frozen condition and the non-frozen condition, cases arise that cannot be judged by such obvious indications. Chemical and histological methods of examination suggest themselves for such cases.

CHEMICAL METHODS OF DETECTION

Before discussing chemical methods of detection it is necessary to have in mind the physical effects of ice crystals upon cells, as are fully described in the studies of Schander and Schaffnit.[1] These include progressive disintegration effects, such as the growth of ice crystals, the instreaming of water from adjacent cells, the concentration of cell saps, cell plasmolysis, the destruction of inner plasma membranes with attending loss of osmotic function, the infiltration of electrolytes, and the coagulation of the proteins of the protoplasm. From this description it may be concluded that such free mingling of materials can rapidly give rise to those products which are normally slowly formed by ripening and by over-ripening.

Changes in fruits after gathering are described by Otto and Kooper[2] as increasing the amount of invert sugar and producing losses of water, cane sugar, acidity, and nitrogen. Contino[3] observes a loss of pectin. Prinsen-Geerligs[4] observes conversion of starch to sucrose and decrease of acids. Tannic acid[5] appears and disappears. Many fruits lose water during ripening,[6] but the total water content may be increased by "metabolic water." The specific gravity[7] of good fruit increases on storing, while that of frozen fruit decreases. With apple after ripening and storage there is a slight increase in invert sugar followed by a continual decrease, and sucrose also gradually decreases.[8]

Since the concentrations of acids vary during ripening and over-ripening, their variation after freezing and thawing was considered as a possible means of detection of the prior frozen state. However, the work of Bigelow and Dunbar[9] indicated that the concentrations of acids are too low and the acids themselves too varied to be of value. Other components con-

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[1] *Landw. Jahrb.*, **52**, 1; *Chem. Zentr.*, **2** (1918), 397.

[2] *Z. Nahr. Genussm.*, **19** (1910), 10, 328.

[3] *Staz. sper. agrar. ital.*, **45**, 60.

[4] *Intern. Sugar J.*, **10** (1908), 372.

[5] Basset, *et al.*, *J. Am. Chem. Soc.*, **33** (1911), 416; *Science*, **33** (1911), 624; Tonegretti, *Staz. sper. agrar. ital.*, **43** (1911), 369; Gerber, *Compt. rend.*, **124**, 1106; Behrens, *Centr. Bakt. Parasitenk.*, **4**, Part II, 7770.

[6] Babcock, University of Wisconsin, *Research Bulletin* **22**, 87.

[7] Webber, *et al.*, California Agricultural Experiment Station, *Bulletin* **304** (1919), 245.

[8] Neidig, *et al.*, Idaho Agricultural Experiment Station, *Report* **1917**, 22.

[9] THIS JOURNAL, **9** (1917), 762. A full bibliography is given. That the acid concentration may increase through rotting was shown by Hawkins, *Am J. Botany*, **2** (1915), 71.

sidered and abandoned were starch,[1] oxidases,[2] water,[3] nitrogen,[4] etc.[5]

That the changes in sucrose concentration could be used was suggested by such observations as the following: Sugars exercise the greatest protective action against freezing;[6] sucrose disappears in rotting fruit,[7] and is transformed to invert sugar during the stages of ripening and over-ripening; sucrose and invert sugar are differently localized[8] in the tissues of the fruit. The method described below makes use of the fact that freezing brings about a very rapid transformation of sucrose to invert sugar, the result, of course, of the free mingling of sucrose with inverting acids or invertase, or both.

METHOD OF ANALYSIS

One half of the fruit to be examined is analyzed directly and the other half is frozen with cracked ice and salt. Each sample of the fruit may be cut into halves, or, with very small fruit, two approximately equal samples may be set aside for the analysis. The directly analyzed portion involves the estimation of invert sugar before and after hydrolysis, yielding A and B; the frozen portion is also analyzed for invert sugar before and after hydrolysis, yielding C and D. In other words, the ratios of invert sugar to sucrose before and after freezing are compared.

In all cases the estimations are made by weighing the cuprous oxide formed after reduction. The respective solutions are measured out in triplicate in 10 cc. samples, treated with 10 cc. each of Fehling solutions I and II, diluted to a known volume (100 cc., for example), and boiled for a known time, say 5 min. The precipitates are filtered hot on weighed Gooch crucibles, washed with water and then with alcohol, and dried to constant weight at about 110° C. When the solutions are prepared in the manner described below no difficulty is met in filtering rapidly on the Gooch crucibles, and the first two analyses will usually agree.

SOLUTION A—The fruit is mashed in a mortar with water containing sufficient free alkali to maintain to the end an alkaline reaction, transferred to a flask or beaker, and boiled until a complete extract of the material is obtained. Since the percentage of invert sugar is not sought,[9] but only its ratio to sucrose, no weighing of fruit and maintaining of constant volumes need be made. A portion of the solution is filtered hot, then cooled and made slightly acid, and again filtered—to separate colloids which would have a fatal effect on subsequent filtering. Enough solution is set aside for analysis (A) and the remainder is treated as follows:

SOLUTION B—A known volume of the solution is treated with a known volume of concentrated hydrochloric acid, estimated to be sufficient to hydrolyze the sucrose[1] when immersed in a boiling water bath for 20 to 30 min. After cooling and filtering, the solution is made alkaline, and analyzed for total reducing sugar, corrections for change of volumes being made in the final calculations.

SOLUTION C—After freezing[2] and thawing, the second half of the fruit is treated exactly as for Solution A.

SOLUTION D—This solution is prepared from C as Solution B is prepared from A.

A sound apple, frozen for 16 hrs., then thawed out and left standing for 24 hrs., was analyzed with the result indicated in Table I.

TABLE I

SOLUTION	Sample (1)	Sample (2)	AVERAGE	Invert	Sucrose	Ratio	Percentage Inversion
A	0.1350	0.1370	0.1360	0.1360	0.1076	100 : 79.1	37.47
B	0.2435	0.2437	0.2436				
C	0.2282	0.2288	0.2285	0.2285	0.0863	100 : 37.7	
D	0.3166	0.3130	0.3148				

If the value 79.1 for sucrose is indicated by S, and the value 37.7 is indicated by s, the percentage of inversion (37.47) resulting from freezing (and thawing and autolysis to the time of analysis) can be calculated by the following, easily derived formula, in which the constant 1.052 is the ratio of molecular weights of two molecules of hexoses to one molecule of sucrose.

$$\text{Per cent of inversion} = \frac{10000\,(S - s)}{100\,S + 1.052\,Ss}$$

With other fruit, as, for example, the peach, similar changes resulted. The data in Table II were obtained with sound peaches frozen 12 hrs. and thawed 3 hrs.

TABLE II

SOLUTION	Sample (1)	Sample (2)	AVERAGE	Invert	Sucrose	Ratio	Percentage Inversion
A	0.3095	0.3030	0.3063	0.3063	0.2313	100 : 75.51	12.00
B	0.5348	0.5385	0.5376				
C	0.1932	0.2228	0.2080	0.2080	0.1262	100 : 60.66	
D	0.3325	0.3358	0.3342				

Samples of this same supply of sound peaches analyzed 2 wks. later under the same conditions gave the following data:

TABLE III

SOLUTION	Sample (1)	Sample (2)	AVERAGE	Invert	Sucrose	Ratio	Percentage Inversion
A	0.2266	0.2286	0.2276	0.2276	0.3184	100 : 139.9	8.93
B	0.5462	0.5459	0.5460				
C	0.2370	0.2368	0.2369	0.2369	0.2668	100 : 112.6	
D	0.5040	0.5034	0.5057				

Since the percentage of inversion here is only about three-fourths of that of the prior case (Table II), it is concluded that storage for 2 wks. produced one-fourth of the total inversion; in other words, freezing and thawing produced in 15 hrs. three times as much inversion as storage for 2 wks.

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[1] Neidig, Prinsen-Geeligs, etc., *Loc. cit.* Some fruits, as for example, peaches, are practically devoid of starch.

[2] Gore, U. S. Dept. Agr., Bureau of Chemistry, *Bulletin* **142**; Yoshida, *J. Chem. Soc.*, **43**, 472; Bertrand, *Compt. rend.*, **118**, 1215; Lindet, *Ibid.*, **120**, 370; Martinand, *Ibid*, **121**, 512; Appleman, *Botan. Gaz.* **50**, 182.

[3] Webber, *Loc. cit.*

[4] Bassett, *Loc. cit.*

[5] Windisch and Schmidt, *Z. Nahr. Genussm.*, **17**, 584.

[6] Maxinov, *Ber. botan. Ges.*, **30** (1912), 52, 293

[7] Hawkins, *Loc. cit.*

[8] DeMoussy, *Compt. rend.*, **161** (1915), 443. Acids and reducing sugars are expressed to the greatest extent with high pressure on the fruits, whereas non-reducing sugars are obtained with slight pressure.

[9] Knowledge of the concentrations of invert sugar and sucrose in the entire fruit is of no value in this connection since these vary with the variety and age of the fruit. The final per cent of inversion could be obtained on this basis, if so desired, but the method would be greatly complicated without yielding added value

[1] For the hydrolysis of sucrose, see Wiley, "Agricultural Analysis," Vol. III, p. 105; Borntráger and Samelson, *Z. angew. Chem.*, **1892**, 334; **1893**, 690; **1894**, 267, 351; Munson and Walher, *J. Am. Chem. Soc.*, **28** (1906), 667.

[2] The freezing is conveniently made one day and the fruit set aside to thaw out during the night. The next day the analysis is begun and advantageously completed.

APPLICATION TO STORAGE FRUIT

Now, what changes can be expected in fruit first frozen in cold storage and then subjected to the foregoing methods of analysis? Evidently changes brought about by freezing in storage will not be repeated by a laboratory freezing, provided the first freezing was thorough and the laboratory freezing was not delayed too long. This was found to be the case with peaches alleged to have been frozen in storage, manifesting obvious characteristics of frozen peaches, and analyzed within a week after removal from cold storage (Table IV).

TABLE IV

SOLUTION	Sample (1)	Sample (2)	AVERAGE	Invert	Sucrose	Ratio	Percentage Inversion
A	0.2595	0.2510	0.2555	0.2555	0.2550	100 : 99.80	1.26
B	0.5120	0.5090	0.5105				
C	0.2180	0.2170	0.2175	0.2175	0.2115	100 : 97.24	
D	0.4289	0.2293	0.4290				

Here only 1.26 per cent of inversion was obtained in the peaches by a laboratory freezing. Now, since unfrozen peaches (Tables II and III) gave much inversion by laboratory freezing, it may be concluded that the fruit analyzed in Table IV had previously been frozen in storage.

In this connection it may be observed that not only is sucrose inverted during ripening, over-ripening, rotting, and freezing, but invert sugar, previously present or formed by inversion, may be lost by chemical decomposition, or by the metabolism of the plant, or by rotting organisms, such as yeast or molds. This is illustrated by the following data obtained from peaches (Table IV) after they had been kept out of cold storage for one month and had become completely covered with mold.

TABLE V

SOLUTION	Sample (1)	Sample (2)	AVERAGE	Invert	Sucrose	Ratio	Percentage Inversion
A	0.0735	0.0715	0.0725	0.0725	0.1325	100 : 182.76	30.01
B	0.2014	0.2086	0.2050				
C	0.1847	0.1735	0.1791	0.1791	0.1464	100 : 81.74	
D	0.3275	0.3235	0.3255				

It must be concluded that mold consumed a large part of the invert sugar, or at least that it consumed invert sugar more rapidly than it did sucrose. Therefore too great deterioration of fruit out of effective cold storage will invalidate the chemical detection of a prior frozen condition.

SUMMARY

The advantages of the method herein described are:

1—Advantage is taken of divergencies in the largest components of the fruit.

2—Inversion subtracts from the sucrose concentration and adds to the invert sugar concentration, thus giving accurate measurements of such divergencies.

3—Accurate gravimetric measurements are made by standard methods.

THE DETERMINATION OF MOISTURE IN BEET-SUGAR FACTORY PRODUCTS[1]

By V. L. Aikin

GREAT WESTERN SUGAR COMPANY, FORT COLLINS, COL.

The problem of obtaining the correct moisture content of various saccharine products is as important to the sugar laboratory chemist as is the knowledge of how to obtain correct data on the percentage of sugar or other constituents. He finds very definite and proved methods for the determination of sugar, alkalinity, ash, etc., in any standard reference book, but the literature is lacking in uniformity in regard to methods that prove experimentally to give correct results for the percentage of moisture.

ACCEPTED METHODS FOR MOISTURE DETERMINATION

The report of the editing committee of the Association of Official Agricultural Chemists gives the following method for the determination of moisture in massecuites, molasses, and other liquid and semi-liquid saccharine products.

DRYING ON QUARTZ SAND—Digest pure quartz sand with strong hydrochloric acid, wash, dry, ignite, and preserve in a stoppered bottle.

Place 6 to 7 g. of the prepared sand and a short stirring rod in a flat-bottomed dish, dry thoroughly, cool in a desiccator, and weigh. Add 3 to 4 g. of molasses, mix with the sand (if necessary, add a little water to incorporate the two thoroughly), dry in a water oven at the temperature of boiling water for 8 to 10 hrs., stirring at intervals of an hour, cool in a desiccator, and weigh. Stir, heat again for an hour, cool, and weigh; repeat the heating and weighing until the loss of water in an hour is not greater than 3 mg.

Pellet recommends that the material be mixed with pumice stone and dried at 102° to 105° C.

GERMAN OFFICIAL METHODS. THICK JUICE—A ratio of 25 parts of iron-free sand to one part of dry substance is sufficient. Three grams of thick juice to 50 g. of iron-free sand are weighed out. The drying takes place *in vacuo* at 105° to 110° C.

MASSECUITES—Two to three grams of massecuite are intimately mixed with 50 g. of iron-free sand in a moisture dish, and given a preliminary drying for a quarter of an hour in a drying oven at 70° C. After again thoroughly mixing, the drying is continued for 6 to 8 hrs. at 105° to 110° C. in a vacuum oven or air bath. The weight is taken as constant when, after repeating the drying for a period of 2 hrs., the loss in weight is less than 0.1 per cent.

PRESENT INVESTIGATIONS

Several years ago the writer did some work on methods for moisture determinations in beet-sugar factory products, and the results are submitted in the hope that they may furnish some information on the various factors influencing the determination of moisture.

As molasses is one of the most impure products with which we have to deal, it was used as a basis for most of the work, and the results were checked on purer products. It was assumed that the method that would give the highest results when using a temperature not above 110° C. was the most nearly correct. All our drying was done in an aluminium dish, 50 mm. in diameter by 30 mm. high, provided with a closely fitting cover.

The investigations covered the following points:

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[1] Presented at the 59th Meeting of the American Chemical Society, St. Louis, Mo., April 12 to 16, 1920.

1—The result where the ratio of sand or other dividing material to molasses was kept constant, while the dividing material was varied in size.

2—The results with varying quantities of molasses and constant quantities of dividing material, and with constant quantities of molasses and varying quantities of dividing material.

3—The efficiency of various kinds of dividing material.

4—The effect of different temperatures of drying.

5—The effect of a short preliminary drying at a lower temperature, followed by a second mixing and a complete drying.

6—The uniformity of results obtained by drying in an ordinary bath at 105° C. as compared with drying in a vacuum oven at lower temperatures.

7—The amount of water or other liquid to add to the substance to give a homogeneous mixture.

8—The time required to mix the samples.

9—The meaning of the term "iron-free sand" as used in the German official methods.

FINENESS OF DIVIDING MATERIAL—It was found that the fineness of the material had a marked influence on the moisture driven off.

The sand used in this series of tests, as in all the rest of the work where sand was the dividing material, was a white sea sand that had been digested with hydrochloric acid, washed, and ignited. The first series of tests was with sand of four different sizes which were graded by passing through screens with circular perforations, *viz.*, coarser than 1 mm., between 1 mm. and 0.5 mm., between 0.5 mm. and 0.25 mm., and finer than 0.25 mm. The drying was done in an ordinary glycerol-filled, double-walled oven at 105° C.

The results of the investigation of this phase of the work are given in Table I.

TABLE I

Time of Heating Hrs.	Sand No. 1 Coarser than 1 Mm. Per cent Loss	Max. Diff.	Sand No. 2 Between 1 and 0.5 Mm. Per cent Loss	Max. Diff.	Sand No. 3 Between 0.5 and 0.25 Mm. Per cent Loss	Max. Diff.	Sand No. 4 Less than 0.25 Mm. Per cent Loss	Max. Diff.
4	16.70	0.18	16.98	0.06	17.09	0.25	17.48	0.19
5	16.72	0.15	16.95	0.10	17.11	0.21	17.42	0.08
6	16.87	0.13	17.10	0.02	17.17	0.19	17.50	0.08
7	16.95	0.01	17.12	0.04	17.21	0.11	17.51	0.07
8	17.06	0.05	17.18	0.04	17.25	0.03	17.52	0.05
9	17.10	0.09	17.19	0.05	17.26	0.04	17.58	0.09
10	17.14	0.06	17.25	0.03	17.33	0.05	17.60	0.10
12	17.20	0.07	17.29	0.06	17.34	0.02	17.62	0.06
14	17.28	0.09	17.34	0.01	17.44	0.03	17.69	0.14
16	17.27	0.18	17.34	0.02	17.39	0.10	17.62	0.08
18	17.29	0.18	17.37	0.07	17.38	0.10	17.66	0.09
21	17.32	0.02	17.38	0.07	17.38	0.08	17.69	0.14
24	17.27	0.10	17.35	0.11	17.37	0.01	17.61	0.14
30	17.43	0.08	17.45	0.02	17.46	0.02	17.76	0.10
36	17.35	0.15	17.35	0.06	17.44	0.07	17.77	0.08
42	17.48	0.12	17.51	0.09	17.54	0.03	17.84	0.06
48	17.44	0.12	17.46	0.10	17.50	0.08	17.84	0.10

Briefly summarized, the results show that the finest of these sands gave the highest moisture content. The minimum time of heating any of the grades to obtain maximum results was 8 hrs. The loss in moisture at the end of this time on the fine sand was more than on the other grades at the end of the same period of heating by about 0.2 to 0.4 per cent, and the loss on the coarser grade never equaled that on the finer, even after 48 hrs. heating.

Later on, sand of 40 to 50 mesh, 50 to 60 mesh, 60 to 100 mesh, and finer than 100 mesh was tried out on another sample of molasses with the results shown in Table II.

TABLE II

MATERIAL	Time of Heating Hrs.	Sand No. 4 Less than 0.25 Mm. Per cent Loss	Sand No. 5 40 to 50 Mesh Per cent Loss	Sand No. 6 50 to 60 Mesh Per cent Loss	Sand No. 7 60 to 100 Mesh Per cent Loss	Sand No. 8 Less than 100 Mesh Per cent Loss
Molasses	4	17.65	17.46	17.58	17.66	...
	8	17.74	17.60	17.74	17.71	17.79
White Massecuite	8	7.63	...	...	...	7.62
Raw Massecuite	8	6.17	...	...	...	5.95
Thick Juice	8	37.44	...	...	...	37.31

From these results it was concluded that the sand must pass a 0.25 mm. screen to be suited to the work. The still finer grades are as satisfactory and may be used as a mixture containing all sizes from 0.25 mm. down. The grade used as a standard had the following composition:

40 to 50 mesh, 25 per cent
50 to 60 mesh, 25 per cent
60 to 70 mesh, 22 per cent
70 to 100 mesh, 22 per cent
Less than 100 mesh, 6 per cent

RATIO OF SAND TO MOLASSES—In both the above series, 25 g. of sand and 1 g. of dry substance were used. This ratio has been shown to be the one best suited to moisture determinations. The 25 g. samples gave as high results as the 30 or 35 g. An increase to 30 or 35 g. of sand is not objectionable, except that a larger dish than the one we used would be needed. In Table III are given the results of varying the amount of sand used with 1 g. of dry substance. Table IV, on the other hand, gives the results obtained when the amount of dry substance was varied.

TABLE III

Time of Drying Hrs.	15 G. Sand Per cent Loss	Max. Variation	20 G. Sand Per cent Loss	Max. Variation	25 G. Sand Per cent Loss	Max. Variation	30 G. Sand Per cent Loss	Max. Variation
4	16.98	0.04	17.61	0.07	17.48	0.19	17.23	0.12
5	17.44	0.04	17.61	0.04	17.42	0.02	17.75	0.14
6	17.38	0.04	17.64	0.03	17.50	0.08	17.62	0.07
7	17.45	0.01	17.67	0.04	17.51	0.07	17.69	0.10
8	17.55	0.01	17.61	0.09	17.52	0.05	17.63	0.15

TABLE IV

Time of Heating Hrs.	20 G. Sand Per cent Loss when 1 G. D. S. Used	25 G. Sand Per cent Loss when 1 G. D. S. Used	30 G. Sand Per cent Loss when 1 G. D. S. Used	35 G. Sand Per cent Loss when 1 G. D. S. Used
4	17.50	17.61	17.47	17.63
5	17.61	17.66	17.60	17.69
9	...	17.69	17.67	17.71
	Per cent Loss when 2 G. D. S. Used	Per cent Loss when 2 G. D. S. Used	Per cent Loss when 2 G. D. S. Used	Per cent Loss when 2 G. D. S. Used
4	17.44	17.48	17.51	17.49
5	17.50	17.54	17.56	17.55
9	17.53	17.54	17.61	17.67
	Per cent Loss when 3 G. D. S. Used	Per cent Loss when 3 G. D. S. Used	Per cent Loss when 3 G. D. S. Used	Per cent Loss when 3 G. D. S. Used
4	17.20	17.41	17.39	17.41
5	17.31	17.49	17.44	17.44
9	17.46	17.58	17.53	17.52
	When No Water Was Used in Mixing			
	Per cent Loss when 1 G. D. S. Used	Per cent Loss when 1 G. D. S. Used	Per cent Loss when 1 G. D. S. Used	Per cent Loss when 1 G. D. S. Used
4	17.13	17.63	17.62	17.40
5	17.33	17.63	17.62	17.52
9	17.42	17.67	17.69	17.60

EFFICIENCY OF DRYING MATERIAL—Sea sand, crushed quartz, and pumice stone were the only kinds of dividing material investigated.

The sea sand and crushed quartz gave identical results where the conditions of fineness and ratio of dry substance to sand were the same. The pumice stone was more difficult to manipulate and in all cases gave lower results in the same length of time of heating.

TEMPERATURE EFFECTS—The present work would indicate a temperature of 105° to 110° C. as the one best suited to drying sugar-house products. A temperature below 100° C. will not give maximum results in any reasonable time.

When trying the effect of a short preliminary drying at a lower temperature (70° C., as called for in the German methods) it was found that often, at the end of the 15 min. period of heating, the mixture had "set," so that a second mixing was impossible. The method did not seem to offer any advantages over the direct drying at 105° C., and increased the time of drying. The two following results on molasses are typical, where the total time of heating in both methods was 8 hrs.

	Sample	
	A	B
Our method, per cent moisture.....	21.88	17.78
German method, per cent moisture	21.36	17.55

The use of the vacuum oven to determine whether there might be some decomposition of the less stable constituents of beet molasses at the higher temperature did not indicate that any decomposition took place, and increased the time of drying. It required 18 hrs. to obtain the same results when drying under 17 in. of vacuum, at 80° to 83° C., as were obtained in 8 hrs. when drying at 105° C. in an ordinary oven.

The following tabulation is from one set of tests where 1 g. of molasses (dry substance) was used with varying amounts of sand.

	Grams of Sand			
	15	20	25	30
Moisture, in vacuum oven (18 hrs.)..	17.61	17.34	17.54	17.67
Moisture, our method (8 hrs.)........	17.55	17.61	17.66	17.67

AMOUNT OF LIQUID TO BE ADDED—No tests were made to determine the maximum amount of water that could be used. It was found that 1 cc. added to all of the heavier products containing 50 per cent or more dry substance gave a product that on mixing would occupy about 3 to 4 times the volume of the original materials. The mass in this condition was very porous and when dry contained many passages through which the moisture had escaped. When this amount of water was used there was no tendency for the sirup to leave the sand particles when the mixture was first heated. If too much water was added, the light, porous mixture was not obtained. A little experience will teach the operator when the proper condition is reached. Alcohol was substituted for water in a series of tests, but it gave no better results and offered no advantages.

TIME OF MIXING—The proper mixing of a sample requires from 3 to 5 min., and should be conducted in two stages. The sand, molasses, and water should be mixed for 2 to 3 min., then warmed on top of a bath for about 5 min., and given a second mixing for 1 or 2 min. When the time of mixing is less than above, there is often found in the dried mass small globules of the product that are not incorporated with the sand.

"IRON-FREE SAND"—The term "iron-free sand," as used in the German methods, apparently does not refer to sand that does not contain iron as one of its constituents, as the writer was unable to find either sand or quartz without at least traces of iron. It is evidently sand free from iron readily soluble in hydrochloric acid, and a series of tests made with mixtures of sand with metallic iron, ferric oxide, and magnetic oxide of iron indicated that in some cases the oxide of iron in small amounts reduced the moisture found. The results were erratic, but indicated that the sand used should be free from soluble iron.

	Sand + Fe_2O_3					
Sand Alone	0.25%	0.5%	0.75%	1%	1.25%	1.5%
79.25	79.03	78.98	79.24	79.02	79.05	78.98
	Sand + Fe_3O_4					
79.25	79.20	79.21	78.85	78.67		
	Sand + Fe (40 Mesh)					
...	79.16	79.35	79.17	79.27		

RESULTS FROM NEW METHOD—Samples of sand collected from nine laboratories, and prepared by sizing to finer than 0.25 mm. and washing and igniting, gave the following results. This series of tests was used as a measure of the uniformity of the dividing material as prepared under varying conditions.

Sand No.	Dry Substance in Molasses
1............................	79.06
2............................	78.92
3............................	78.78
4............................	79.04
5............................	79.13
6............................	79.06
7............................	79.20
8............................	79.05
9............................	79.03

With the exception of Sands 3 and 7, all the results are very uniform. All results given so far in this report were run in duplicate or triplicate and it was found very easy to check within 0.10 per cent on a duplicate determination. In nearly all cases, however, two sets of determinations, made on the same materials on different days, would not check. A difference of 0.20 per cent would often occur between duplicates run on different days. It was also found that the dried samples were very hydroscopic, and a gain in weight equivalent to 0.20 per cent moisture often occurred when the samples stood for 10 to 12 hrs. in a desiccator.

RECOMMENDED METHOD

In conclusion, these results are summarized in the following method, which is our standard as used at the present time.

Use only sand that will pass a screen with 0.25 mm. perforations; digest the sand in hot hydrochloric acid, wash, and ignite. Use 25 to 30 g. of sand, and dry and weigh just previous to making the determination. Weigh into the dish not over 1 g. of dry substance, add 1 cc. of water, place the dish on top of a drying oven until warm, mix for 3 min., and warm and mix again, until a perfectly homogeneous mixture is obtained. Dry at a temperature of 105° C. for 6 hrs., cool, and weigh. Repeat until the loss in weight after heating for a period of 1 hr. is less than 0.10 per cent.

Make all weighings as soon as the temperature of the desiccator is within 2° C. of the temperature of the balance. Repeat all determinations where the duplicates do not check within 0.20 per cent.

THE DETERMINATION OF NITRATES IN SOIL

By A. L. Whiting, T. E. Richmond and W. R. Schoonover
Department of Agronomy, University of Illinois, Urbana, Illinois

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The analysis of soils for nitrate nitrogen is of considerable importance in connection with studies of the decomposition of farm and green manures and of the various factors controlling the production and accumulation of nitrates in soils. Nitrate nitrogen is recognized as the form of nitrogen preferred by most nonleguminous crops. In order to determine whether soils are properly meeting the crop demands for nitrate, systematic determinations of the nitrate nitrogen must be made under diverse conditions and especially in the presence of the growing crop.

During the last nine years nitrate studies involving many different conditions have been in progress in this laboratory. Five years' results of nitrate determinations on field soils have afforded excellent opportunity to study the value and accuracy of nitrate methods.

The method herein described has resulted from important modifications of the Devarda method. It has been applied on thousands of soil samples with excellent success. In principle, it depends upon the oxidizing action of sodium peroxide and the completeness of extraction of the nitrate with hydrochloric acid.

DETERMINATION OF NITRATE NITROGEN

The water-free samples from moisture determinations are placed in 400 cc. shaker bottles and 300 cc. of approximately 0.5 per cent hydrochloric acid are added. The mixture is then shaken in a mechanical shaker for 1 to 3 hrs. and allowed to settle over night. Five grams of sodium peroxide are placed in a 800 cc. Kjeldahl flask. A 200 cc. aliquot part of the acid soil extract is blown off into a graduated flask, then poured on the peroxide, and the contents of the flask boiled down to 20 to 25 cc., or, if urea is present, to complete dryness. Two hundred cc. of nitrogen-free distilled water are now added, together with 0.5 g. of Devarda's alloy (50 per cent aluminium, 45 per cent copper, and 5 per cent zinc), and the mixture distilled for 40 min., and collected in standard sulfuric acid. Sodium hydroxide of a strength such that 1 cc. = 0.5 mg. of nitrogen is used for titration. Rosolic acid or methyl red is the best indicator. A table of titrations reading direct to pounds per 2,000,000 lbs. of wet soil avoids laborious calculations.

NOTES ON THE METHOD

COLLECTION OF SOIL SAMPLES—From 24 to 30 borings are taken to a depth of 6.66 in. per 0.1 acre. These borings are placed in a 4-in. soil pan and carefully mixed. A composite sample is placed in a properly labeled glass fruit jar, to which 8 to 10 drops of toluene, or more, depending upon the amount of soil to be taken, have been added. The jars are then tightly sealed. Samples taken in this way may be shipped long distances without danger of bacterial changes that would affect the nitrogen. Samples without toluene were tested as to nitrate increase and found to have gained 10 lbs. in 2 days at normal moisture and to have lost all their nitrate when saturated.

DETERMINATION OF MOISTURE—One hundred grams of the thoroughly mixed sample are rapidly weighed into a seamless tin weighing box of 5 oz. capacity. Samples are dried in an electric oven at 110° C. for 10 to 14 hrs., then rapidly weighed. The loss on drying gives the per cent of moisture on a field basis. A table of factors is employed for referring the per cent to a water-free basis or to pounds per 100 lbs. of water-free soil. By moving the decimal point one place to the right for any figure reported on the water-free basis, tons of water per acre are obtained. Dividing the tons per acre by 113.25 tons expresses the results in equivalent inches of rainfall.

HYDROCHLORIC ACID EXTRACT—Hydrochloric acid was selected as the proper extractant for getting the nitrate out of the soil. It was thought that its action on colloids should cause the solution to settle with sufficient clearness to permit accurate analysis without filtration.

Hydrochloric acid was tested against sulfuric acid, acetic acid, water, sodium chloride, calcium and magnesium carbonates, calcium, magnesium, sodium and potassium hydroxide, calcium and magnesium oxides, and alum, and found to be the most efficient in removing the nitrate and yielding a clear soil extract.

A 0.2 per cent solution of the acid is very satisfactory where soils are not heavily treated with carbonates. The strength of the acid has not been found to affect the results within the limits of 0.2 and 1 per cent.

That the extraction of the nitrate with hydrochloric acid is complete, within a small error, is shown by a typical case represented below, where A represents the nitrate contained in the first extraction and B the nitrate contained in the second extraction:

$$B - \frac{A}{3} = 0$$

$$0.37 - \frac{1.15}{3} = 0$$

$$0.37 - 0.38 = -0.01$$

SODIUM PEROXIDE MODIFICATION—Sodium peroxide is used in place of sodium hydroxide for expelling ammonia and giving the required alkaline solution. By the use of this strong oxidizing agent the organic matter is destroyed at the same time, and hydrolysis of organic nitrogenous compounds during distillation with the metal is avoided. Sodium peroxide possesses the following advantages:

1—It gives a vigorous oxidation, although not a dangerous one, hydrolyzes the organic nitrogen, and expels the ammonia, leaving the required alkaline solution.

$$Na_2O_2 + 2HCl = H_2O_2 + NaCl$$

$$Na_2O_2 + H_2O = 2NaOH + O$$

2—It oxidizes to nitrate any nitrite present, and is without effect upon the ammonia or nitrate.

TESTS OF THE METHOD—Ammonia has been added to the soil both before and after extraction. It is always completely removed and does not influence the results. Nitrite has been added before and after extraction, and if present in large amounts will be lost because of the acid solution. Nitrates have been added before extraction, after extraction, and before reduction, and are always recovered within a very small experimental error. Tests for ammonia, made after boiling down to expel it and during the reduction with the metal, failed to yield any nitrogen. Amino acids, acid amides, urea and calcium cyanamide were introduced in the procedure to test the complete removal of the ammonia and to see if any organic nitrogen would be reducible by the alloy. The results proved that the nitrogen in the compounds, with the exception of that in urea and calcium cyanamide, was completely removed or rendered unreducible by the alloy. It was later found that nitrites present in the calcium cyanamide accounted for the apparent incomplete removal of nitrogen from that compound. For some unknown reason urea requires more complete boiling down than less easily hydrolyzable compounds.

TESTING FOR COMPLETE REDUCTION—Tests for nitrite and nitrate were made at various points in the procedure. Attention should be called to the fact that diphenylamine sulfuric acid cannot be used to test for nitrite or nitrate in the presence of any peroxide. In studying the completeness of the reduction it was found that the nitrates disappear in the first 5 min. of boiling. Ammonia did not accumulate sufficiently to give a test with Nessler's reagent which would read much above a blank. Nitrites persisted, however, for some 10 min. after boiling had started. A small amount of nitrogen was distilled after this time up to 40 min.

The metal is very rapidly spent, especially the aluminium and the zinc. Copper is left in extravagant quantities and is unable to effect a further reduction. It would seem that an alloy more highly compounded in aluminium and zinc, and with less copper would be as efficient and much less expensive. Five-tenths of a gram of alloy, all of which will pass a 20 mesh sieve, is used in this laboratory for most determinations of nitrate. If the quantity of nitrogen to be reduced is 25 mg., a gram of alloy should be used. Different lots of alloy vary widely in their reducing efficiency, a fact explainable on the basis of the differences in the degrees of fineness of different lots. The phenoldisulfonic acid, zinc-copper couple in acetic acid, iron-by-hydrogen, titanous sulfate, and aluminium reduction methods have been compared with the method herein described. The only one of these methods giving promise of being workable on a large variety of soils was the aluminium reduction method. Organic matter and possibly potassium aluminate greatly interfere with the rate of reduction if aluminium strips or aluminium powder are used. In one case with an ordinary soil it required 7 days in the cold before reduction was out of the nitrite stage in the aluminium reduction method.

CONFIRMATORY TEST WITH NITRON[1]—In order to determine whether all the nitrogen obtained by the reduction with Devarda's alloy was nitrate, a confirmatory method was sought. Precipitation of the nitrate with nitron in acetic acid solution offered the most satisfactory method.

A 10 per cent solution of nitron in 5 per cent acetic acid was used as the precipitant. One-tenth gram of nitron when treated with Na_2O_2 and reduced with the alloy gave no ammonia. Two typical soils were analyzed by the two methods.

	—Nitrate Nitrogen (Pounds per Acre)—	
Soil	Modified Devarda	Nitron Nitrate, Followed by Modified Devarda
1	55	57
2	270	277

A uniform acid soil extract was made up and analyzed as follows:

(1) 200 cc. by modified Devarda gave	12 mg. nitrate nitrogen
200 cc. by precipitation with nitron gave	0.3200 g. nitron nitrate crystals
0.3200 g. of nitron nitrate gave by reduction	9.5 mg. nitrate nitrogen
Filtrate from nitron nitrate gave by reduction	2.9 mg. nitrate nitrogen
Found	12.4 mg. nitrate nitrogen
Error based on modified Devarda	0.4 mg. nitrate nitrogen
(2) 200 cc. as above	12 mg. nitrate nitrogen
200 cc. by precipitation with nitron gave	0.3005 g. nitron nitrate crystals
0.3005 g. nitron nitrate gave by reduction	8.5 mg. nitrate nitrogen
Filtrate from nitron nitrate gave by reduction	3.5 mg. nitrate nitrogen
Found	12.0 mg. nitrate nitrogen
Error	0

The complete precipitation of the nitrate by nitron acetate in a weak hydrochloric acid soil extract is seriously interfered with by colloidal silicic acid. A water extract acidified with acetic acid while still in contact with the soil gives more satisfactory conditions for the precipitation of the nitrate with nitron solution. Even under the latter conditions precipitation is not complete, as seen from the above results. Organic matter and colloidal materials interfered with the precipitation under the conditions studied. It is evident that the nitron nitrate crystals contained impurities. Diphenylamine proved the presence of unprecipitated nitrate in the filtrate. The differences in the two methods are not large when the amounts of nitrate present in the soils are taken into consideration. From the results it is concluded that the modified Devarda method determines only nitrate nitrogen in the soil extract.

CONCLUSIONS

1—A method is described which involves important modifications in the Devarda method.

2—A modification of the method of extracting soils for nitrate determinations is reported in the use of a hydrochloric acid solution.

3—Sodium peroxide is used in place of sodium hydroxide. It serves to oxidize the organic matter and any nitrite that may be present. It yields an alkaline solution which expels the ammonia and leaves the proper condition for reduction with Devarda's alloy.

4—The method determines only nitrate nitrogen, as confirmed by precipitation of the nitrate in the soil extracts with nitron solution and the analysis of the crystals of nitron nitrate and the filtrate from the same.

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[1] Part of the nitron used in these experiments was made by the Division of Organic Chemistry, University of Illinois, Urbana, Ill

Slightly lower results are given by the Devarda method as herein modified than by the nitron method.

5—The method has been successfully used on thousands of soil samples representing varied conditions as to type and treatment. It has also been applied with satisfactory results to crop samples.

THE PROXIMATE ANALYSIS OF HARDWOODS: STUDIES ON QUERCUS AGRIFOLIA

By W. H. Dore

University of California Agricultural Experiment Station, Berkeley, California

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In previous papers[1] the author reported methods for the summative analysis of wood, and analyses of three coniferous woods and two hardwoods. It was shown that the procedure succeeded with the coniferous woods but not with the hardwoods. The present investigation was undertaken for the purpose of modifying the original scheme so as to make it applicable to the latter. Studies made upon one of the hardwoods (*Quercus agrifolia*), with which the original methods were unsuccessful, have resulted in a satisfactory accounting for the constituents of that wood. Further work is necessary to establish it as a method applicable to hardwoods in general.

The failure of the original scheme with the hardwoods was partly due to the fact that König's 72 per cent sulfuric acid method for lignin does not give reliable results with the woods of the broad-leaved trees. This has been observed by Johnsen and Hovey[2] as well as by the present author[3] and more recently by König and Becker.[4] These last authors have made a comparative study of König's sulfuric acid method, the 42 per cent hydrochloric acid method of Willstätter,[5] and a method of treatment with gaseous hydrochloric acid, as applied to woods. They found the three methods equally applicable to the coniferous woods, but with the hardwoods the hydrochloric acid methods alone gave the full yield of lignin. The gaseous hydrochloric acid method was recommended by these authors for the broad-leaved woods.

It appeared probable that the methods used previously for the analysis of the coniferous woods might be advantageously applied to the hardwoods, with the substitution of the newer method for lignin. Experiments were accordingly conducted with the object of working these out with the hardwood mentioned. In addition to the changes made in the lignin determination, attention has been given to the possibility of the presence of constituents not found in the coniferous woods.

PREPARATION OF MATERIAL

The material used in this investigation was the wood of coast live oak (*Quercus agrifolia*) in the form of fine sawdust. A sound branch about 5 in. in diameter was obtained, the bark removed, and cross-sectional cuts made by a fine saw (13 teeth to the inch) until the quantity of sawdust amounted to about 150 g. The sawdust was sifted through a sieve having 50 meshes to the linear inch. The oversize was dried at 100° C. for several hours, after which it was ground to pass through the 50 mesh sieve. The entire material was then well mixed and preserved in a screw-top Mason fruit jar to avoid changes in moisture content.

It was the intention at the beginning of this work to use the same analytical methods as were employed previously for the coniferous woods, with the single exception of the method for lignin. It was soon discovered, however, that simple extraction with benzene and alcohol did not produce a complete purification of the wood tissue from adventitious substances, as shown by the formation of a brown solution on washing with cold water, preliminary to chlorination. The use of the former procedure was objectionable in that it afforded no means of estimating the water-soluble constituents, which would accordingly not be accounted for in the summation. Furthermore it was found, as will be shown later, that this wood, when extracted with benzene and alcohol only, gives unsatisfactory results, as to yield and quality of product, in both the cellulose and lignin determinations.

The method finally adopted to overcome these objections was that of following the benzene and alcohol extractions with successive digestions in cold water and cold dilute sodium hydroxide solution. That redwood cellulose is unaffected by this treatment has been pointed out by the author.[1] Oak cellulose is similarly resistant.

ANALYTICAL METHODS

Methods for determining loss on drying, benzene extract, and alcohol extract are identical with those previously described in the case of coniferous woods.[2]

SOLUBLE IN COLD WATER—The residue from the alcohol extraction was dried, transferred to a 250 cc. beaker, 200 cc. of cold water added, and the mixture allowed to digest for 24 hrs. It was then filtered off on a tared Gooch crucible provided with a filtering disk of mercerized cotton cloth, washed, dried for 16 hrs. at 100° C., and weighed in a glass-stoppered weighing bottle. The difference between weights gives the residue after water extraction. The amount soluble in cold water is calculated by adding together the percentage figures for loss on drying, benzene and alcohol extracts, and residue after water extraction, and subtracting this sum from 100 per cent.

SOLUBLE IN COLD 5 PER CENT SODIUM HYDROXIDE SOLUTION—The residue from the water-soluble determination was transferred to a suitable beaker, and 100 cc. of 5 per cent sodium hydroxide solution were added. The mixture was left for 24 hrs., then filtered off upon the same Gooch crucible as before. It was washed thoroughly with water, several times with dilute acetic acid, and finally with water. After drying for 16 hrs. at 100° C. it was again weighed. The loss in weight from the previous weighing represents

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[1] This Journal, **11** (1919), 556; **12** (1920), 264, 476.

[2] *Paper*, **21**, No. 23 (1918), 36; also *J. Soc. Chem. Ind.*, **37** (1918), 132*t*.

[3] This Journal, **11** (1919), 562.

[4] *Z. angew. Chem.*, **32** (1919), 155; through *J. Soc. Chem. Ind.*, **38** (1919), 530*a*.

[5] *Ber.*, **46** (1913), 2401; through *Chem. Abs.*, **7** (1913), 3412.

[1] This Journal, **12** (1920), 268.

[2] *Ibid.*, **12** (1920), 477.

material soluble in cold 5 per cent sodium hydroxide solution.

CELLULOSE—Cellulose was determined upon the residue from the above successive treatments. The analysis was carried out by the Sieber and Walter method previously described by the author.[1]

LIGNIN—For this determination the gaseous hydrochloric acid method of König and Becker was employed, with slight modification. The method proposed by these authors consists in adding 6 cc. of water to 1 g. of the wood (previously extracted with benzene and alcohol) in a test tube, then passing gaseous hydrochloric acid through the mixture until it is thinly liquid, in the meantime cooling the tube by immersion in ice. In the present investigation the wood was moistened with ordinary concentrated hydrochloric acid instead of with water. Excessive evolution of heat was thereby avoided, and cooling by simple immersion in water was found sufficient.

Four samples were run at the same time. Amounts of 1 g. each were subjected to the same purification treatment as for the cellulose determination, transferred to 1 × 10 in. test tubes, and treated with about 10 cc. of concentrated hydrochloric acid. The test tubes were closed with rubber stoppers, each containing two glass tubes for the introduction and exit of the gas. The inlet tubes extended nearly to the bottom of the test tubes. Hydrochloric gas, generated by dropping concentrated hydrochloric acid into strong sulfuric acid, was passed through the tubes containing the mixtures of wood and hydrochloric acid for about 2 hrs. The tubes were left closed for 24 hrs., then diluted, and the contents filtered on tared Gooch crucibles containing mercerized cotton cloth filtering disks, washed thoroughly, dried for 16 hrs. at 100° C., and weighed in glass-stoppered weighing bottles.

PENTOSANS NOT OTHERWISE ACCOUNTED FOR—The filtrates and washings obtained in four cellulose determinations were combined and evaporated to a little less than 1000 cc., transferred to a one-liter volumetric flask, and diluted to the mark. Aliquot portions of 125 cc. (= 1 g. of wood) were placed in the distilling flask of the pentosan apparatus, 30 cc. of concentrated hydrochloric acid added, and the furfural distilled off in the usual manner. The furfural was precipitated as phloroglucide, and the precipitate filtered off, washed, dried, and weighed. The results were calculated to pentosan by means of Krober's tables.[2]

The furfural-yielding constituents of oak are partly soluble in the alkali solution and most of the insoluble portion remains with the cellulose. The small amount unaccounted for with either of these proximate groups is found in the chlorination filtrates and washings.

MANNAN (RESIDUAL)—Ten grams of wood were dried, extracted with benzene and alcohol, and digested in water and 5 per cent sodium hydroxide solution as before, then hydrolyzed with hydrochloric acid (sp. gr. 1.025), and the mannan determined by precipitation as mannose phenylhydrazone. The details of the method have been described in a previous paper.

An attempt was made to determine total mannan by direct hydrolysis of the raw wood, but, owing to the interfering action of tannin or other substances dissolved from the wood, it was unsuccessful.

GALACTAN (RESIDUAL)—Five grams of wood were prepared as before, by successive extraction. The purified material was evaporated with nitric acid and the galactan converted into mucic acid by the method described for coniferous woods.[1]

FURFURAL AND METHOXY DISTRIBUTION—The methods used were those described in a previous paper.[1]

RESULTS OF EXPERIMENTS

The composition of oak wood as found by these methods is given in Table I. The figures are in every case averages of two or more determinations.

TABLE I—COMPOSITION OF LIVE OAK WOOD (*Quercus agrifolia*)

CONSTITUENT	Air-dry Basis Per cent	Oven-dry Basis Per cent
Loss on drying	4.20	..
Benzene extract	0.50	0.52
Alcohol extract	4.33	4.52
Soluble in cold water	3.66	3.82
Soluble in cold 5 per cent sodium hydroxide	18.71	19.53
Cellulose	45.48	47.47
Lignin	20.25	21.14
Pentosans not otherwise accounted for	1.89	1.97
Mannan (residual)	Nil	Nil
Galactan (residual)	1.49	1.56
TOTAL	100.51	100.53

In this table the first five groups of substances represent extraneous matter removed from the wood in the course of the purification process, while the last five groups represent substances contained in the residual purified tissue. The amounts obtained for each of the first five groups vary considerably with the manner in which the determinations are carried out, but the weight of purified residue remaining is in all cases about the same. In Table II the individual, as well as average values are given for constituents of the purified tissue, also for the yield of purified tissue.

TABLE II—COMPOSITION OF PURIFIED WOOD TISSUE
(Results in percentages of air-dry material, 4.20 per cent moisture)

	Individual				Average
Cellulose	45.33	45.04	46.19	45.38	45.85
Lignin	20.03	20.47			20.25
Pentosans not otherwise accounted for	1.80	1.98			1.89
Galactan (residual)	1.38	1.61			1.49
TOTAL					69.11
Residue after extraction (purified tissue)	68.80	68.50	68.86	68.22	68.60

The separate extracts obtained in the purification process have not been systematically examined. The benzene extract, consisting probably of oils and resins, is trifling in amount, as would be expected from the non-resinous character of the wood. The alcohol extract is a reddish brown material, consisting of tannin and possibly other coloring substances. The water and alkali solutions contain coloring substances not completely removable by alcohol extraction. In addition, the alkali solution contains a considerable amount of furfural-yielding groups. Two portions of the solution, on distillation with 12 per cent hydrochloric acid, yielded furfural corresponding to 11.47 and 11.11 per cent of pentosan. Two determinations of the acetic acid yielded by the raw wood upon hydrolysis with 2.5 per cent sulfuric acid gave 4.51 and 4.84

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[1] THIS JOURNAL, **12** (1920), 267.

[2] Browne, "Handbook of Sugar Analysis," Appendix, p. 83

[1] THIS JOURNAL, **12** (1920), 472.

per cent, after correction for formic acid by the method given in a previous paper.[1] The residue after digestion in sodium hydroxide solution yielded only traces of volatile acids. The series of treatments therefore removes the readily hydrolyzable acetic-yielding groups. It appears probable that the cleavage of acetic groups takes place during the alkaline digestion, rather than during the less drastic extractions that precede it. The alkaline extract could not be directly examined for acetic acid, because acetic acid had been introduced during the washing of the wood residue. The alkali-soluble portion probably consists chiefly of pentosans, substances yielding acetic acid upon hydrolysis, and tannin or other coloring substances.

To determine whether oak cellulose is injured by the treatments with cold water and alkali, cellulose determinations were made upon material so treated, and also upon material extracted with benzene and alcohol only. The products were examined by the mercerization test of Cross and Bevan.[2] The results of these experiments are given in Table III.

TABLE III—INFLUENCE OF WATER AND ALKALI DIGESTION ON YIELD AND QUALITY OF CELLULOSE

(Results in percentages of air-dry wood)

PRELIMINARY TREATMENT	No. of Chlorinations Required	Total Cellulose	α-Cellulose	β-Cellulose	γ-Cellulose
Extraction with benzene and alcohol only	9	46.18			
	8	44.79	29.38	10.08	5.33
	9	45.69	27.94	12.60	5.15
	8	44.23			
AVERAGE		45.22			
Extraction with benzene and alcohol and digestion in cold water and alkali	4	45.33	32.93		
	4	45.04	32.99	14.34	
	4	46.19	33.75		
	4	45.38	33.80		
AVERAGE		45.48			

It will be seen that the average of cellulose is practically the same in both cases, but the partly purified material requires much longer chlorination than that which was thoroughly extracted, in order to obtain a product equally free of lignin. The agreement of individual determinations is much better with the completely extracted material. The fully extracted material yields more α- and more β-cellulose than the partly extracted material, showing that, in the latter case, the excessive chlorination effects a partial degradation of the α-cellulose to lower forms. It was found difficult to obtain the β-cellulose in a form that could be filtered and washed. The single determination in the case of completely purified material is obviously inexact, as the sum of α- and β-cellulose is greater than the total cellulose. The results for α-cellulose, however, afford a reliable comparison of the quality of cellulose by the two processes, and show that a much better product is obtained when the alkali treatment is used.

The effect of the water and alkali treatment upon the lignin was also studied. Material completely extracted gave 20.03 and 20.47 per cent lignin. Material extracted with benzene and alcohol only gave on three determinations 22.11, 23.72, and 25.53 per cent of lignin. The latter results are variable and considerably higher than those on the completely extracted wood, due probably to the partial retention of substances soluble in sodium hydroxide solution but not in hydrochloric acid. Preliminary treatment with the alkaline solution is therefore essential to obtaining a pure lignin. The methoxy content of lignin is not changed by the alkaline digestion, as will be shown later in this article (see Table V).

A study of the distribution of the furfural-yielding groups in the wood gave the results shown in Table IV.

TABLE IV—DISTRIBUTION OF FURFURAL-YIELDING GROUPS IN OAK

(Results in percentages of air-dry wood, 4.20 per cent moisture)

	As Furfural			As Pentosan		
	Individual		Av.	Individual		Av.
Untreated wood	13.12	12.69	12.90	22.38	21.65	22.01
Completely extracted wood	6.84	6.82	6.83	11.71	11.68	11.69
Soluble in cold 5 per cent NaOH	6.71	6.50	6.60	11.47	11.11	11.29
Soluble in cold water	...	...	Nil	...	...	Nil
TOTAL (compare with untreated wood)	...	...	13.43	...	...	22.98
In cellulose	6.12	6.10	6.11	10.70	10.67	10.68
In chlorination solutions	1.15	1.05	1.10	1.98	1.80	1.89
In lignin	...	...	Nil	...	...	Nil
TOTAL (compare with completely extracted wood)	...	...	7.21	...	...	12.57

It will be observed that slightly more furfural was obtained from the fractions into which the wood was separated than from the wood itself. The same relation also holds with respect to the furfural yield from the fractions composing the completely extracted wood. The yield is variable, depending upon the conditions maintained during the analysis. By separating the material into several portions and subjecting each to the treatment prescribed for the pentosan determination, the opportunity for furfural production is extended, and increased yields are to be expected. With this explanation, the data in Table IV may be regarded as consistent.

The distribution of methoxy groups is shown in Table V.

TABLE V—DISTRIBUTION OF METHOXY GROUPS IN OAK

(Results in percentages of air-dry wood, 4.20 per cent moisture)

	Individual				Av.
Untreated wood	5.68	5.45			5.56
Wood extracted with benzene and alcohol	5.87	5.25			5.56
Completely extracted wood	4.43	4.36	4.21	(3.71)[1]	4.33
Lignin in wood extracted with benzene and alcohol	3.73	3.40			3.56
Lignin in completely extracted wood	3.53	(2.94)[1]			3.53

[1] Figures in parenthesis omitted from average.

The method and apparatus used gave good results with pure vanillin (20.35 per cent against 20.4 theoretical). Considerable difficulty was experienced, however, in getting concordant results with wood and lignin. This is believed to be due partly to imperfect contact between reagent and material, and partly to losses incidental to the excessive manipulation required in preparing the necessarily small sample for the determination. While there is considerable variation between duplicate determinations, the data nevertheless indicate marked differences in the methoxy content of the different preparations.

DISCUSSION

The methods here applied to oak wood as a typical hardwood may be regarded as fulfilling the following requirements of a satisfactory procedure for a summative analysis:

(1) They account for practically all of the material of the wood. The sum of constituents is as close to

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[1] THIS JOURNAL, 12 (1920), 474.

[2] "Paper Making," 1916 Ed., p. 97; THIS JOURNAL, 12 (1920), 267.

100 per cent as could be expected with methods of this character.

(2) As compared with other procedures tried, maximum yields of cellulose and lignin are obtained, with a minimum of impurities or degradation products.

(3) Overlapping of constituents is avoided. The cellulose was found free from lignin. The studies of König and Becker have shown that the gaseous hydrochloric acid method gives a cellulose-free lignin. The galactan is determined by a method too specific to include either of these constituents. The other constituents are determined in separate successive extractions and cannot therefore overlap with the above "residue constituents."

(4) No substances of importance have been overlooked. In addition to constituents specifically named in the analysis, woods are known to contain in greater or less amount: acetic-yielding groups, furfural-yielding groups (pentosans, etc.), methoxy groups, cutin, pectin, nitrogenous substances, and ash. A brief consideration of the available data will show that these substances are largely accounted for in the fractions determined.

It has been shown that the groups yielding acetic acid on hydrolysis are wholly contained in the extracts removed in purifying the wood tissue. A study of the furfural distribution shows that the pentosans are fully accounted for, partly in the alkali-soluble portion and partly in the chlorination filtrates and washings. The balance of the furfural yield is from the cellulose. The methoxy distribution shows that these groups are largely associated with the lignin. Most of the methoxy groups that are not so associated are accounted for in the water- and alkali-soluble portions. A small amount (0.8 per cent), however, is apparently split off during the hydrochloric acid treatment, and this portion is unaccounted for in the sum of constituents. Cutin is absent, as shown by the complete solubility of the cellulose residue in 72 per cent sulfuric acid. Precise information is lacking as to the chemical nature of pectins and their occurrence in woods. It is known that pectin contains methoxy, and yields furfural on distillation with hydrochloric acid and mucic acid on evaporation with nitric acid. The presence of galactan, pentosan, and non-lignin methoxy groups in the residue may be taken as a possible indication of pectin. If so, it is largely accounted for in its above-mentioned decomposition products.

The purified wood tissue after successive treatments with the four solvents contains only a few tenths of a per cent of nitrogen and a similar amount of ash. Presumably these small quantities are distributed over the constituents cellulose and lignin. No considerable error can result from neglecting them altogether.

As has already been noted, the composition of the various extracts has not been fully worked out. In their aggregate, the amount of these extracts measures the total amount of adventitious substances, as distinguished from the wood substance proper.

The distribution of furfural-yielding groups shows that there are probably three forms of these substances present in oak wood: the pentosans soluble in cold, dilute, sodium hydroxide solution, the furfural-yielding constituent of the cellulose, and the comparatively small amount of pentosan, resistant to the alkali treatment but dissolved during chlorination. It would appear that the first of these is wood gum (xylan or araban), and the second oxycellulose. The last may be due to more resistant pentosan or to pectin. The simultaneous presence of galactan and methoxy groups not due to lignin suggests the latter.

The present investigation indicates that alkaline digestion is necessary for the best results with oak wood, and presumably with the hardwoods generally. From the work done so far, it would appear that the coniferous woods should be prepared without, and the hardwoods with, alkaline digestion. Further work is necessary to determine whether this rule is generally applicable. It appears probable that the method of alkaline digestion will be found effective with all highly colored woods.

SUMMARY

1—Methods previously used for the analysis of coniferous woods were investigated as to their applicability to the hardwoods. Oak wood, as a typical hardwood, was analyzed by suitable modifications of these methods, with the results herein presented.

2—The purification treatment employed for the tissue of coniferous woods (successive extraction with benzene and alcohol) was supplemented with digestion in cold water and cold 5 per cent sodium hydroxide solution. These treatments remove all adventitious substances, but do not injure either the cellulose or the lignin.

3—Lignin was determined by the gaseous hydrochloric acid method recently proposed by König and Becker.

4—The modified procedure conforms to the requirements of a satisfactory analytical scheme in that it accounts for all of the material of the wood, yields the maximum amount of main constituents free from impurities or degradation products, avoids overlapping of constituents, and overlooks no constituents of importance.

NITRATE CONTENT OF CERTAIN WATERS CONSIDERED BACTERIOLOGICALLY SAFE[1]

By M. Starr Nichols

Wisconsin State Laboratory of Hygiene, University of Wisconsin, Madison, Wisconsin

The quantity of nitrate nitrogen permissible in a potable water has been the subject of much consideration and speculation. While every sanitarian has his own quantity standard upon which he bases his judgment as to the source and quality of a given water, each agrees that a large amount of nitrate nitrogen cannot be disregarded. Richards and Woodman[2] say, "In eastern America nitrates above 0.5 part per million would arouse suspicion, and above 5 parts per million

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[1] Presented at the 59th Meeting of the American Chemical Society St. Louis, Mo., April 12 to 16, 1920.

[2] "Treatise on Air, Water, and Food," 3rd Ed., 1911, p. 92.

would in most cases prove previous pollution." Booth[1] concludes from his investigation that, "if nitrates are present in water above one part per million, it may have an unwholesome source." Stoddart,[2] in an article published in 1893 on the interpretation of water analyses, maintains "that natural waters can, at most, contain but from 0.1 to 0.2 grain of nitrogen per imperial gallon" (approximately 1.4 to 2.8 parts per million) "from sources other than animal matter." Quoting from Rideal[3] we find, "Therefore a water which contains over 0.5 to 0.6 part of nitrogen, as nitrates or nitrites in 100,000, may be certified as dangerous." On the other hand, Kühl[4] contradicts these opinions, after working with certain types of denitrifying organisms, by saying, "The presence of nitrates in water is not an indication of contamination."

DETAILS OF PROCEDURE

The present paper is a report of the nitrate-nitrogen findings of 808 (Wisconsin) waters which were found to be safe bacteriologically. The bacteriological standards were those adopted by the Treasury Department of the United States for drinking water supplied to the public by common carriers in interstate commerce. The samples were collected in sterilized glass-stoppered bottles from deep wells, shallow wells, springs, and rivers; iced; and shipped to the laboratory in special containers. Drilled wells were arbitrarily considered deep, while those dug and driven were classified as shallow. A sanitary survey of the source of the water was not made in any regular manner, and only fragmentary data given by the local health officer who collected the sample were available for comparison. No correlation of these data with the analytical results has been attempted. The nitrate nitrogen was determined by the phenoldisulfonic acid method of the American Public Health Association,[5] using 50 cc. of the sample for a determination. A complete list of analyses will not be included in this paper, but only such groupings as will give a fair idea of the quantities present.

In order to compare the results of these analyses with analyses of normal waters given by other investigators, a compilation of their respective results is given in Table I.

TABLE I

SOURCE	LOCATION	NITROGEN AS NITRATES P. p. m.	INVESTIGATOR
Spring	Adirondack Mts.	0.28	Mason
Watershed	Croton, N. Y.	0.08 to 0.209	Fuller
Well water	Hyde Park, Mass.	0.532	Mass. State Board of Health
Spring	Arlington, Mass.	1.25	Mass. State Board of Health
Fresh pond	Cambridge, Mass.	0.3	Mass. State Board of Health
Driven well	South Carolina	0.6	Richards and Woodman
Deep well	Texas	0.0	Richards and Woodman
Deep well	Lake Winnipeg	1.6	Richards and Woodman
New wells	Lyon, N. Y.	0.1	Booth
Well	Norwich, England	8.0	Thresh
Well	Alexandria, Va.	0.3	Clarke
Artesian well	Rocky Ford, Col.	0.13	Hillebrand
Spring	Webster Grove, Mo.	4.0	Hillebrand and Howard

In Table II are given the total results of analyses of 808 waters irrespective of source.

TABLE II

Nitrate Nitrogen P. p. m.	Number of Waters	Percentage
0.00– 1.0	475	58.8
1.01– 5.0	193	23.9
5.01–10.0	101	12.5
10.01–20.0	35	4.4
20.01–30.0	1	0.1
30.01–40.0	1	0.1
40.01–50.0	1	0.1
50.01–60.0	1	0.1

From these results it is seen that a water may be entirely safe bacteriologically and yet have exceedingly high nitrates. In fact in each of 140 of these waters there is enough nitrate nitrogen to prove previous pollution, according to the standard of one author quoted. Bacteriological examinations tell us nothing, therefore, of the past history of a bacteriologically safe water, nor do they tell us anything of any potential danger. In other words, a bacteriological examination can at most tell us only whether the water sample at hand does or does not exceed the standard in number of certain counts and types of organisms.

In Table III the analyses are grouped to show the nitrate-nitrogen findings as related to the source of the supply.

TABLE III

Nitrate Nitrogen P. p. m.	Number of Waters	Percentage
	SPRINGS (71 Waters)	
0.00– 1.0	35	49.0
1.01– 5.0	20	28.0
5.01–10.0	13	19.0
10.01–20.0	3	4.0
20.0+	0	0.0
	SHALLOW WELLS (250 Waters)	
0.00– 1.0	124	50.0
1.01– 5.0	60	24.0
5.01–10.0	46	18.0
10.01–20.0	17	6.8
20.01–30.0	1	0.4
30.01–40.0	0	0.0
40.01–50.0	1	0.4
50.01–60.0	1	0.4
	DEEP WELLS (446 Waters)	
0.00– 1.0	277	62.1
1.01– 5.0	111	24.9
5.01–10.0	42	9.4
10.01 20.0	15	3.4
20.01–30.0	00	0.0
30.01–40.0	1	0.2
	LAKES (28 Waters	
0.00–0.1	15	52.0
0.11–0.5	11	40.0
0.51–1.0	1	4.0
1.01–2.0	1	4.0
	RIVERS (13 Waters)	
0.00–0.1	7	54.0
0.11–0.5	5	38.0
0.51–1.0	0	0.0
1.01–2.0	1	8.0

It is to be seen that low values for nitrate nitrogen, up to 5 parts per million, are found in 87 per cent of the deep well waters, while even the shallow wells and springs show a similar low figure for nitrate nitrogen, in 74 and 77 per cent, respectively. In the results for lakes and rivers no high values for nitrate nitrogen are found.

SOURCES OF NITRATE NITROGEN

A question naturally arises as to the source of this large amount of nitrogen which is present as nitrate in some ground waters. If it is derived from unpolluted soil leachings, from niter beds, or from nitrogen carried down from the atmosphere by rain as nitrates, we should not be at all concerned. The Rivers Pol-

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[1] "Water Analysis and the Nitrogen Content of Water," *J. Am. Water Works Assoc.*, **2** (1915), 61.

[2] *Analyst*, **18** (1893), 293.

[3] "Water and Its Purification," 2nd Ed., **1902**, p. 202.

[4] "The Reduction of Nitrates by Denitrifying Bacteria and Its Importance in the Judgment of Waters."

[5] "Standard Methods of Water Analysis," **1917**.

lution Commission,[1] after examination of a large number of samples of rain water, found the mean amount to equal 0.32 p. p. m. nitrate nitrogen.

Gale[2] says that no extensive beds of nitrates are to be found in the United States, but that small deposits occur in many places throughout the country, especially in certain caves. Nitrogen as nitrate occurs in the soil in varying quantities, depending upon the nature of the soil, as well as on the time of year, kind of crop, and amount of cultivation. In general, soil contains from 5 to 200 p. p. m. of nitrate nitrogen, though Headdon[3] found as high as 60,000 p. p. m. in certain brown spots in Colorado soil. No such soil has been found, to the author's knowledge, in any other locality in the United States. That the amount of nitrates varies with the depth at which the sample is taken is illustrated by the work of King and Whitson,[4] who found that soil under clover and oats showed, in p. p. m. of the dry soil, 23.39, 18.33, 9.47, and 7.9 for the first, second, third, and fourth foot of soil, respectively. That manure piles, cesspools, cesspits, privies, sewage, and in fact any decaying animal matter may yield enormous amounts of nitrogen as nitrates is a well-known fact hardly necessary to repeat.

That ground waters receive large amounts of nitrate nitrogen from the soil is not borne out by the work of Malpeaux and Lefort,[5] who found that nitrates plowed to a depth of 10 in. appeared at the end of 11 days in the top 3 in., and those plowed to a depth of 20 in. reappeared in one month in the top 3 in. They finally concluded "that the summer rains never carry the nitrates beyond the reach of the roots of plants." Aladjem[6] concludes that "in waterlogged soils," a condition obtaining in many water-bearing strata, "nitrates are decomposed." Ritter[7] states that nitrates are reduced by the nascent hydrogen formed in the decomposition of peat. Tkachenko[8] remarks that there was "little leaching of nitrates during the rainy periods, and this was not noticeable in any case below 25 to 50 cm." Mendelejeff[9] gives his opinion that nitric nitrogen loses its oxygen on penetrating into the earth. A careful study of wells[10] in the immediate locality in which Dr. Headden reported 60,000 p. p. m. nitrate nitrogen in the soil, previous to the appearance of the niter trouble, failed to disclose more than a trace of nitrates. That surface waters do not abstract much nitrate from the soil is shown by the invariably low nitrate content of rivers and lakes at all seasons of the year. However, by allowing rain water to drain down through 2 ft. layers of soil samples contained in percolating pots, Fraps[1] obtained 11 to 200 p. p. m. of nitrate nitrogen. It seems possible, therefore, that if a fissure should form in the subsoil at a depth of 2 or 3 ft., a ground water might be obtained which contained a large amount of nitrates derived from the surface soil. In any event, the water so obtained could not be considered safe. In this connection Stoddart[2] describes an experiment in which sewage containing cholera spirilla was passed through a nitrifying bed of coarsely powdered chalk, with the result that although the organic matter in solution was completely nitrified, the cholera spirilla could be detected in the effluent. That the character of the soil does not have much effect upon the quantity of nitrate nitrogen in the ground water is indicated by the fact that ground waters in every locality of the state, representing soil ranging from the sand and gravel types to the heavy black soil of the marshes, are found with less than 1 p. p. m. In more than 75 per cent of the counties the low figure for nitrate nitrogen is below 0.1 p. p. m. These facts also oppose the theory that there are mineral deposits of nitrates from which the nitrate nitrogen is derived.

The work of Willis,[3] confirmed by the following example, shows that a well may be potentially dangerous, although safe bacteriologically: Dug well, in basement of a hotel in a small Wisconsin village, protected from surface washings, but subject to possible pollution from outhouses; soil, sandy loam. The bacteriological examination showed no *B. coli*, only 4 bacteria growing at 37° C., and only 13 growing at 20° C., but the nitrate nitrogen was 60 p. p. m. Judged bacteriologically, this is an entirely safe water, yet there are few sanitarians who would not condemn the supply on the nitrate findings.

CONCLUSIONS

1—An excessive quantity of nitrate nitrogen is not a normal component of safe ground waters.

2—Many difficulties must be surmounted before it will become possible to set an accurate standard, but from the results here presented and from the evidence contained in the literature, a water containing 5 or more p. p. m. of nitrate nitrogen should be considered as a potentially dangerous supply until a sanitary survey can be made by a competent person.

3—The nitrate-nitrogen determination should be included in every ground-water examination.

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[1] John C. Thresh, "Water Supplies," 2nd Ed., p. 166.

[2] U. S. Geological Survey, *Bulletin* **666**-Z.

[3] Colorado Agricultural Experiment Station, *Bulletin* **186** (1913).

[4] Wisconsin Agricultural Experiment Station, *Bulletin* **93**.

[5] "The Circulation of Nitrate in Soils," *Ann. Sci. Agron.*, **30** (2), 705.

[6] "Production of Alkali in Soils by Denitrification," *Cairo Sci. J.*, **8**, 274; through *Chem. Abs.*, **10** (1916), 3128.

[7] "Peculiarities of Nitrate Formation and the Nitrate Content of Moor Soils," *Intern. Mitt. Bodenk.*, **2**, 411; through *Chem. Abs.*, **8** (1914), 1180.

[8] "Observation on the Formation and Layer Distribution of Nitrates in Soils, with Different Nitrogen Fertilizers," *Khoziaistvo*, **37-40** (1912); *Zhur. Opytu. Agron.*, **14** (1913), 585; *Expt. Sta. Record*, **33** (1915), 422.

[9] "Chemistry," p. 223.

[10] Walter G. Sackett, "The Nitrifying Efficiency of Certain Colorado Soils," Colorado Agricultural Experiment Station, *Bulletin* **193**, 5.

[1] Texas Agricultural Experiment Station, *Bulletin* **171** (1914), 5.

[2] John C. Thresh, "Water Supplies," 2nd Ed., p. 167.

[3] "Value of Nitrate Figure in Determining Fitness of Water for Drinking Purposes," *J. Proc. Roy. Soc. New S. Wales*, **45**, 408.

RELATIONSHIP OF HYDROGEN-ION CONCENTRATION OF NATURAL WATERS TO CARBON DIOXIDE CONTENT[4]

By R. E. Greenfield and G. C. Baker

STATE WATER SURVEY DIVISION, URBANA, ILLINOIS

The effect of hydrogen-ion concentration upon biological processes has recently been much studied by biologists. The results indicate that it is more of a governing factor than is the total acid or alkali content.

[4] Presented at the 59th Meeting of the American Chemical Society, St. Louis, Mo., April 12 to 16, 1920.

Illustrations are found in the fact that the limiting H^+-ion concentration of bacterial growth is as characteristic of each species as most other general tests, and that fresh-water and marine flora are found to vary with changing H^+-ion concentration.

Few data are available concerning the H^+-ion concentration of natural waters. Complete data concerning the carbon dioxide and carbonate content of waters are, however, often available, and may be used as a basis for the calculation of the H^+-ion concentration, since other salts or acids which would affect this value are rarely found in natural waters.

The following mass-law equations have been shown to be correct for carbonic acid:

$$\frac{(H^+)\,(HCO_3^-)}{(H_2CO_3 + CO_2)} = 3.0 \times 10^{-7}$$ (1)[1]

$$\frac{(H^+)\,(CO_3^{--})}{(HCO_3^-)} = 6.0 \times 10^{-11}$$ (2)[2]

Since most natural waters have a fairly high bicarbonate content and contain considerable free carbonic acid, Equation 1 should nearly approximate the conditions, for in the presence of appreciable amounts of both bicarbonate and free carbonic acid the ionization represented by Equation 2 would be slight. If, then, we have a record of the concentration of bicarbonate ion and of free carbonic acid, we can calculate the H^+-ion concentration.

According to "Standard Methods of Water Analysis," American Public Health Association, bicarbonate is determined by titration with 0.02 *N* acid, using methyl orange as an indicator. This value is, of course, that of the total concentration. It is probable that the bicarbonate is only about 85 per cent ionized. Free carbonic acid is determined by titration with 0.045 *N* sodium carbonate, using phenolphthalein as an indicator. The phenolphthalein end-point, under the conditions of titration, is obtained at a H^+-ion concentration of about 1×10^{-8}. Substituting in Equation 1, and solving for the amount of free carbonic acid, we obtain

$$(H_2CO_3 + CO_2) = 3.333 \times 10^{-8} \times (HCO_3^-) \qquad (3)$$

The free carbonic acid in the solution at the end of titration is a function, therefore, of the bicarbonate content, and is an appreciable quantity at all times. In Equation 1 we may therefore substitute the expression $(CO_2) + 3.333 \times 10^{-8} \times (HCO_3^-)$ for $(H_2CO_3 + CO_2)$, 85 per cent of the bicarbonate determined by titration for (HCO_3^-); and express the CO_2 determined as p. p. m. CO_2, and the bicarbonate as p. p. m. $CaCO_3$. The equation then becomes

$$(H^+) = \frac{4\,CO_2 \times 10^{-7}}{(HCO_3^-)} + 1 \times 10^{-8} \qquad (4)$$

If both bicarbonate and free carbon dioxide are expressed in terms of cc. of CO_2 per liter, or in terms of p. p. m. CO_2, Equation 4 becomes

$$(H^+) = \frac{3.5 \times 10^{-7}\,CO_2}{(HCO_3^-)} + 1 \times 10^{-8} \qquad (5)$$

The two equations offer a convenient means of calculating the H -ion concentration of any water for which the content of free carbonic acid and carbonates is known.

To check the accuracy of these calculations, several samples of water, from a variety of sources and varying widely in mineral and organic content, were examined. Bicarbonate and free carbon dioxide were determined according to "Standard Methods of Water Analysis." The free carbon dioxide titrations were continued to a faint pink which was persistent for 3 min. The H^+-ion concentration was determined colorimetrically,[1] using standard buffer solutions which had been checked by means of the hydrogen electrode. The results were expressed in terms of P_h^+, *i. e.*, the negative logarithm of the H^+-ion concentration.

TABLE I—COMPARISON OF CALCULATED H^+-ION CONCENTRATION WITH THAT DETERMINED COLORIMETRICALLY

SOURCE OF SAMPLE	Res. on Evap.	Free CO_2 P.p.m.	Bicarb. as P.p.m. $CaCO_3$	P_h^+ Det.	P_h^+ Calc.	Error
Drift Well..........	947	10.5	408	7.8	7.70	—0.10
	947	24.5	408	7.5	7.46	—0.04
	947	15.0	410	7.6	7.64	0.04
	947	34.0	409	7.4	7.35	—0.05
	947	12.0	408	7.8	7.66	0.14
Mine Water........	1172	0.0	292	8.0	8.00	0.00
	1172	7.0	291	7.6	7.71	0.11
	1172	9.0	292	7.6	7.65	0.05
	1172	14.0	293	7.4	7.44	0.04
	1172	23.0	292	7.4	7.40	0.00
Drift Well..........	1573	10.0	352	7.6	7.66	0.06
	1573	16.0	353	7.5	7.54	0.04
	1573	24.0	352	7.4	7.40	0.00
	1573	25.0	354	7.4	7.40	0.00
	1573	26.0	352	7.4	7.40	0.00
Swimming Pool.....	446	1.0	96	7.8	7.85	0.05
	446	5.0	94	7.4	7.45	0.05
	446	6.0	90	7.4	7.43	0.03
	446	10.5	90	7.2	7.26	0.06
	446	22.5	90	6.8	6.95	0.15
Vermillion River....	375	0.0	154	7.9	8.00	—0.10
	375	7.0	152	7.5	7.54	0.04
	375	15.5	152	7.2	7.28	0.08
	375	16.5	152	7.1	7.29	0.19
	375	29.5	152	6.9	7.05	0.15
Vermillion R. Filtered	344	7.0	132	7.5	7.50	0.00
	344	22.0	130	7.0	7.10	0.10
	344	38.0	130	6.7	6.90	0.20
Shallow Well.......	459	4.0	376	7.9	7.84	—0.06
	459	4.0	374	8.0	7.84	0.16
	459	6.0	374	7.9	7.80	—0.10
	459	33.0	364	7.3	7.30	0.00
	459	35.0	362	7.3	7.30	0.00
Drift Well..........	328	7.0	218	7.6	7.62	0.02
	328	6.0	216	7.6	7.66	0.06
	328	16.0	214	7.3	7.38	0.08
	328	36.0	210	7.0	7.10	0.10
	328	38.0	210	6.9	7.05	0.15
Drift Well..........	330	7.0	224	7.8	7.64	—0.16
	330	9.0	222	7.7	7.57	—0.13
	330	21.0	216	7.3	7.32	0.02
	330	36.0	216	7.0	7.13	0.13
	330	43.0	214	6.9	7.00	0.10
Reservoir...........	280	1.0	74	7.6	7.80	0.20
	280	8.0	74	7.4	7.27	—0.13
	280	13.0	74	7.0	7.18	0.18
Reservoir Filtered...	254	5.0	64	7.4	7.38	—0.02
	254	14.0	64	6.9	7.00	0.10
	254	26.0	64	6.6	6.78	0.18
Kankakee River.....	384	6.0	100	7.3	7.47	0.17
	384	14.0	100	7.1	7.18	0.08
	384	25.0	96	6.7	6.94	0.24
Kankakee R. Filtered	328	6.0	78	7.3	7.40	0.10
	328	17.0	80	6.9	7.02	0.12
	328	44.0	80	6.8	6.66	—0.14
Kankakee R. Filtered	230	16.0	28	6.3	6.62	0.32
	230	27.5	26	6.2	6.35	0.15
	230	37.0	28	6.2	6.24	0.04
	230	1.0	26	7.6	7.57	—0.03
Ohio River.........	206	15.0	44	6.9	6.83	—0.07
	206	29.0	44	6.5	6.52	0.02
	206	30.0	44	6.5	6.52	0.02
Mississippi River....	225	11.0	90	7.3	7.23	—0.07

Each sample of water was examined without modification and also after the addition of increasing amounts of water saturated with carbon dioxide. In taking the samples for titrations and for P_h^+ determinations, no special precautions were taken to

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[1] Landolt and Börnstein, "Physikalisch-Chemische Tabellen," p. 1132.

[2] Auerbach and Pick, *Arb. Kais. Gesundh.*, **38** (1912), 243.

[1] W. M. Clark and H. A. Lubs, *J. Bact.*, **2** (1917), 1, 109, 191.

prevent aëration. The results of 63 such determinations are given in Table I.

In only one case was the difference between the determined and calculated P_h^+ greater than 0.3, and the mean variation is about 0.1. It will also be noted that the wider variations occurred in the cases of low bicarbonate content, which is to be expected from the assumptions made in the development of the equation. Somewhat larger variations are found in cases of high free carbon dioxide content than in similar cases with less carbon dioxide. This is probably due to the loss of carbon dioxide by aëration in the determination of both the carbon dioxide content and the P_h^+.

From their experiences with the colorimetric P_h^+ determinations, the authors do not feel that determinations can be made much more accurately than 0.2 P_h^+, using open tubes and ordinary methods of transferring the test sample to the tube. The effect of aëration of such unstable solutions as natural waters should amount to this much or more. It is advisable in all cases to make several determinations.

The formula cannot be applied to waters which are alkaline to phenolphthalein. An attempt was made to develop such an equation, but no waters naturally alkaline to phenolphthalein were available for checking the calculations. For unusual cases of this kind and cases of low bicarbonate content, it may be better to use some more complete and more complex equation, such as has been developed by Prideaux.[1]

CONCLUSIONS

Fairly accurate calculations of the H^+-ion concentration of natural waters can be made from the simple mass law equation of the primary ionization of carbonic acid.

Equations are developed for calculating H^+-ion concentration, in which the carbon dioxide and bicarbonate are expressed in the manner in which they are ordinarily determined. These equations are less accurate with low bicarbonate concentrations and do not apply to waters alkaline to phenolphthalein.

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A NEW TECHNICAL METHOD FOR THE ESTIMATION OF THE SACCHAROGENIC POWER OF DIASTATIC PREPARATIONS

By Kokichi Oshima

TAKAMINE LABORATORY, INC., CLIFTON, N. J.

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The most practical method for the estimation of the saccharogenic power of diastatic preparations is that of Lintner,[2] which is briefly outlined:

LINTNER METHOD

Separate volumes of 0.1, 0.2, 0.3, up to 1.0 cc., of 5 per cent diastase solution are added to a series of 10 test tubes, each containing 10 cc. of 2 per cent soluble starch solution. The tubes are allowed to incubate for one hour at constant temperature, at the end of which time 5 cc. of Fehling's solution are added to each tube, the liquids mixed, and the tubes immersed in a boiling water bath for 10 min. If, at the end of that period, the Fehling solution in the tube containing 0.1 cc. of diastase solution is just completely reduced, the diastatic power of the diastase is taken as 100. If 0.2 cc. reduces the 5 cc. of Fehling's solution, the diastatic power is 50, etc. More exact results may be obtained, if necessary, by taking 0.1, 0.15, 0.2, 0.25 cc., etc., of the diastase solution for a series of tubes, and determining more accurately the amount of digest which will just reduce 5 cc. of Fehling's solution.

The following formula is used for calculating the diastatic power of malt by the Lintner scale:

$$V : 0.1 = 100 : \text{diastatic power}$$

V is the volume of diastatic solution, 0.1 being the unit quantity used to make the value of 100 on the Lintner scale.

FAULTS OF LINTNER METHOD—This method has justly been criticized by Sherman and his associates:[1] first, as not being accurate, since there are only ten points on the Lintner scale at which an accurate determination can be made in the first operation; second, the probable error of the method increases rapidly with the diastatic power of the sample; if the end-point falls between the last two tubes (0.9 and 1.0 cc.) the diastatic power will be between 10 and 11.1, with a relatively small variation; but if it falls between the first two tubes (0.1 and 0.2 cc.) the diastatic power lies between 50 and 100, with a very large possible error.

The Lintner method can be further criticized as not easy or quick enough for technical purposes, particularly when a large number of tests have to be made as a routine in factory procedure. For example, to test 10 samples by the Lintner method, one has to use 100 test tubes, and different quantities of the diastatic solutions have to be tested 100 times at the definite intervals of time.

MODIFICATIONS OF METHOD—Ling[2] modified the Lintner method as follows:

A quantity of diastatic solution is added to 100 cc. of 2 per cent soluble starch solution in a 200 cc. flask, and kept at a constant temperature for one hour. At the end of this time, 20 cc. of 0.1 *N* sodium hydroxide are added and the solution is made up to 200 cc. with distilled water. After mixing, this solution is introduced into a buret and gradually run into 5 cc. Fehling's solution, diluted with a little water and kept boiling, until the solution just loses its blue color. If 25 cc. of the liquid (100 cc. of which correspond to 1 g. of soluble starch and 1.5 cc. of malt extract) are required to reduce 5 cc. of Fehling's solution, the

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[1] *Proc. Roy. Soc. London* [A], **91**, 535.

[2] *Z. prakt. Chem.*, **34** (1886), 386.

[1] *J. Am. Chem. Soc.*, **32** (1910), 1075.

[2] Euler's "General Chemistry of Enzymes," **1912**, p. 290.

diastatic power of the sample will be $\frac{100}{25 \times 1.5} = 26.7$.

From practical considerations, this method also has various defects, chief among which are the slowness and inexactness of determining the quantity of sugar. There is no accurate agreement with the Lintner scale, since, by the method of Ling, the quantity of enzymes and production of sugar do not give an exact proportion; particularly is there a noticeable difference when the production of sugar is too much or too little. To obviate these difficulties, Sherman and his associates proposed a method which depends upon the gravimetric estimation of copper oxide. The method is, however, for that reason too troublesome for routine factory work.

PROPOSED METHOD

1—In the case of a solid sample, it must be first extracted with distilled water for 3 hrs. at room temperature. From 1 to 10 g. of the sample are usually extracted in 100 cc. of water. If the enzyme is too concentrated, the solution is further diluted with a known amount of distilled water.

2—Ten cc. of the extract or the diluted extract are put into a flask containing 100 cc. of 2 per cent soluble starch solution, which has been placed in a water bath kept at 40° C., the contents of flask are mixed, and the flask is allowed to remain in the bath for 30 min. At the end of that period, 10 cc. of 0.2 *N* sodium hydroxide are added at once to stop further enzymatic action.

3—Graduated quantities of the digest are then poured into a series of test tubes each containing 5 cc. of Fehling's solution; and the tubes are placed in a boiling water bath for 10 min., the tubes being shaken once during that period. The smallest quantity of the digested starch solution which just reduces 5 cc. Fehling's solution is determined. It may be more convenient to use at first only 2 or 3 tubes containing quantities of the digest within wide regions of variation, so as to determine the approximate concentration of the digest to be used. The reduction of the Fehling solution is then carried out within the narrow limits of this approximate value.

4—Knowing the amount of digested starch solution which will just reduce 5 cc. of Fehling's solution, we can calculate, as shown later, the Lintner value. The exact value is obtained by dividing the value found in the table by the percentage of the solid or liquid sample in the diluted enzyme solution.

CALCULATION TO LINTNER SCALE—Lintner's scale is very useful and popular; it was, therefore, found convenient to recalculate the values obtained by the new method in terms of this scale. An extract of a culture of *Aspergillus oryzae* (grown on bran) and an extract of malt were used in this investigation. The experiments were repeated numerous times so as to verify the results.

It was found that, with a definite extract of *Aspergillus oryzae* grown on bran, tested by the Lintner method at 40° C., 0.262 cc. of 1 per cent solution reduced 5 cc. of Fehling's solution. The following results were obtained by using the new method:

Strength of Extract Per cent	Vol. of Digest Required to Reduce 5 Cc. Fehling's Solution Cc.
4	3.5
3	4.0
2	5.0
1.5	5.75
1	7.5

In each case, 10 cc. of the particular concentration of diastase solution were added to 100 cc. of 2 per cent soluble starch solution, incubated for 30 min. at 40° C., then treated with 10 cc. of 0.2 *N* NaOH. The soluble starch was prepared according to Lintner, and its reaction so adjusted that 100 cc. of the 2 per cent solution required 0 to 1 cc. of 0.01 *N* NaOH to make it neutral with rosolic acid as an indicator.

By using the formula given by Lintner (on the Lintner scale), allowing for the concentration of the enzyme, we can calculate the value of the data obtained by the new method which would be comparable to those obtained by the original Lintner method.

V : 0.1 = 100 : diastatic power (on Lintner's scale), since V = 0.262, when the concentration of the enzyme is not 5 per cent (as used by Lintner) but Y per cent, we find that:

$$\text{Diastatic power} = \frac{100 \times 0.1}{0.262} \times \frac{5}{Y} = \frac{184}{Y}$$

If Y = 1, then the diastatic value of the preparation used is 184 on the Lintner scale. The results of calculation to the Lintner scale are shown in Table I.

TABLE I—SACCHAROGENIC POWER SCALE FOR DIASTASE FROM *Aspergillus oryzae* (40° C.)

Obtained Value	Lintner Scale × Y	Obtained Value	Lintner Scale × Y
3.5[1]	735	10.5	126
3.75	643	11.0	120
4.0[1]	551	11.5	114
4.25	505	12.0	109
4.5	459	12.5	104
4.75	413	13.0	99
5.0[1]	367	13.5	94
5.25	336	14.0	89
5.5	305	14.5	84
5.75[1]	275	15.0	79
6.0	262	16.0[1]	69
6.25	249	17.0	65
6.5	236	18.0	61
6.75	223	19.0	57
7.0	210	20.0	53
7.25	197	22.0[1]	46
7.5[1]	184	24.0	42
7.75	178	26.0	38
8.0	172	28.0[1]	34
8.25	166	30.0	31
8.5	160	33.0	27
8.75	154	36.0[1]	24
9.0	148	37.0[1]	23
9.25	143	39.0	21
9.5[1]	138	45.0	19
9.75	135	50.0	17
10.0	132	...	...

[1] Experimental value.

This table can be used for every form of diastase originated from *Aspergillus oryzae.* If too much sugar is present in the diastase solution it is necessary to correct the obtained Lintner value by a blank test.

If the diastase is of different origin, the table may be changed somewhat since the course of digestion differs according to the enzyme.

The same procedure was followed to develop a scale for the diastase of malt, using an extract of powdered malt. This scale is shown in Table II.

Attention should be called here to the fact that the values falling between the experimental values were obtained by mere arithmetical calculations and not by mathematical interpolation. But, since this method is looked upon as a working factory method, the results

TABLE II—SACCHAROGENIC POWER SCALE FOR MALT DIASTASE (40° C.)

Obtained Value	Lintner Value × Y	Obtained Value	Lintner Value × Y
3.5[1]	735	10.5[1]	92
3.75[1]	551	11.0	89
4.0[1]	367	11.5	86
4.25	336	12.0	83
4.5	305	12.5	80
4.75[1]	275	13.0	77
5.0	262	13.5	75
5.25	249	14.0	73
5.5	236	14.5	71
5.75	223	15.0[1]	69
6.0	210	16.0	65
6.25	197	17.0	61
6.5[1]	184	18.0	57
6.75	177	19.0	53
7.0	170	20.0	49
7.25	163	21.0[1]	46
7.5	157	22.0[1]	44
7.75	151	24.0	40
8.0	144	26.0	36
8.25[1]	138	27.0	34
8.5	132	28.0	33
8.75	127	30.0	30
9.0	122	33.0	27
9.25	117	35.0[1]	23
9.5	112	36.0	22
9.75	107	39.0	20
10.0	102	45.0	18
...	...	50.0	16

[1] Experimental value.

are quite satisfactory. The best results are obtained by the use of 6 to 30 cc. digested starch solution (Lintner scale 200 to 30), which just reduce 5 cc. of Fehling's solution. Within these limits, the variation is rather small so that even the mere arithmetical averages are entirely satisfactory.

The following experiments will prove the adaptability of the new method for investigations of diastatic preparations.

(1) TIME EFFECT ON LINTNER VALUE—The influence of time upon the Lintner scale values obtained by the new method was determined. The results shown in Table III indicate that the Lintner value is practically proportional to the digestion interval.

TABLE III

Digestion Hrs.	Obtained Value Cc.	Lintner Scale	Time Factor	Lintner Scale × Time Factor
0.25	35.0	25	2	50
0.5	22.0	44	1	44
0.75	16.0	69	2/3	46
1.0	12.5	104	1/2	52
1.5	9.75	135	1/3	45
2.0	8.0	172	1/4	43

(2) TIME EFFECT ON SUGAR CONCENTRATION—The sugar content of the samples was determined at the end of 1 hr. The digested starch solution was kept for 48 hrs. protected with a cork stopper and the sugar content was determined again. (Further action of the enzyme, takadiastase in this case, was prevented by the presence of the alkali.)

TABLE IV

Samples	Obtained Value	
	1 Hr.	48 Hrs.
A	35.0	35.0
B	22.0	22.0
C	16.0	16.0
D	12.5	12.5
E	9.75	9.75
F	8.0	8.0

(3) RELATION OF TIME TO AMOUNT OF DIASTASE—As shown in Table V, the quantity of diastase × period of digestion = constant. Takadiastase was used in the experiment.

TABLE V

	Duration of Digestion Hrs.	Obtained Value	Lintner Scale
Standard solution (10 cc.)	0.25	18.0	61
0.5 diluted solution (10 cc.)	0.5	18.5	59
0.25 diluted solution (10 cc.)	1.0	18.5	59
0.125 diluted solution (10 cc.)	2.0	19.0	57

EXPERIMENTS AT 50° C.—In many cases, 50° C. is used as the temperature of the enzyme action, since the digestion of the starch is more rapid and there is less change in slight differences in the temperature of digestion than there is at 40° C.

TABLE VI—SACCHAROGENIC POWER SCALE FOR THE DIASTASE OF *Aspergillus oryzae* (50° C.)

Obtained Value	Lintner Scale × Y	Obtained Value	Lintner Scale × Y
3.25[1]	952	12.75	81
3.5	833	13.0	79
3.75[1]	714	13.25	77
4.0	595	13.5	75
4.25[1]	476	13.75	73
4.5	429	14.0[1]	71
4.75	381	14.25	70
5.0[1]	333	14.5	69
5.25	311	14.75	68
5.5	289	15.0	67
5.75[1]	267	15.5	65
6.0	254	16.0	63
6.25	242	16.5	61
6.5	229	17.0	59
6.75	217	17.5	57
7.0	204	18.0	55
7.25[1]	191	18.5	53
7.5	178	19.0	51
7.75[1]	167	19.5	49
8.0	159	20.0	48
8.25	151	21.0	45
8.5[1]	143	22.0	42
8.75	138	23.0	40
9.0	133	24.0	37
9.25	128	25.0	35
9.5	123	25.5[1]	33
9.75[1]	119	26.0	33
10.0	115	27.0	32
10.25	112	28.0	30
10.5	108	29.0	29
10.75	105	30.0	28
11.0	101	32.0	26
11.25	98	34.0	24
11.5[1]	95	36.0	21
11.75	92	38.0[1]	19
12.0	89	40.0	17
12.25	86	45.0[1]	14
12.5	83	50.0[1]	10

[1] Experimental value.

Table VI has been worked out for 50° C. as the temperature of incubation.

TABLE VII—SACCHAROGENIC POWER SCALE FOR MALT DIASTASE (50° C.)

Obtained Value	Lintner Scale × Y	Obtained Value	Lintner Scale × Y
3.125[1]	666	9.5	96
3.25[1]	500	10.0	92
3.5[1]	333	11.0[1]	83
4.0	283	12.0	77
4.5[1]	233	17.0	71
5.0	199	14.0[1]	66
5.25[1]	182	15.0	62
5.5	173	16.0[1]	58
6.0	157	17.0	54
6.5	141	18.0[1]	50
6.75[1]	133	19.0	48
7.0	129	20.0	45
7.5	123	25.0[1]	33
8.0[1]	117	30.0	28
8.5	108	35.0[1]	23
9.0[1]	100	40.0	18
...	...	43.0[1]	13
...	...	45.0[1]	12
...	...	50.0[1]	10
...	...	60.0[1]	7

[1] Experimental value.

CONCLUSION

The method outlined is very convenient for experimental studies on various diastatic products, such as malt and its various preparations, takadiastase, polyzime, etc. It is also convenient for the study of the influence of alkalinity, acidity, antiseptics, salts, etc., upon the activity of the diastatic preparation. The method has been used, as a routine factory procedure for over one year, with very good results.

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THE ANALYSIS OF AROMATIC NITRO COMPOUNDS BY MEANS OF TITANOUS CHLORIDE[1,2]

By F. L. English

E. I. du Pont de Nemours & Co., Wilmington, Delaware

Although considerable work has been done upon the determination of nitrogen in nitro compounds of the benzene series by means of titanous chloride, the method appears to be neither as well known nor as extensively applied as its merits deserve. This is probably attributable to the fact that a somewhat complicated apparatus is required, in addition to special care in the preparation of the standard solution, and analytical manipulation slightly out of the ordinary, especially in routine laboratories. These difficulties are, however, apparent rather than real, as it has been our experience, extending over a period of about three years, that the method satisfactorily meets the requirements of the research laboratory, where accuracy is of paramount importance, and of the control laboratory, where the time element is of almost equal weight.

The systematic application of this reagent to analytical chemistry is the result of the comprehensive researches of Knecht and Hibbert[3] on its application to the analysis of numerous types of reducible compounds, inorganic and organic, including a number of nitro derivatives of benzene and its homologs, as well as a few in the naphthalene series. It was the purpose of the present investigators to elaborate upon their work upon the aromatic nitro derivatives with a view to adapting their methods to the purposes of commercial control analysis. If this work lacks systematic coherence, it must be attributed to the fact that the prevailing conditions were such as to render it impossible to undertake the study as a fundamental research, the work being done fragmentarily to meet the demands of plant operation.

EXPERIMENTAL

In outline, this method depends upon the reduction of the nitro group to an amino group by treatment in a strongly acid boiling solution with an excess of standard titanous chloride solution. The excess is subsequently titrated cold with standard ferric alum solution, ammonium thiocyanate being used as indicator. As titanous chloride solutions are readily oxidized by atmospheric oxygen, the volumetric solution must be preserved under an inert gas, preferably hydrogen, and the analysis must be performed also in an innocuous atmosphere, most conveniently carbon dioxide.

STRENGTH OF STANDARD SOLUTIONS—Knecht and Hibbert[4] recommend an approximately 0.033 *N* solution of titanous chloride, the ferric alum solution being of about the same strength. Our experience has led to the adoption of two strengths of $TiCl_3$ solution, approximately 0.05 *N* and 0.25 *N*. The former is used for the estimation of small amounts of nitro compounds occurring in wash liquors, sludge cakes, etc., while the latter is employed in determining the purity of finished products. The stronger solution is preferable wherever it can be used without entailing an inconveniently large sample, as it yields more accurate results without in any way increasing the time of analysis. With both of these $TiCl_3$ solutions, a 0.05 *N* ferric alum solution is used, as experience has shown that this concentration combines speed, convenience, and accuracy.

PREPARATION OF STANDARD SOLUTIONS—In order that a stable solution may be obtained, due precautions must be observed in its preparation. In the first place, it is essential that the distilled water used be free from dissolved oxygen. The water is boiled for 20 to 30 min. and cooled in an atmosphere of carbon dioxide or hydrogen. Titanous chloride usually comes upon the market in 20 per cent aqueous solution. To prepare a 0.05 *N* solution, 33.5 cc. of the stock solution and 70 cc. of concentrated HCl (sp. gr. 1.19), for each liter of standard solution desired, are boiled together for about a minute. After cooling in an atmosphere of CO_2 or hydrogen, this solution is added to the previously prepared distilled water contained in the stock bottle in which it is to be preserved. Thorough mixing is obtained by passing a rapid stream of carbon dioxide or hydrogen through the solution. The 0.25 *N* solution is prepared similarly from 167 cc. of 20 per cent $TiCl_3$ and 150 cc. HCl per liter of standard solution.

It is essential that the concentrated titanous chloride solution and the distilled water be approximately at room temperature before mixing, as a high temperature in a dilute solution favors hydrolysis of the titanium compounds present, with the ultimate formation of a white precipitate, probably metatitanic acid, $TiO(OH)_2$. If such a sediment is noted in a standard solution, it should be filtered off at once through asbestos in a closed system, as this compound seems to catalyze further decomposition. For use in control laboratories, solutions may conveniently be prepared in 18 to 20 liter quantities.

The addition of about 50 cc. of carbon tetrachloride to the stock bottle containing the standard solution tends to absorb the trace of grease frequently present in distilled water, as well as that carried mechanically into the solution from the stopcock lubricant. The carbon tetrachloride has no apparent effect upon the utility of the titanous chloride solution and greatly decreases the frequency with which the buret must be cleaned, an operation somewhat inconvenient, owing to the connection of the top of the buret to the hydrogen reservoir over the standard solution.

The iron solution is prepared from ferric alum. Ferric chloride could probably be used equally well if obtainable in the pure state, but most of the C. P. $FeCl_3$ available contains relatively large quantities of ferrous salts which slowly oxidize, with consequent change in the relation between the iron and titanium solutions. For each liter of standard solution desired,

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[1] Presented at the 59th Meeting of the American Chemical Society, St. Louis, Mo., April 12 to 16, 1920.

[2] This investigation was carried out in collaboration with Mr. H. G. Tanner who was at the time connected with this laboratory.

[3] Their work has been published in the form of a monograph entitled "New Reduction Methods in Volumetric Analysis," Longmans, Green & Co., **1910**, reprinted with additions in **1918**.

[4] *Loc. cit.*, **1918**, p. 46.

24.2 g. of ferric alum are dissolved in water acidified with 50 cc. of 40 per cent sulfuric acid. The final solution should be free from ferrous iron, and may also be advantageously treated with carbon tetrachloride.

APPARATUS FOR STORAGE AND USE OF TlCl$_3$ SOLUTIONS—It has been found convenient to set up a 0.05 N and 0.25 N TiCl$_3$ solution and a 0.05 N ferric iron solution closely adjacent to one another, the last being between the other two. The solutions are connected to their respective burets by means of the usual siphon tube, in which, for accurate work, a thermometer should be placed. Another tube connects the top of the titanous chloride buret to the space above the solution in the stock bottle. This space is also connected to a small hydrogen generator. When the solution is in place and the system completely connected, the stopcock of the TiCl$_3$ buret should be turned to the delivery position, and a rapid stream of hydrogen allowed to pass through the apparatus for one-half hour or more to displace the air.

Where a large number of samples are to be analyzed, a large stock bottle of 40 per cent sulfuric acid may advantageously be placed on the same shelf close to the standard solutions. The siphon tube of this bottle should be fitted with a measuring tube roughly calibrated to deliver 25 cc. of solution.

As the analytical process is conducted under carbon dioxide, a carbon dioxide generator must be available. This apparatus, preferably of the Kipp type, is best charged with pink Tennessee marble, as experience shows that this material contains less occluded oxygen than the white Vermont variety.

The reaction is carried out in a 300-cc. Erlenmeyer flask provided with a tri-perforated stopper. Two of the holes serve for the entrance and exit of carbon dioxide, while the third accommodates the tip of the buret. To the exit tube is attached a 100-cc. flask serving as a trap to prevent air from being sucked back into the reaction flask on cooling.

STANDARDIZATION OF TiCl$_3$ SOLUTIONS—Knecht and Hibbert[1] recommend the standardization of the TiCl$_3$ solution by means of pure ferrous ammonium sulfate. A known quantity is titrated in H_2SO_4 solution to an exact end-point with dilute potassium permanganate, and the equivalent of ferric iron thus formed is then titrated in the cold with TiCl$_3$, with potassium thiocyanate or methylene blue as an indicator. The iron factor thus determined is calculated in terms of nitrogen.

Several objections may be raised to this procedure. In the first place, ferrous ammonium sulfate itself is not a desirable ultimate standard, especially for use in works laboratories, for, unless very carefully preserved, it is subject to oxidation and change in its water of crystallization content. Also, as a general principle, it is desirable to standardize a solution through as nearly as possible the same reaction and procedure as is to be used in the analysis, thereby automatically compensating for at least some of the inherent errors. It was found that in applying a 0.05 N TiCl$_3$ solution, standardized with ferrous alum, to the analysis of a pure nitro compound, the introduction of a correction of 0.3 to 0.4 cc. of TiCl$_3$ was necessary to obtain theoretical results. This "blank" was proved to be occasioned by extraneous oxidation resulting from atmospheric oxygen and possibly from other oxidizing agents in the reagents and the carbon dioxide. This extraneous oxidation does not occur to the same extent in the course of the standardization because it is run entirely at room temperature.

For these reasons, search was made for an aromatic nitro compound which would serve as a satisfactory ultimate standard. Fairly good results were obtained upon TNT (symmetrical, m. p. 80.78°), but this compound left much to be desired on account of its slight solubility in water and the inconveniently small sample demanded by its high nitrogen content. Its volatility with steam also jeopardizes its accurate use with the 0.25 N solution, where the sample required greatly exceeds the solubility of TNT in the reaction mixture. Consequently, some of the sample may be volatilized upon boiling before it can be reduced. *m*- and *p*-Nitroanilines, *m*-nitro-*p*-toluidine, and other nitro compounds are admirably suited to the purpose. The results given in Tables I and II indicate the accuracy with which standardizations may be accomplished, as well as the agreement that may be expected among results obtained with the various ultimate standards.

TABLE I—STANDARDIZATION OF 0.25 N TiCl$_3$ SOLUTIONS AGAINST *p*-NITROANILINE, TRINITROTOLUENE, AND *m*-NITRO-*p*-TOLUIDINE

	Grams Nitrogen Found per Cc TiCl$_3$ Using		
	p-Nitroaniline[1]	TNT	M. N. P. T.[1]
	0.0005039	0.0005039	Standard Solution A
	0.0005044	0.0005037	
	0.0005042	0.0005039	
Av.	0.0005042	0.0005039	
	Standard Sol. B	0.0005074	0.0005074
		0.0005069	0.0005075
		0.0005070	0.0005074
		0.0005073	0.0005077
		0.0005075	......
Av.		0.0005072	0.0005075

[1] The melting points of the *p*-nitroaniline and M N. P. T. samples used were, respectively, 148.7° and 115 3° C.

TABLE II—STANDARDIZATION OF 0.05 N TiCl$_3$ SOLUTION AGAINST FERROUS AMMONIUM SULFATE, TRINITROTOLUENE, AND *p*-NITROANILINE

	Grams of Nitrogen Found per Cc. TiCl$_3$ Using		
	Ferrous Ammonium Sulfate	TNT	*p*-Nitroaniline
	0.00010495	0.00010443	0.00010441
	0.00010493	0.00010453	0.00010445
	0.00010494	0.00010453	0.00010449
	0.00010491	0.00010464	......
	0.00010495	......	......
Av.	0.00010494	0.00010453	0.00010445

The same samples of *p*-nitroaniline and TNT were used in this as in the previous case. The ferrous ammonium sulfate was purified by several recrystallizations from water and was free from ferric iron. It will be noted that the average factor obtained with this material is about 0.4 per cent higher than either of the other two factors. This is attributable to the extraneous oxidation being included in the TNT and nitroaniline factors to a greater extent than it is in the ferrous sulfate factor.

As *p*-nitroaniline is more readily available than *m*-nitro-*p*-toluidine, and is also more easily purified, it has been adopted as the ultimate standard in this laboratory. *m*-Nitroaniline is equally satisfactory.

The relation between the TiCl$_3$ and ferric iron

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[1] *Loc. cit.*, **1918**, p. 48.

solutions is established by boiling 50 cc. of the 0.05 *N* $TiCl_3$ solution or 25 cc. of the 0.25 *N* with 25 cc. of 40 per cent H_2SO_4 and 25 cc. of water or alcohol, cooling, and titrating with the iron solution exactly as described in carrying out the analytical process. As our experience has proved the necessity for strict adherence to apparently minor points of manipulation, this is described in detail below.

ANALYTICAL PROCEDURE—Weigh a sample of the nitro compound containing 0.020 to 0.025 g. of nitro nitrogen. If the 0.25 *N* $TiCl_3$ solution is to be used, transfer the sample directly to a 300-cc. Erlenmeyer flask and treat with 25 cc. of water or alcohol, depending upon in which it is the more soluble. The sample should be completely dissolved, by gently heating, if necessary. If the 0.05 *N* solution is to be employed, dissolve the sample in alcohol, water or dilute acid, dilute to 250 cc., and transfer a 25-cc. aliquot part to the Erlenmeyer flask. From this point on, the procedure with either strength of standard solution is the same.

Add 25 cc. of 40 per cent sulfuric acid, connect the flask to the buret and, after sweeping for 5 min. with a rapid stream of CO_2, add 50 cc. of $TiCl_3$. Remove the flask, plugging the vacant hole with a glass rod, and maintain just at the boiling point for 5 min. During the boiling, the rate of passage of CO_2 may be greatly reduced. Cool the flask to room temperature or below by immersing in cold water, the flow of CO_2 being increased at this point to prevent the drawing of water from the trap back into the reaction flask. If the volume of solution has materially diminished, it should be diluted to approximately its original concentration with distilled water added through the stopper by means of a pipet. Connect the flask with the iron solution buret and titrate until the violet color of the $TiCl_3$ has been just discharged. Disconnect the flask and add through the stopper 10 cc. of 10 per cent NH_4CNS solution. Again connect the flask to the buret and continue the titration until a faint pink color, permanent for one minute, is obtained.

Since six equivalents of $TiCl_3$ are required for the reduction of one nitro group, one cc. of 0.05 *N* $TiCl_3$ is equivalent to 0.00011675 g. of nitrogen.

DISCUSSION OF ANALYTICAL PROCEDURE—The total time required for a determination, including weighing and aliquoting the sample, should not exceed one-half hour. By using two outlet tubes from the carbon dioxide generator, one sample may be swept out while another is being titrated, thus reducing the time somewhat.

The vital point in the determination is to be found in the excess of $TiCl_3$ used. It is absolutely essential for the complete reduction of the majority of the compounds studied that the final concentration of $TiCl_3$ after boiling be equivalent to about 25 cc. of 0.05 *N* $TiCl_3$ in a volume of 100 cc. A greater excess is in no way detrimental, but appreciably less is almost certain to result in incomplete reduction. In the case of the 0.25 *N* solution, the back-titer of iron solution should be in the neighborhood of 50 cc.

It is hardly necessary to state that oxidizing agents other than nitro compounds must not be present in the sample when analyzed. Among the interfering substances most frequently found in crude works materials may be mentioned ferric iron and nitrates.

In highly accurate work, it is essential that the reagents be as free as possible from dissolved oxygen. The water and alcohol (ethyl or a non-pyridine denatured) should be freshly distilled and preferably condensed in an atmosphere of CO_2. For control purposes, however, such precautions are unnecessary. If alcohol is used generally as the solvent, the standardization of the solution should be run with 25 cc. of alcohol instead of water, for unless the alcohol is very pure, a slightly different factor may be obtained. This point, also, need not be considered in plant work.

It will be noted that the details given above vary from those laid down by Knecht and Hibbert principally in the following respects:

1—Sulfuric acid has been substituted for hydrochloric acid because it has been found to contain less reducible impurity. It has also been noted that ferric chloride exerts an appreciable oxidizing action upon the thiocyanate indicator, this tendency being exhibited to a far less degree by ferric sulfate.

2—The period of boiling has been reduced to 5 minutes.

3—The practice of replacing the loss during boiling has been found advantageous, as the end-point varies somewhat with the concentration of the indicator. This variation becomes appreciable if the solution has become highly concentrated during boiling.

4—The ammonium thiocyanate indicator is added toward the end of the back titration, rather than at the beginning, to minimize the oxidation of the NH_4CNS by the ferric sulfate.

COMPOUNDS TESTED, AND RESULTS

The following are the more important nitro compounds specifically studied. In all cases they were analyzed with the 0.25 *N* $TiCl_3$ solution, following the procedure detailed above, unless otherwise specifically stated.

NITRO HYDROCARBONS—Mononitrobenzene, toluene, xylene, and naphthalene have received very little attention so far, as their analysis by this method was not sufficiently important from the works standpoint to warrant investigation. It was established, however, that they are not reduced completely when treated according to the standard procedure. Their analysis after previous sulfonation[1] has not been checked.

MONONITRO COMPOUNDS CONTAINING ADDITIONAL POSITIVE OR NEGATIVE GROUPS—The application of the method to *p*-nitroaniline has been described above, and the results obtained upon the *m*-isomer were equally satisfactory. The sample was purified by repeated crystallizations from water and melted at 112.5° C.

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[1] Knecht and Hibbert, *Loc. cit.*, p. 73.

o- and *p*-Nitrophenols (m. p. 44.8° and 113.2°, respectively), as well as their sodium salts, readily yielded quantitative results. *m*-Nitro-*p*-toluidine (m. p. 115.3° C.) gave very good results, the figures obtained upon the corresponding *o*-derivative (1-methyl-2-nitro-4-aminobenzene, m. p. 77.7° C.) indicating an equal degree of accuracy. Typical results on these compounds are given in Table III. The results obtained with various samples of 3- and 5-nitrosalicylic acids are also given.[1]

TABLE III—PERCENTAGE PURITIES OBTAINED FOR TYPICAL MONONITRO COMPOUNDS

m-Nitroaniline	*o*-Nitrophenol	*p*-Nitrophenol	*m*-Nitro-*p*-toluidine	*o*-Nitro-*p*-toluidine	5-Nitro-salicylic Acid		3-Nitro-salicylic Acid	
					M.P. ° C.	Pur.	M.P. ° C.	Pur.
100.00	100.09	100.07	99.92	100.01	234.5	99.97	145.3	99.72
99.92	100.08	100.00	99.93	100.05	230.8	99.89	145.6	99.87
100.03	100.15	99.95	100.10	100.03	230.5	99.92	144.8	99.02
100.00	100.10	100.15	99.90	100.05	228.6	99.93	145.5	99.73

From the above results, it seems that the introduction of either positive or negative groups into the nitrohydrocarbon molecule renders it susceptible to quantitative reduction, but this conclusion does not apply to the nitrochloro compounds, so far as studied. *o*- and *p*-Nitrochlorobenzene, for example, were reduced to the extent of only 70 to 80 per cent. When the chlorine is present in a side chain, on the other hand, it seems to have but little effect, as illustrated in the case of *p*-nitrobenzyl chloride. The presence of other strongly negative groups in addition to the chlorine, however, invariably resulted in over-reduction, probably at the expense of the chlorine atom. Examples of this over-reduction are to be found in the cases of dinitrochlorobenzene and the dihydrate of *p*-nitrochlorobenzene-*o*-sulfonic acid (1-chloro-2-sulfonic-4-nitro).

TABLE IV—PERCENTAGE REDUCTION OBTAINED FOR VARIOUS NITROCHLORO DERIVATIVES OF BENZENE

o-Nitrochlorobenzene M. P. 32.5°	*p*-Nitrochlorobenzene M. P. 83.0°	*p*-Nitrobenzyl chloride M. P. 72.57°	Dinitrochlorobenzene M. P. 49.8°	Nitrochlorobenzene Sulfonic Acid
77.5	74.0	100.5	102.1	100.5
67.2	81.4	100.3	102.2	100.6
66.8	68.3	100.7	105.3	100.5
....	71.4	100.4	101.5	100.4

DINITRO COMPOUNDS—The study of the dinitro compounds has so far not been very extensive, but the results indicate that the method is generally applicable with at least sufficient accuracy for control analyses.

TABLE V—PERCENTAGE PURITIES OBTAINED FOR VARIOUS DINITROBENZENE DERIVATIVES

m-Dinitrobenzene M. P. 84.4°	1,2,4-Dinitrotoluene M. P. 70.1°	Picramic Acid M. P. 169.9°
100.11	99.93	99.92
100.00	99.99	100.02
100.14	100.05	......
99.99	99.85	......

The method has also been successfully applied to dinitroxylyl dichlorides [$C_6H_2.(CH_2Cl)_2.(NO_2)_2$], thoroughly satisfactory results having been obtained upon the pure 1,3-CH_2Cl-2,4-NO_2 compound, as well as upon the mixtures of isomers resulting from commercial nitrations.

TRINITRO COMPOUNDS—All of the trinitro compounds investigated were found to be easily and quantitatively reducible. The following results upon trinitrotoluene and picric acid indicate the accuracy that may be expected in the analysis of this class of compounds.

TABLE VI—PERCENTAGE PURITIES OBTAINED UPON TRINITROBENZENE DERIVATIVES

Trinitrotoluene M. P. 80.78°	Picric Acid M. P. 122.5°
99.94	100.14
99.90	100.16
99.87	100.17
99.96	100.15

Other trinitro compounds successfully analyzed were trinitroxylene and trinitroaniline. It will be noted that the results given above for picric acid are about 0.15 per cent high. They have been checked by several analysts working independently upon samples purified in different ways, but in all cases results between 0.1 and 0.2 per cent high were obtained. It is interesting to note that the purities found by Knecht and Hibbert[1] are almost identical with the above.

TETRANITRO COMPOUNDS—Tetryl (*sym*-trinitrophenylmethylnitramine) was the only representative of this class considered. Complete reduction could not be obtained by the regular procedure with a 0.05 *N* solution of $TiCl_3$, and the analysis was not considered sufficiently important to warrant investigation. The few results obtained indicated that three of the nitro groups were completely reduced and the fourth partially. It is reasonable to suppose that the nitro group attached to the side chain is the refractory one.

NAPHTHALENE DERIVATIVES—Although very little work has been done upon the nitro naphthalene derivatives, preliminary experiments seem to indicate, as in the benzene series, that the presence of other substituents in general facilitates the reduction. Thus, α-nitronaphthalene is reduced to the extent of only 60 to 70 per cent by the standard procedure, while promising results were obtained upon two of the dinitrodisulfonic acid isomers.

CONCLUSIONS

The results obtained upon the various classes of nitrobenzene derivatives seem to justify the following general conclusions:

1—Mononitro hydrocarbons are exceedingly resistant toward reduction by titanous chloride.

2—The presence of positive or negative substituents, with the exception of chlorine, in the nucleus facilitates the reduction of the nitro groups.

3—It would appear, further, that the orientation of the substituents with respect to the nitro group has no appreciable effect; thus, *m*- and *p*-nitroaniline are reduced with equal ease, as are *o*- and *p*-nitrophenols, *o*- and *m*-nitro-*p*-toluidines, and two of the nitrosalicylic acid isomers. Conversely, *o*- and *p*-nitrochlorobenzenes are about equally refractory.

Since the completion of the work described above, the results of an investigation conducted by Callan, Henderson and Strafford[2] along similar lines have been published.

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[1] These two compounds, as well as the *o*-nitrophenol, were synthesized and analyzed by W. L. Perdue of this laboratory.

[1] *Loc. cit.*, **1918**, p. 27.

[2] *J. Soc. Chem. Ind.*, **39** (1920), 86*t*.

THE ANALYSIS OF MOLYBDENUM, COBALT, AND CHROMIUM ALLOYS

By J. R. Camp and J. W. Marden

Chemical Laboratory, University of Missouri, Columbia, Missouri

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In recent years certain alloys of molybdenum, cobalt, and chromium have assumed commercial importance. Stellite, which makes remarkable cutting tools, has been found by the French government[1] to have twice the cutting power of the hardest carbon steel. In a study of this alloy no difficulty was found in preparing metal somewhat similar to stellite, but trouble was experienced in making the analysis. According to Peele,[2] stellite consists of 10 to 25 per cent chromium, 75 to 90 per cent cobalt, with traces of molybdenum and tungsten. Johnson,[3] however, gives its composition as: cobalt 60.80 per cent, molybdenum 24.10 per cent, chromium 13.20 per cent, with small amounts of iron, manganese, silicon, and phosphorus. Since the alloy is said to be prepared in the carbon arc furnace, a complete analysis should include a determination of carbon.

The alloys to be analyzed were prepared on a small scale by the aluminothermic reduction of the oxides, using for preliminary trials 41.39 g. Co_2O_4, 18.07 g. MoO_2, and 9.7 g. Cr_2O_3, mixed with 22.6 g. aluminium, and about 10 g. calcium fluoride to slow up the reaction. It was afterward shown that these first samples were not very similar in composition to stellite, as claimed by either Peele or Johnson. Attempts were made to analyze this alloy by the method given by Johnson. The following table shows that incomplete separations were made on two different samples, some of the molybdenum separating with the cobalt and some of the cobalt with the molybdenum, making the total percentage considerably over 100.

Element	Sample I	Sample II
Cobalt	87.70	81.84
Molybdenum	29.56	51.40
Chromium	0.82	0.03
Total	118.08	133.27

In view of this difficulty the various methods of precipitation and determination of these metals were tried out. The following table shows some of the results obtained on Sample 1:

Method	Cobalt Per cent	Molybdenum Per cent	Chromium Per cent
Johnson[1]	87.7	29.56	0.82
Scott[2]	...	23.95	..
Smith[3]	81.06	21.69	..

[1] *Loc. cit.*

[2] "Standard Methods of Chemical Analysis." D. Van Nostrand Co., N. Y., **1917**.

[3] "Electro-Analysis," Blakiston & Sons, Philadelphia, **1911**.

Trials of other methods, such as the determination of cobalt by the potassium cobaltinitrate method and the titration of molybdenum with lead acetate using tannic acid as an indicator,[4] were not attended with success.

The best results were obtained by the following method: Place the sample in a 200 cc. Erlenmeyer flask and add a few cc. each of concentrated hydrochloric and nitric acids. (The weight of sample taken depends on the composition of the alloy. Both the peroxide and sulfide separations work best when the quantities of metal are small.) Heat gently or allow to stand over night until the alloy is all dissolved, cool, add 3 cc. concentrated H_2SO_4, and evaporate, until white fumes just begin to appear, to remove the excess of aqua regia. Cool, dilute to 100 cc., and transfer to a small pressure bottle. The solution is of the proper acidity for the preparation of molybdenum. Pass hydrogen sulfide into the solution for 5 to 10 min. to thoroughly saturate, close the bottle and place it in boiling water. After boiling for one hour, allow to cool and let the precipitate settle. Filter, wash with cold water until the washings show no acidity to litmus, and again saturate the filtrate with hydrogen sulfide and boil to insure complete separation of the molybdenum. It is usually advisable to redissolve and reprecipitate the MoS_2 in order to make the separation complete. Ignite the precipitate of MoS_2 at a dull red heat in the muffle for 2 hrs. and weigh as MoO_3.

Boil the filtrate to remove hydrogen sulfide, cool, and add sodium peroxide to precipitate completely the cobalt, as $Co(OH)_3$. Boil, filter, and wash with dilute hydrogen peroxide until the precipitate is free as possible of sodium hydroxide. In most cases it is necessary to redissolve the precipitate in 1:1 hydrochloric acid and peroxide again to insure a complete separation. Ash the black cobaltic hydroxide, and weigh as Co_3O_4.

Acidify the filtrate from the peroxide treatment with sulfuric acid, and boil to free the solution from hydrogen peroxide. Titrate the chromates in the solution with ferrous ammonium sulfate solution, using either electromotive force measurements in the solution or potassium ferricyanide as an outside indicator. Most excellent results may be obtained using the electromotive force titrations, but they take more time than the better-known spot plate method and were used in this work only for standardizations.

In tests upon solutions of known composition the percentages of cobalt, molybdenum, and chromium checked within the limits of experimental error. The following table shows the results of a series of analyses made on samples of metal obtained by the aluminothermic reduction of a mixture of 20 g. each of Co_3O_4, Cr_2O_3, MoO_3, and Al powder.

Sample No.	1	2	3	4	5	Average
Molybdenum	41.40	41.05	41.07	42.27	(41.79)	41.52
Cobalt	50.30	51.63	(50.89)	50.66	51.00	50.89
Chromium	7.63	7.69	7.59	7.16	7.75	7.56
Total						99.97

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[1] *Iron Age*, May 10, 1917.

[2] "Mining Engineers' Handbook," John Wiley & Sons, Inc., N. Y., **1918**.

[3] "Rapid Methods for Chemical Analysis of Special Steels," John Wiley & Sons, Inc., N. Y., **1914**.

[4] *Mining Sci. Press*, **1916**, 113.

A RAPID AND SYSTEMATIC METHOD FOR THE ANALYSIS OF LIGHT ALUMINIUM CASTING ALLOYS

By Russell M. Berry

U. S. Navy Yard, Philadelphia, Pa.

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Since alloys containing 90 or more per cent of aluminium are practically insoluble in nitric acid, the usual procedure for analysis has been to dissolve the alloy in aqua regia, fume out the hydrochloric acid with sulfuric acid, and proceed in much the same way as with other alloys.

Inasmuch as time, as well as accuracy, is a large factor in most laboratories, the above method is objectionable because it is slow and tedious, and unless extreme care is taken considerable error will be introduced by the occlusion of other metals in the aluminium hydroxide. Also, the amount of acid which must be present to keep the aluminium in solution during electrolysis makes it difficult to remove the last traces of copper.

In the following procedure the loss of time due to fuming out the hydrochloric acid and concentration of filtrates is eliminated. The accuracy of the method lies in the fact that a larger sample may be taken for analysis, inasmuch as the main bulk of the aluminium is removed at the start from all the other metals, except the zinc, thereby making it much easier to handle the remaining elements.

METHOD OF PROCEDURE

Dissolve one gram of the alloy in 20 cc. of a 25 per cent sodium hydroxide solution, and dilute to 300 cc. immediately after effervescence ceases. The dilution must be made at once because, although tin is practically insoluble in dilute solutions of fixed alkali at normal temperatures, it does dissolve slowly in concentrated solutions at high temperatures.

Filter through a No. 41 Whatman filter and wash at least 10 times with one per cent sodium hydroxide. The alkali-insoluble portion contains the tin, copper, lead, iron, nickel, and magnesium, part of the manganese, and traces of aluminium. The filtrate will contain about 99 per cent of the aluminium and zinc, and the remainder of the manganese.

ANALYSIS OF THE FILTRATE

To the filtrate, add formic acid (sp. gr. 1.2) until the solution is just acid to litmus paper, then add 25 cc. of formic acid in excess. (The solution will be cloudy, but will clear on boiling.) Heat to boiling and pass a rapid stream of H_2S into the liquid for 30 min. If zinc is present the white sulfide will be observed adhering closely to the end of the delivery tube and to the beaker, at the surface of the liquid. Filter on a 15 cm. No. 42 Whatman filter paper, and wash with hot water. Return paper and precipitate to the original beaker and digest on a steam bath with 20 cc. of 1 : 1 HCl for 30 min. Filter, and wash with hot water. Boil the filtrate and washings until all hydrogen sulfide is removed, and titrate with potassium ferrocyanide according to the method given by Heath.[1]

ALKALI-INSOLUBLE PORTION

TIN—Transfer the filter paper containing the original alkali-insoluble portion to a 250 cc. beaker and add 10 cc. of concentrated nitric acid. Cover with a watch glass, and digest on a hot plate until everything soluble goes into solution, and the tin is converted into metastannic acid. Dilute with 20 cc. hot water and digest 10 min. longer. Filter through a double filter of No. 44 Whatman filters. Wash 5 or 6 times with hot water. Extract the paper with the tin precipitate in a small beaker or flask by heating gently with 20 cc. of yellow ammonium sulfide and 2 g. of ammonium chloride, filter, and wash thoroughly with dilute yellow ammonium sulfide. This dissolves the tin, while silica and any black sulfides of copper, lead, or iron are filtered off. The polysulfide solution, after filtering, is made acid with 50 per cent acetic acid, heated to boiling, again filtered, and the precipitate of tin sulfide is washed with ammonium acetate solution saturated with hydrogen sulfide. The tin sulfide is ignited directly with the moist paper to SnO_2, care being taken to ignite to constant weight. This ignition must proceed slowly and carefully until the sulfur is roasted off. If the sulfur is allowed to burn, some tin sulfate may be formed. If the SnO_2 weighs more than 20 mg., the blast lamp should be used.

$$\frac{\text{Wt. of SnO}_2 \times 78.77}{\text{Wt. of sample}} = \text{Per cent Sn}$$

COPPER AND LEAD—The first filtrate from the tin is caught in a 200 cc. electrolytic beaker, diluted to 150 cc. with distilled water, and electrolyzed for copper and lead with a current of one ampere and 2.5 volts. After one-half to three-quarters of an hour, the sides of the beaker and cover glasses are washed down with enough distilled water to raise the surface of the solution about 0.25 inch. If after 10 min. no black deposit collects on the newly exposed portions of the anode, all lead has been removed from the solution. Two cc. of 1 : 1 sulfuric acid are now added to bring the electrolyte back to its original acid concentration and to allow the last trace of copper to plate out. When all the copper has apparently been removed, dilute with the same amount of water as before and continue the current. If at the end of 10 min. no deposit shows on the newly exposed part of the cathode, all copper has been removed. Cathode and anode are at once removed from the electrolyte, washed twice with distilled water, and once with alcohol. The cathode is dried in an oven at 80° C. for 15 min., and the anode in a separate oven at 210° C. for 0.5 hr. The increase in weight of the cathode is the copper in the sample, while the increase in weight of the anode is PbO_2.

$$\frac{\text{Wt. of Cu} \times 100}{\text{Wt. of sample}} = \text{Per cent Cu}$$

$$\frac{\text{Wt. of PbO}_2 \times 86.62}{\text{Wt. of sample}} = \text{Per cent Pb}$$

IRON—To the electrolyte from the copper and lead determination, add 2 or 3 g. of ammonium chloride, and make barely ammoniacal with ammonia. Boil off any excess ammonia, allow to settle, and filter off the iron and traces of aluminium.[1] Wash well with distilled water, redissolve the iron and aluminium hydroxides in dilute hydrochloric acid, and titrate the iron with potassium permanganate, after reduction with stannous chloride. (Zimmerman-Reinhardt Method.)

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[1] "Analysis of Copper," 1st Ed., **1916**, p. 249; or Price and Meade, 2nd Ed., **1917**, p. 165.

[1] It is the experience of the writer that whatever manganese is precipitated with the Sn, Cu, Pb, Fe, Ni, and Mg in dissolving the alloy is so small that the ammonium chloride just added prevents more than traces of it for precipitating with the hydroxides of iron and aluminium, and therefore does not affect the titration of the iron.

NICKEL—The filtrate from the iron and aluminium hydroxides is neutralized and made just acid to litmus with hydrochloric acid.[1] Heat nearly to boiling and add dimethylglyoxime, make just ammoniacal, and place on a low heat hot plate for an hour. Filter through a weighed Gooch crucible, wash well with hot water and finally with alcohol. Dry in an oven at 110°, and weigh.

$$\frac{\text{Ni ppt.} \times 20.31}{\text{Wt. of sample}} = \text{Per cent Ni}$$

MAGNESIUM—Make the filtrate from the nickel precipitation strongly ammoniacal and heat to boiling, and precipitate the magnesium with ammonium phosphate. Cool in a sink of cold water for 4 or 5 hrs. and filter off the ammonium magnesium phosphate through a Gooch crucible, previously *ignited* to constant weight. Wash well with 2 per cent ammonia solution and ignite to constant weight in a high-temperature muffle furnace, or with full heat of the blast lamp. Weigh as $Mg_2P_2O_7$.

$$\frac{Mg_2P_2O_7 \times 21.839}{\text{Wt. of sample}} = \text{Per cent Mg}$$

MANGANESE—Treat one gram of the alloy with 25 per cent sodium hydroxide solution, add sufficient concentrated nitric acid to dissolve the alkali-insoluble matter, followed by 30 per cent excess acid. Add a few crystals of silver nitrate, boil, and oxidize with ammonium persulfate. Cool and titrate rapidly with standard arsenite solution, as described by Johnson.[1]

SILICON—Dissolve one gram of alloy in 10 cc. of a mixture of nitric and sulfuric acids and water (450 cc. HNO_3: 250 cc. H_2SO_4: 1000 cc. H_2O) with a few drops of concentrated hydrochloric acid added. Evaporate to complete dryness. Take up with 50 cc. concentrated hydrochloric acid and hot water. Heat to boiling, filter, ignite, and weigh. Treat the ash with hydrofluoric acid, and determine the loss in weight.

$$\frac{\text{Loss in wt.} \times 46.93}{\text{Wt. of sample}} = \text{Per cent Si}$$

CONCLUSION

By the above method it is possible to make a complete analysis of a sample of aluminium alloy in the time usually spent in fuming out hydrochloric acid and concentrating filtrates. Moreover, more accurate results are easily obtained.

The following percentages were obtained by the writer upon three samples of alloy analyzed by the new method:

	Sample A		Sample B		Sample C	
Mn	0.01	0.01	...	...	0.02	0.02
Si	0.33	0.33	0.47	0.46	0.02	0.01
Zn	...	...	...	...	0.55	0.55
Sn	1.55	1.62	0.20	0.26	...	...
Cu	7.71	7.70	7.65	7.60	2.43	2.43
Pb	0.05	0.05	0.05	0.05	...	...
Fe	0.12	0.13	0.30	0.32	0.21	0.26
Ni	0.28	0.21	0.27	0.23	1.19	1.19
Mg	0.10	0.12	0.20	0.19	1.04	1.04
Al	89.85	89.83	90.86	90.89	94.55	94.50

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[1] If the nickel is precipitated in a *very slightly acid* solution, which is then made just ammoniacal, it comes down in a more crystalline form, which is easier to filter and wash.

[1] "Chemical Analysis of Special Steels, Steel-Making Alloys and Graphites," 2nd Ed., **1914**, p. 283.

LABORATORY AND PLANT

SODA LIME AS AN ABSORBENT FOR INDUSTRIAL PURPOSES[1,2]

By Robert E. Wilson

Research Laboratory of Applied Chemistry, Massachusetts Institute of Technology, Cambridge, Mass

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Although soda lime has long been a familiar reagent in the laboratory, and has frequently been used for absorbing various acid gases on a fairly large scale, the literature contains practically nothing concerning the best methods for its preparation. A few of the older reference books state that it is made by "stirring lime into molten caustic to cook, and breaking up the resultant cake." This seems to be essentially the standard commercial process of to-day. As will be indicated later by comparative tests, soda lime made by any such process has many undesirable physical properties, and its efficiency in gas absorption is extremely low.

As has been previously pointed out by the writer and others,[3] soda lime was one of the main constituents of the absorbent mixture used in all American gas-mask canisters for the absorption of toxic gases. On account of its importance from a defensive standpoint, an extremely careful study was made of every factor which might possibly have a bearing on the stability or absorptive efficiency of the product under any conceivable service conditions. Experiments were carried out both on a small and a large scale until the effect of practically every variable in the raw materials or the method of preparation was thoroughly appreciated.

REQUIREMENTS FOR MILITARY SODA LIME

The soda lime which was devised for military purposes had to meet four rather exceptional requirements which placed severe limitations on its composition and resulting absorptive activity. In the first place, it had to possess a high degree of hardness or resistance to abrasion, on account of the extremely severe handling to which the canisters were subjected during transportation over rough roads in motor trucks, and during actual service in the trenches. In order to secure this degree of hardness it was necessary to use a considerable amount of binding agent in the soda lime, which greatly reduced its absorptive activity.

A second requirement was that it must not be sufficiently hygroscopic to form any free solution or tend to cake together even after prolonged use in very moist air. This requirement completely eliminated the ordinary types of soda lime containing from 20 to 40 per cent sodium hydroxide.

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[1] Published by permission of Brig. Gen. Amos A. Fries, Chief, C. W. S., U. S. Army.

[2] Presented at the 60th Meeting of the American Chemical Society, Chicago, Ill., September 6 to 10, 1920.

[3] This Journal, **11** (1919), 420.

It also seemed desirable to have in the soda lime some active oxidizing agent which would remain stable over long periods of time when not exposed to gas. Pure sodium permanganate in the presence of a *small* amount of alkali proved best for this purpose. This imposed very definite limitations on the alkali content of the soda lime.

In the fourth place, absorptive *capacity* was relatively more important for military purposes than absorptive *activity* (the rate of taking up the gases), because in general the concentrations of gas in the field were very low, but persistent over long periods of time, and the difficulty and cost of supplying new canisters were great.

REQUIREMENTS FOR INDUSTRIAL SODA LIMES

For industrial purposes the conditions which must be met are greatly different. In the first place, the concentrations to be encountered are higher, which places a premium on absorptive activity, while the ease of replacing the canisters is much greater, so that absorptive capacity could be sacrificed if necessary. Second, in industrial uses the canister will in general receive very little rough handling, certainly not a tenth as severe as that to which the military canister was subjected. Finally, there is in general no need of providing an oxidizing agent to handle a few special gases which would probably never be encountered in industrial work.

In order to devise a soda lime which would be really well adapted for industrial purposes, it was necessary to re-survey the whole field, striking a new balance between the various desirable properties and aiming in this case to get the maximum absorptive activity, coupled with a reasonable, but not high, degree of hardness or resistance to abrasion.

Shortly before the signing of the armistice the Research Division, Chemical Warfare Service, undertook an intensive study of absorbents for industrial purposes. This was not entirely completed before the cessation of experimental work at the American University, but has now been completed in this laboratory.

EXPERIMENTAL METHODS

Although the objects of this work were somewhat different from that previously undertaken, the experimental methods which had already been worked out were of great advantage in getting rapid and accurate results. The general steps in the process of manufacture had so clearly demonstrated their worth for a wide variety of formulas that it was decided to adopt them, at least as a preliminary basis for the experimental work. The steps in the manufacture (see previous article for details) consisted essentially in mixing the dry ingredients thoroughly with a solution of caustic soda, adding just enough water to make possible thorough and uniform mixing without any tendency toward fluidity. The maintenance of this stiff consistency was found to be very important in getting satisfactory hardness in the finished granules. The plastic mass was then spread by hand on wire-bottomed trays into slabs, which were allowed to set for about 3 days in a room of approximately normal temperature and humidity, during which time the soda lime lost about 10 per cent of its moisture. It was then dried under carefully controlled conditions for about 12 hrs., ground, and screened to the desired mesh (usually 8 to 14). Each of the foregoing details was found of definite importance in securing a maximum degree of hardness, coupled with the degree of porosity necessary to give high absorptive activity.

Of the greatest assistance in carrying out this investigation was the presence of a trained corps of men who were thoroughly experienced and appreciated the importance of controlling every detail in the process of manufacture, if dependable and reproducible results were to be secured. Another important factor was the routine testing methods which had been very carefully worked out and standardized to show the efficiency of absorbents against a wide variety of gases.

As a result of this previous experience it was possible in the experiments hereinafter described to obtain a remarkable concordance between check results. In fact, most of the results were reproducible within 5 per cent, as compared with variations of 50 to 100 per cent which very frequently occurred during the earlier work. Those who have had experience in preparing synthetic granular materials of high porosity for catalytic or absorbent purposes will bear witness to the fact that concordant and reproducible results are extremely difficult to obtain except under the very best conditions.

At the outset it seemed desirable to study mixtures containing only alkali and lime, omitting the kieselguhr and cement which were used in the army formula to give hardness, and the sodium permanganate which was used as an oxidizing agent. Such simple mixtures had, of course, been previously tested out in a preliminary way, but found unsatisfactory for military purposes on account of their lack of hardness, although their great absorptive activity was recognized.

SELECTION OF LIME—The first experiments were designed to determine the best brand of lime. A dozen lots of hydrated lime from different sources were made up into a standard preliminary formula containing 4 per cent sodium hydroxide and 96 per cent calcium hydroxide. These samples showed a wide variation in absorptive efficiency, the average service time against gases being about 60 per cent of the maximum, while the minimum fell as low as 20 per cent of the maximum. The hardness of the granules was also quite variable.

While the results were reproducible and conclusive as far as the selection of the best brand was concerned, it was not found possible to coördinate them with the chemical analyses of the various samples of lime. Certain general conclusions, however, may be stated as follows:

(1) Hardness was in general inversely proportional to absorptive efficiency. This was apparently caused by the formation of sodium silicate during the drying, due to a reaction between the alkali and the silica present in the lime. The harder samples invariably gave a precipitate of silicic acid when dissolved in acid. This sodium silicate served as a binding agent, but also tended to clog up the pores of the absorbent.

(2) The tendency to form sodium silicate was not directly proportional to the amount of silica present in the lime. There is apparently a great difference in the reactivity of the silica present in different samples of lime, which may be due either to fineness of subdivision or possibly to its existence as calcium or magnesium silicate in some cases, and as free silica in others.

(3) Limes containing over 5 per cent of magnesium oxide did not give as good results as the high calcium limes. Even fairly high dolomitic limes, however, gave absorptive efficiencies as high as 70 per cent of the maximum.

(4) A low content of CO_2 and Fe_2O_3 seemed to be desirable.

(5) Extra fine, air-separated lime gave granules which were harder, but not as absorptive, as those made with lime of normal fineness (about 90 per cent through 200 mesh).

(6) Completeness of hydration seemed to be important to insure stability and hardness of the resulting granules. The evidence on this point is, however, rather indirect, as the analytical results for combined water were found to be variable and unsatisfactory, as might be expected, and the Bureau of Standards "soundness test," designed to show completeness of hydration, did not parallel the results obtained on soda lime. The evidence as to the effect of completeness of hydration is that certain samples, which showed a distinct tendency to crumble on standing in moist air for several days after manufacture, lost this tendency when the original lime was rotated in a ball mill with water for several days.

On the basis of the foregoing tests, two brands of lime stood out as giving very good absorptive activity and apparently adequate hardness. As the results obtained with the two samples were not greatly different, one brand was arbitrarily selected for most of the tests, while a few comparative batches were later made with the other brand.

AMOUNT OF ALKALI AND WATER—Having determined the best brands of lime, and the method of manufacture which appeared to give maximum hardness, there remained the two fundamental variables—the NaOH and H_2O contents of the soda lime—which were the main objects of this study.

Several different types of gas were selected as tests of the value of the soda lime for general industrial purposes. Phosgene ($COCl_2$) was selected as a gas which must be hydrolyzed to be absorbed, and which then acts as a strong acid gas. The test was run at a fairly high concentration (one per cent by volume), and had been found a severe test of the *activity* of the absorbent. Superpalite ($CCl_3.COOCl$), which behaves similarly to phosgene, was run at a much lower concentration to test absorptive capacity rather than activity. Sulfur dioxide was used as an example of an acid gas of medium strength, and carbon dioxide as a very weak acid gas, but one whose quantitative absorption is extremely important in many analytical processes. Chlorine was selected as a gas of still different type of considerable industrial importance. An absorbent which would give good results against these five gases could certainly be relied upon for general industrial purposes, especially if mixed with charcoal.

In studying two independent variables, it is customary to hold one constant while the other is varied. This is difficult in the case of soda lime, however, because it is very hard to approximate the desired final water content after drying down, grinding, and screening small samples; yet in many cases the water content is more important than the alkali content. Furthermore, if a systematic attempt is made to cover the whole field in this way, the number of experiments required is very large.

A somewhat more convenient method of obtaining the same result, and one which could well be used more frequently where one of two variables is hard to control but easy to determine, is to vary both factors simultaneously as they happen to occur, and to represent the results, theoretically in three dimensions, but practically by locating the points on a plane surface (in this case with the NaOH and H_2O contents as coordinates), designating the efficiency (service time) by numerical figures corresponding to each point, and drawing in contour lines to represent horizontal sections of equal efficiency in the hypothetical three dimensional diagram. These contours serve to show very clearly the optimum combination of the two variables to give the maximum service time against each gas, and by passing sections through, parallel to either axis, it is easy to determine the effect of either variable when the other is held constant. When the results of the first series of ten or twelve experiments are plotted in this way it is a simple matter to determine the especially interesting or doubtful portions of the field, and to fill in the vacancies by a very few more experiments.

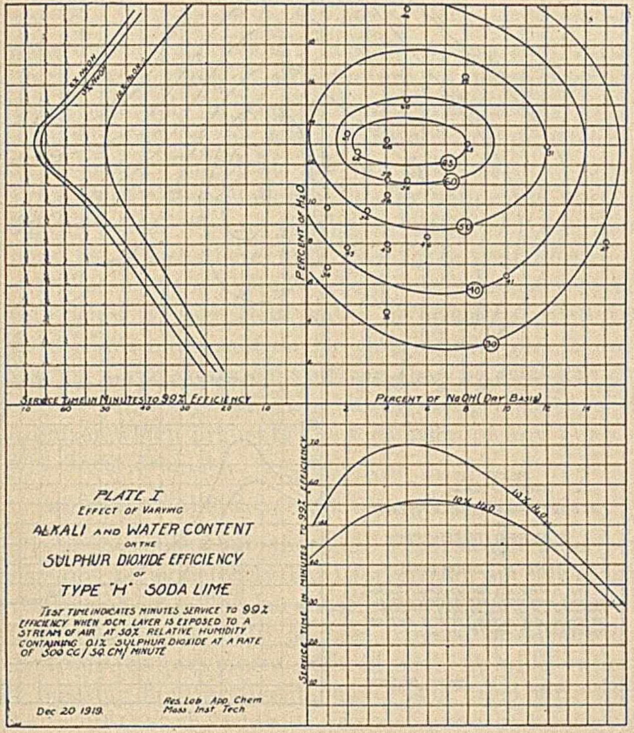
The tabulated results of the principal series of experiments are shown in Table 1. They do not include the results against CO_2, which were determined previously upon another series of similar composition, but mostly with higher water content. The latter work was carried out with a specific purpose in view, which accounts for the fact that the test conditions are considerably different from those used for the other four gases.

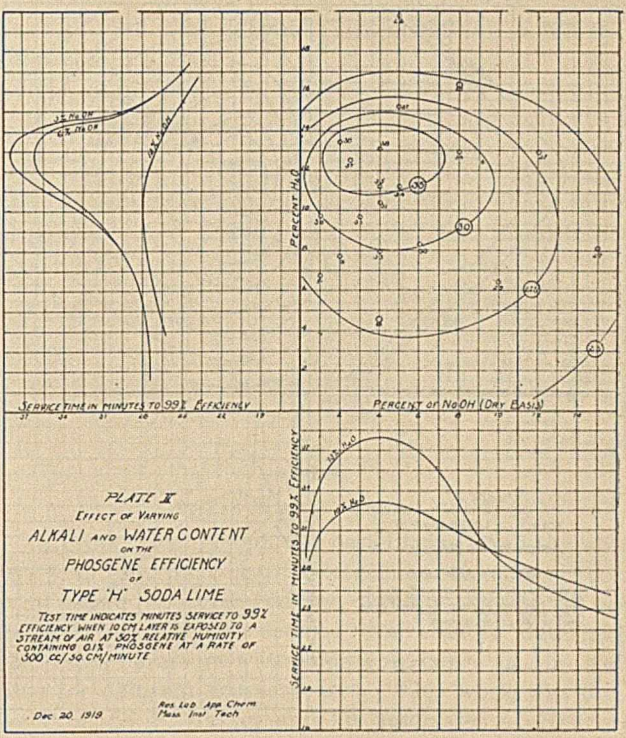
TABLE 1—DATA ON "H" SERIES SODA LIME

				Service Time to 99 Per cent			
NUMBER	NaOH Per cent	H_2O Per cent	Hardness	Cl_2	Superpalite	Phosgene	SO_2
H204......	1	6.78	58.2	32	215	31	34
H205......	2	7.76	69.4	40	213	31	43
H206......	3	9.64	63.0	44	224	31	52
H207......	4	10.42	80.0	65	237	31	58
H208......	5	15.20	87.8	62	185	27	60
H209......	6	8.34	96.0	57	189	30	46
H210......	8	12.98	82.0	25(?)	145	34	65
H211......	10	6.43	78.0	72	180	29	41
H212......	12	12.94	82.0	83	124	27	51
H213......	15	8.10	76.2	100	172	27	27
H214......	5	11.22	84.4	60	200	34	56
H215......	1	9.87	37.4	36	207	30	44
H216......	2	13.44	57.4	29	207	38	61
H217......	4	13.18	..	45	207	38	68
H218......	4	4.56	86.1	37	202	28	33
H220......	4	7.97	37.6	51	228	33	43
H221......	4	11.22	41.2(?)	..	242	35	59
H222......	8	16.34	84.3	55	122	25	55
H243......	5	19.80	90.6	27	134	22	46
H244......	2.5	12.60	81.8	31	212	37	66

DISCUSSION OF RESULTS—In order to appreciate the significance of the results, reference should be made to the five plates on which the service times for each point are indicated numerically, and contour lines of equal service time are drawn.

Sulfur Dioxide—Plate I, showing the SO_2 efficiency for the different samples, illustrates very clearly the method of constructing the plots. Here a very marked maximum service time occurs at about 5 per cent alkali and 13 per cent water, any considerable variation from this point giving poorer results.





Inspection shows that the results are all remarkably consistent and that the contour lines as drawn represent very closely the service times which can be expected for any combination of the two fundamental variables. It is true that the exact location of the curves in the upper part of the figure is not especially definite, but the curves are drawn in on the assumption that they are reasonably smooth and continuous between known points. They are certainly well established in the immediate vicinity of the maximum, which is the important part of the field.

The contours of equal service time are obviously elliptical in shape near the maximum, with the long axis on the 13 per cent H_2O line. This indicates that in this vicinity the water content is a more important variable than the alkali content.

By passing sections through the contours parallel to the two axes it is possible to determine fairly accurately the effect of varying the NaOH content with the H_2O content constant, or *vice versa*. The curves thus obtained are shown in the two sections of the figure adjoining the contour curves. It will be noted, for example, that 13 per cent H_2O gives the maximum service time regardless of the amount of NaOH present.

Phosgene—Plate II, for phosgene, gives very similar results, with a maximum at practically the same point. In this case, however, the maximum is by no means so sharply defined—for example, decreasing the water content to 4 per cent cuts the SO_2 service time to 50 per cent of the maximum value, while the $COCl_2$ service time at this point is still 73 per cent of the maximum.

Carbon Dioxide—Plate III, which presents the results on the very weakly acid gas CO_2, shows a very pronounced maximum—in this case at about 4.5 per cent alkali and 18 per cent H_2O. The high water content required to give the best results is at variance with the results on all other gases, but seems to be well established. Here again the results for water contents above 18 per cent are very uncertain, and there is really little justification for prolonging the contours in this region. This part of the field has little interest, however, since it is impractical to work with such high water contents, and the maximum is unquestionably approximately as indicated.

Superpalite—The results shown in Plate IV for superpalite appear at first sight to be quite at variance with the results on Plate II for the very similar gas, phosgene. The variation is due, however, to the difference in the conditions of test—the superpalite test being run at a much lower concentration, and lasting for a longer time. As a result, the initial water content is of much less importance in the neighborhood of the maximum, since this adjusts itself by taking up or giving off moisture to the 50 per cent humid air which is passing through the tube during the test. If the results were plotted against *final*, rather than *initial*, water contents, the curves would probably be very similar for the two gases. For the higher NaOH soda limes, however, a sample which would start with about 12 per cent water would pick up possibly 6 per cent more before the end of the test, while very dry samples—containing, say, 4 or 5 per cent water—would approach the optimum water content at about the end of the test. Samples containing much alkali, therefore, would be expected to give the best results when they had very little water to start with, as is actually indicated by the contours.

Chlorine—Plate V shows the very different type of contours which are obtained with chlorine, which appears to be absorbed in a somewhat exceptional manner. Here the water content is relatively unimportant, while

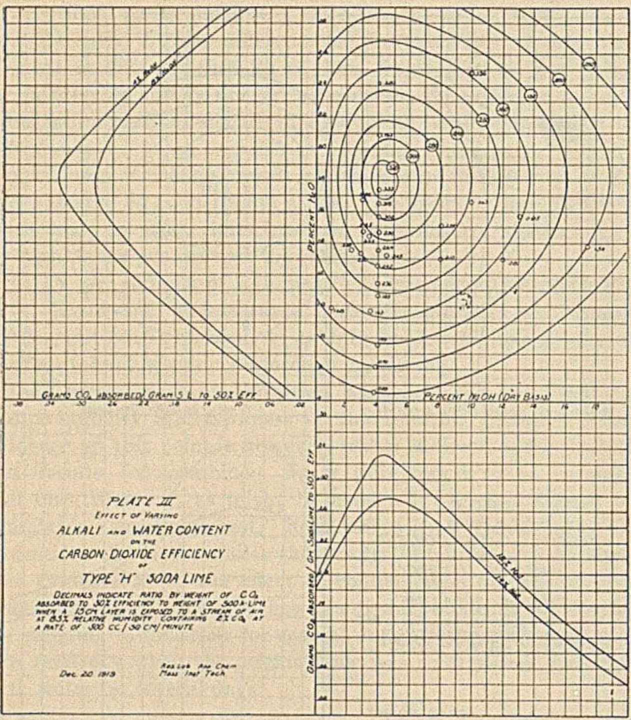


PLATE III
Effect of Varying
ALKALI and WATER CONTENT
on the
CARBON DIOXIDE EFFICIENCY
of
TYPE "H" SODA LIME

Decimals indicate ratio by weight of CO_2 absorbed to 50% efficiency to weight of soda lime when a 15 cm layer is exposed to a stream of air at 85% relative humidity containing 2% CO_2 at a rate of 500 cc/50 cm/minute

Dec. 20, 1919 Res. Lab. App. Chem. Mass. Inst. Tech.

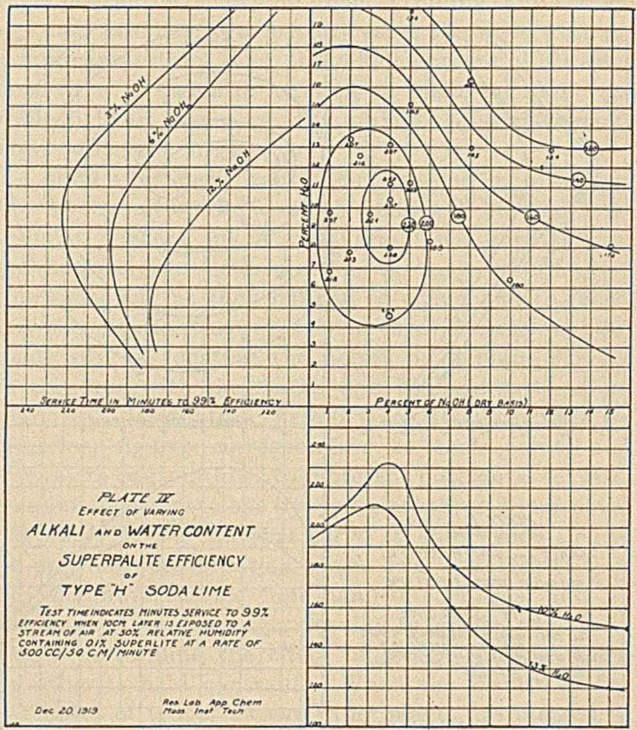


PLATE IV
Effect of Varying
ALKALI and WATER CONTENT
on the
SUPERPALITE EFFICIENCY
of
TYPE "H" SODA LIME

Test time indicates minutes service to 99% efficiency when 10 cm layer is exposed to a stream of air at 50% relative humidity containing 0.1% superpalite at a rate of 500 cc/50 cm/minute

Dec. 20, 1919 Res. Lab. App. Chem. Mass. Inst. Tech.

a high alkali content seems to be essential for good results. Very possibly the calcium hypochlorite formed is markedly less stable than the sodium salt at the comparatively high temperature produced in this high concentration test. Since samples containing over 10 per cent alkali tend to be markedly deliquescent in service, no attempt was made to reach the maximum service time, which appears to be above 16 per cent alkali content. The indications are that water contents in the neighborhood of 10 per cent give the best results, but this is not very definitely established by the results obtained thus far.

HARDNESS—The most important remaining variable is the hardness of the various granules. These were determined by a special type of test which consisted essentially in placing 50 g. of the 8 to 14 mesh soda lime, together with 30 three-eighths inch steel ball bearings, in the pan of a Rotap shaking machine, and running for 30 min. This rather severe test abraded the softer granules to a considerable extent. The percentage hardness represents the per cent of the material remaining on a 20 mesh screen at the end of the test. By carefully standardizing the shape of the pan bottoms and the method of screening before and after the test, it was possible to secure very reproducible and significant results.[1]

When the preliminary plot of the hardness data was made for the foregoing series of soda limes, it was found that the water content was of practically no importance. The hardness values (Plate VI) are, therefore, plotted directly against the alkali content, disregarding the water content. (The hardness values for very high water contents above 16 per cent are probably higher than they should be, on account of the tendency of the fine material produced in the test to ball together and remain on the 20 mesh screen, instead of going through as they should.) The results indicate fairly clearly that up to 5 per cent alkali content the hardness is greatly increased by the alkali. Beyond 6 per cent there seems to be a slight but fairly definite decrease.

SELECTION OF OPTIMUM COMPOSITION FOR VARIOUS PURPOSES

Having thus presented in detail the effect of the alkali and water content on the various important properties of soda lime, there remains but to select the best combination of the two variables for different industrial purposes.[2] For soda lime to be used in gas-mask canisters for general toxic gas absorption, an alkali content of 5 per cent (dry basis) and a water content of 10 to 13 per cent appear to be the most desirable. Where soda lime is to be used almost solely for CO_2 absorption, as in steel analyses and oxygen-helmet apparatus for mine rescue work, etc., an alkali content of 4.5 per cent and a water content of 16 to 19 per cent appear to be the best. If chlorine only is to be dealt with, an alkali content as high as 8 or 9 per cent might well be used; higher alkali contents would give still better results in case of short service times in very high concentrations, but in ordinary service an 8 per cent alkali soda lime will give as good results against chlorine alone as one containing 12 or 15 per cent alkali, and the latter would be almost certain to give trouble from caking.

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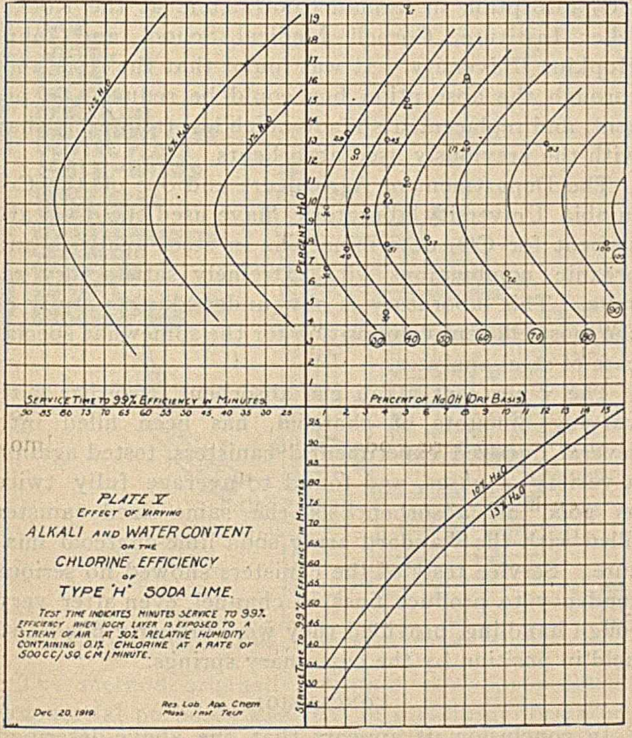
[1] By changing the length of time of the test and the number and size of the ball bearings it is possible to use this general method of testing hardness, and to secure a satisfactory degree of severity for practically any granular material. For example, the test was made much more severe for the regular army soda lime by using larger ball bearings (15.5 in. and 15³/₈ in.). It is believed that this method of testing should prove valuable for many different types of closely sized granular materials where hardness or resistance to abrasion is an important factor.

[2] The methods of manufacture and general formulas found best are covered by U. S. Patent 1,333,524.

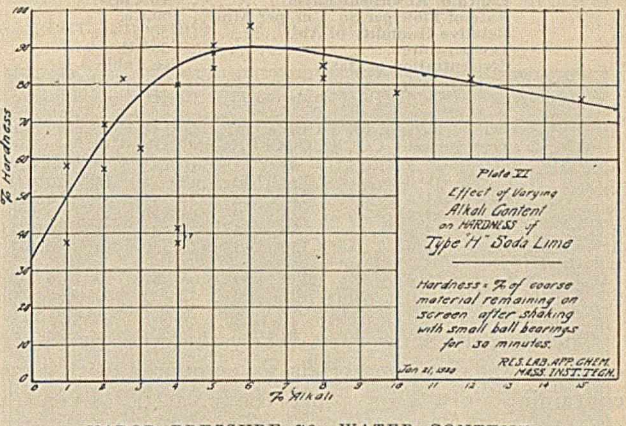
It must be again emphasized that the results presented in this report apply only to the specific method of manufacture previously described, and that within limits the method of manufacture is more important than variations in the formula. This seems to be especially true in the case of CO_2 absorption, where it is, of course, important to prevent exposure to air containing CO_2. Vacuum drying appeared to be slightly better than air drying for CO_2 absorption, but for other gases there appeared to be no difference. In the case of the CO_2 absorbent it is necessary to dry well below 16 per cent water in order to grind the material without continually clogging the grinder and screens. The water content can then be raised to the proper point by spraying, using a special type of atomizer which prevents the formation of any but the very finest droplets.

MODIFICATIONS TO SECURE GREATER HARDNESS

It is possible that the soda lime above described may not be sufficiently hard for certain special industrial purposes. The hardness can easily be increased, however, though only at the expense of absorptive efficiency, as previously pointed out. A wide variety of possible binding agents have been tried out, with the result that the addition of 1 or 2 per cent kieselguhr was found to give the greatest increase of hardness for a given decrease in absorptive efficiency. The binding action is probably due to the formation of sodium silicate during drying, but when a similar increase in hardness was obtained by adding sodium silicate direct, or by adding a brand of lime containing reactive silica, the decrease in absorptive efficiency was much greater—apparently due to clogging the pores of the granules, which in the case of kieselguhr is largely offset by the increased porosity which it gives.



Incomplete results indicate that if 2 per cent kieselguhr is used the optimum alkali content is about 3 instead of 5 per cent.



VAPOR PRESSURE *vs.* WATER CONTENT

In order to work out the best drying conditions for the soda lime, and also to determine what water content would be produced by exposure to air of any definite humidity, it seemed desirable to determine the vapor pressure-water content curve of the soda lime for different temperatures. This work was done by Prof. G. P. Baxter and his associates at Harvard University, with the results shown in Plate VII. While the *absolute* vapor pressure changes quite rapidly with temperature, the *relative* vapor pressure (per cent of that of pure water at the same temperature) increases but very slowly.

It will be noted that although the army soda lime contains only 1 per cent alkali, it holds its water more tenaciously than the 4 per cent alkali industrial soda lime. This is undoubtedly due to the presence of the sodium permanganate and kieselguhr in the former. The army soda lime composition was carefully controlled so as to maintain its optimum water content (11 to 12 per cent) under the average prevailing humidity in France (70 per cent). It would appear from this that the 4 per cent alkali industrial soda lime is not sufficiently hygroscopic to maintain its optimum water content under ordinary weather conditions in this country, but a few tests on the 5 per cent alkali material recommended herein indicate that it approximates the army curve very closely.

COMPARISON WITH ORDINARY COMMERCIAL MATERIALS

In view of the great advantage of low alkali contents from practically every standpoint, it is surprising to find that of the five principal (if not the only) brands of soda lime on the market up to June 1918, four had an alkali content in the neighborhood of 40 per cent, and the other contained about 20 per cent. All appeared to be made by essentially the old type fusion process previously mentioned. These commercial brands were carefully tested on all the standard gases, together with samples from large-scale batches of soda lime made at the Gas Defense chemical plant in accordance with the three formulas described in this article. The results are summarized in Table 2, the commercial samples being designated A, B, C, D, and E. All were screened to the same mesh before testing.

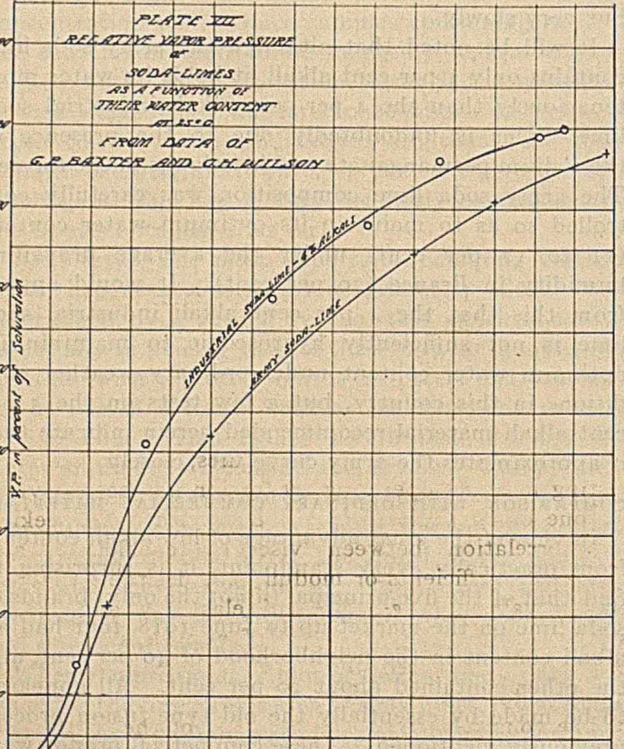
TABLE 2—COMPARISON OF COMMERCIAL SODA LIME WITH ARMY AND INDUSTRIAL SODA LIMES

Conditions of Tests (except CO_2—see Plate III)

Mesh of Soda Lime	8–14
Depth of Absorbent Layer	10 Cm.
Rate of Flow per Sq. Cm. per Min.	500 Cc.
Relative Humidity of Air	50%
Temperature	20° C.
Concentration of Gas	See Table

Sample	H_2O Per cent	NaOH Dry Basis Per cent	—Minutes to 99% Efficiency— 1% $COCl_2$	0.1% CCl_3-COOCl	0.1% CNCl	1% SO_2	0.1% Cl_2	2% CO_2	To 50% Efficiency Grams CO_2 per Grams Soda Lime
A	14.8	41.5	15	98	5	19	41	17	0.029
B	1.2	21.0	4	24	0	15	14	14	0.024
C	14.4	43.4	17	86	8	23	44	34	0.063
D	2.1	40.8	6	35	0	13	18	12	0.020
E	11.7	39.9	13	70	5	20	35	26	0.041
Army S. L.	11.5	1.0	25	130	3	24	30	15	0.033
Industrial S. L.	12.0	5.0	36	230	30	65	62	70	0.240
CO_2 S. L.	17.6	4.0	26	165	20	52	43	110	0.320

These results show very clearly the great inferiority of the high alkali materials as compared with those containing only 4 or 5 per cent NaOH. Even the very hard, low-alkali army soda lime is better against most gases than the commercial brands. The industrial soda lime shows its greatest degree of superiority against weakly acid gases, such as CO_2, and against high concentrations, where great activity is the prime requisite. The high-alkali soda limes show up relatively most favorably against chlorine, as would be expected, though even here the low-alkali product is fully 50 per cent better. In the case of CO_2, the CO_2 soda lime is four times as good as the best commercial product which was specifically recommended for that purpose.



The quantitative results against gases are, however, by no means the most favorable basis of comparison for the low-alkali soda limes. A canister filled with 8 to 14 mesh high-alkali (41 per cent) soda lime was found to deliquesce and clog so badly during one-half hour's service on a moist day that it was impossible to continue to breathe through it. A strong solution of caustic soda is produced almost as soon as the absorbent comes into contact with moist air, and this attacks the cotton pads, clogs the wire screens, runs out through the valve, and in general renders such materials hopeless for use in gas-mask canisters. If larger granules are used, as is customary for such materials, the clogging does not take place so rapidly, but the gas absorption is much less efficient.

RESULTS OF PRACTICAL TESTS

The CO_2 soda lime described above was designed primarily for the absorption of CO_2 on submarines, and gave excellent results in service during the latter part of the war; in fact, the much greater efficiency of the new material made possible submergence periods four times as long as had previously been possible.

Several canisters were made up for the absorption of CO_2 in self-contained oxygen breathing apparatus. Volume for volume the new material lasted 3.8 times as long as the best now in service, and had the further advantage of delivering a much cooler gas to the wearer—the high-alkali soda limes heating the air, due to the absorption of moisture. The only disadvantage was the high humidity of the effluent air, but it was found possible to reduce this without great loss in efficiency by using 7 per cent alkali and 14 per cent H_2O—a high water content not being necessary in this case, because of the high humidity of the air coming to the absorbent.

The material has been used with great success for CO_2 absorption in human calorimeters at the Rockefeller Institute, Cornell Medical School, and Johns Hopkins University. It was found that the resistance through the absorption box could be reduced 60 per cent, and replacements made much less frequently than with the previously used absorbents.

The Department of Agriculture and one of the Columbia University laboratories have used the CO_2 absorbent for CO_2 determinations in steel analyses and organic combustions with extremely satisfactory results. This laboratory is now undertaking a study of the most efficient composition for the somewhat special case of steel analyses.

The 5 per cent alkali gas absorbent, together with varying amounts of charcoal, has been filled into several hundred experimental canisters, tested against a variety of gases, and found to average fully twice as good an absorbent as the same sized canister filled with the standard army soda lime-charcoal mixture. Service tests of the canisters showed no serious tendency to produce fines or channel, even after very rough handling, provided they were properly filled and held in position by the customary springs.

CONCLUSION

In conclusion, it appears that the above-described soda limes are a great improvement, both in stability and efficiency, over any of the customary types. The best composition for a variety of different purposes has been carefully worked out, and found entirely satisfactory under actual service conditions. The single objection to the product is its complicated method of manufacture, which is admittedly much more difficult and expensive than the customary simple processes. It is nevertheless felt that the new product can be made more cheaply per unit absorption than any of the previous materials, and will find a wide use wherever a high degree of absorptive activity and capacity is desired.

ACKNOWLEDGMENTS

The writer desires to express his appreciation of the careful work of Lieut. W. B. Ross and his assistants at American University in carrying out most of the experiments on which this article is based; and also of Dr. C. P. McNeil and Lieut. E. P. Brown, who verified the majority of the conclusions by large-scale experimentation in the Gas Defense chemical plant at Astoria, L. I.

THE JELLY STRENGTH OF GELATINS AND GLUES

By S. E. Sheppard, S. S. Sweet and J. W. Scott, Jr.

Research Laboratory, Eastman Kodak Company, Rochester, N. Y.

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For several uses of gelatins and glues the tensile strength of the jelly is regarded as the most important test.[1] This has been particularly the case in rating glues, but it is also of considerable importance for gelatins used in photography and in the paper industry. Analogously to the "wet strength" of papers, the jelly strength of a gelatin is obviously of primary importance for its use in photographic operations. This is perhaps even more the case on account of the increasing use of flexible film support in place of the rigid glass base.

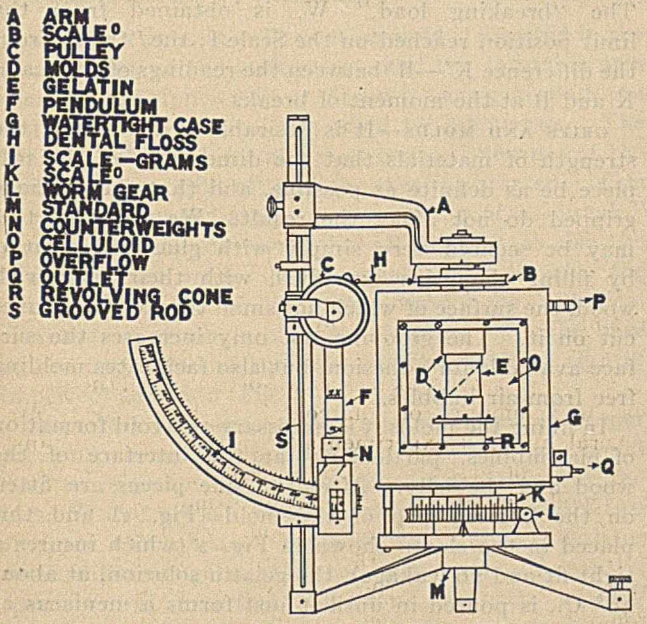

Fig. 1—Diagram of Jelly-Strength Testing Machine

The method originally recommended for practical commercial purposes was that of measuring, or rather comparing, the resistance of the jelly by means of the finger, grading the jellies by comparison with a set of arbitrary standards. Although no doubt satisfactory for many commercial purposes, the purely comparative and very subjective nature of the test obviously made it desirable to have a method giving values independent of comparison with an arbitrary standard, and objective in character.

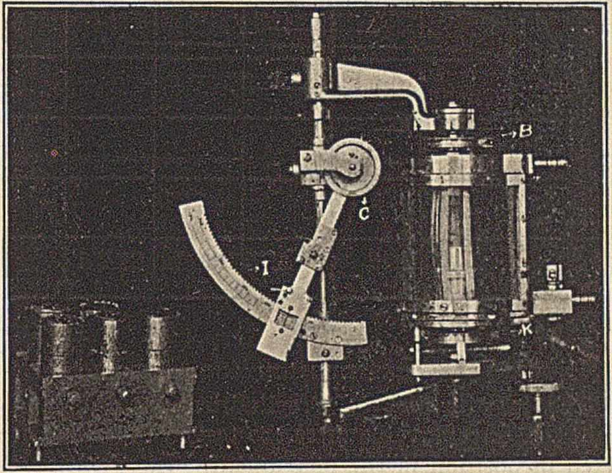

Fig. 2

To this end various methods[1] have been devised. Practically all consist of mechanical imitations of the "finger test," substituting some type of loaded plunger for the finger, and determining the load necessary to break through the jelly surface. As pointed out by Alexander,[2] all methods which depend upon the breaking or compression of a jelly in open glasses or molds are subject to errors due to the formation of a "skin," of greater or less thickness (depending upon humidity, temperature, etc.), and in some cases to errors from variations of diameter, giving a surface of uncertain area. To avoid these troubles, Alexander[3] has devised a tester operating on jelly blocks free from containing walls, and with the surface skin at the bottom.

A further defect in the methods referred to is that the stress applied affects both elasticity of bulk and elasticity of figure.

TENSILE STRENGTH UNDER TORSION

For more exact testing, and particularly for research on the properties of gelatin jellies, a jelly-strength testing machine operating by torsion has been devised by one of the writers (S. E. Sheppard). In seeking for correlation between viscosity coefficients and elasticity coefficients or moduli, it is desirable that the elastic values, *e. g.*, limit of elasticity and tensile strength, should be obtained for pure shear. This condition is secured by submitting cylinders of the material to be tested to torsional stress.[4]

The construction and mechanism of the instrument will be readily grasped from the diagram (Fig. 1), and the photograph (Fig. 2).

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[1] R. L. Fernbach, "Glues and Gelatins," D. Van Nostrand Co., New York, 1906, p. 45.

[1] See bibliography at end of paper. A detailed description of the methods is given in a forthcoming monograph on "gelatin" by one of the authors.

[2] "Proteins," in Allen's "Commercial Organic Analysis," 4th Edition, Vol. VIII, p. 607 (Blakiston, Philadelphia, 1913).

[3] *J. Soc. Chem. Ind.*, **27** (1908), 459; also U. S. Patent 882,731.

[4] See textbooks on Strength of Materials.

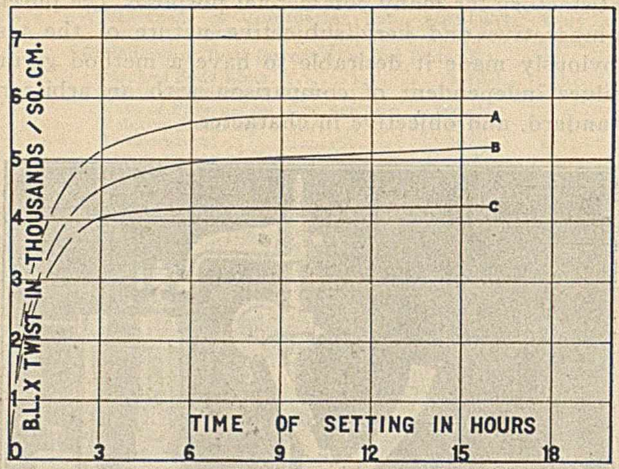

Fig. 3

GENERAL CONSTRUCTION AND OPERATION

The jelly is cast in a cylindrical mold having a split jacket removable after the test cylinder has been fixed in position in the instrument. In operation the jelly cylinder is twisted at a uniform rate by rotating the base at constant (angular) speed. This is effected by a worm drive, operated either by hand, or, where greater accuracy at low speeds is required, by a constant-speed electric motor. The circular base is graduated in degrees—Scale K—and the upper head of the "test cylinder" also carries a circular scale graduated in degrees—Scale B. One of the feet of the tripod base carries as a standard a steel rod grooved on opposite sides for its entire length. A short section at the top is free to rotate. This grooved standard carries an arm (Fig. 1) which is free to move up and down except as fixed by an adjustable setting collar, but which cannot rotate except when in position on the top section of the standard. This arm carries the upper "grip" for the jelly cylinders, which is rigidly connected with a pulley revolving freely on a ball race. The pulley (about 2.5 in. in diameter) carries Scale B. The grooves in the standard bring the pulley and the upper grip into perpendicular and centered alignment with the lower grip, the pulley wheel connecting, as shown, by a silk or fine chain cable with a lever, moving, as shown, along a calibrated scale, I. The lever or pendulum carries a set of pawls running lightly over the ratchet on the scale and keeping it from dropping back from any position to which it has been raised. The load of this counterpoise can be altered by placing jockey weights on the bob, so that multiplying factors of two and three times the scale readings are obtainable. The actual range with the first instrument constructed is from 10 to 550 g. The "breaking load," W, is obtained from the limit position reached on the Scale I; the "twist" from the difference K′—B′ between the readings of the scales K and B at the moment of break.

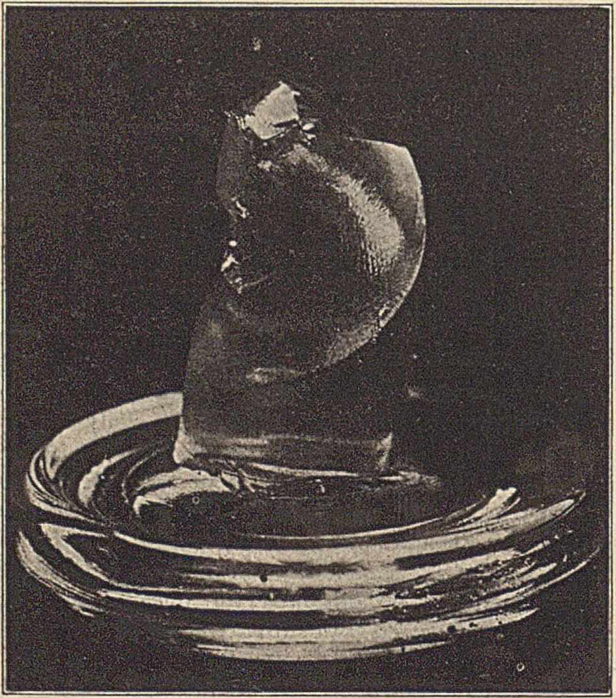

Fig. 4

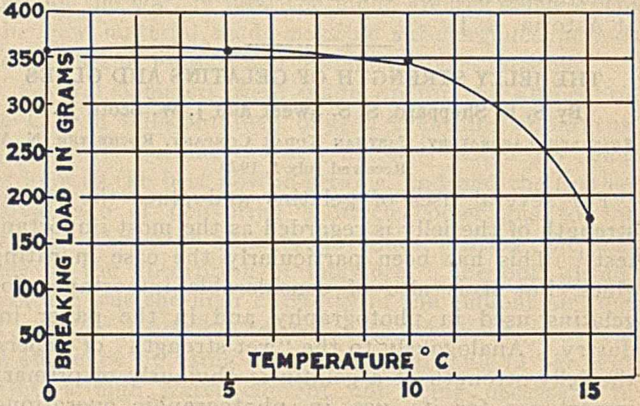

Fig. 5

GRIPS AND MOLDS—It is desirable in any test of the strength of materials that the dimensions of the test piece be as definite as possible, and that the portions gripped do not affect the result. We find that this may be secured very simply with glue and gelatin[1] by filling the grips just flush with their ends with wood, the surface of which has small transverse grooves cut on it. The grooving not only increases the surface available for adhesion, but also facilitates molding free from air bubbles.

In filling the molds it is necessary to avoid formation of air bubbles, particularly at the interface of the wood and the jelly. After the side pieces are fitted on the bottom grip of the mold (Fig. 2) and this placed in the clamp shown in Fig. 2 (which insures a tight fit and no leakage), the gelatin solution, at about 40° C., is poured in until it just forms a meniscus at the top of the side plates. The upper grip is now carefully pushed across in the direction of the grooves, thus allowing air to be displaced. It is then pushed down into the mold, the excess gelatin solution and residual air being displaced through vent holes in the wooden core.

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[1] For information on this subject the author has to thank Major Taylor, R. A. F., who has found in experiments with gelatin models of shafts that gripping by adhesion gives the least "end" error.

CHILLING THE TEST SPECIMENS—Experiments in chilling the test cylinders showed that after 3 hrs. at 0° C., little or no further increase in strength occurred (Fig. 3).

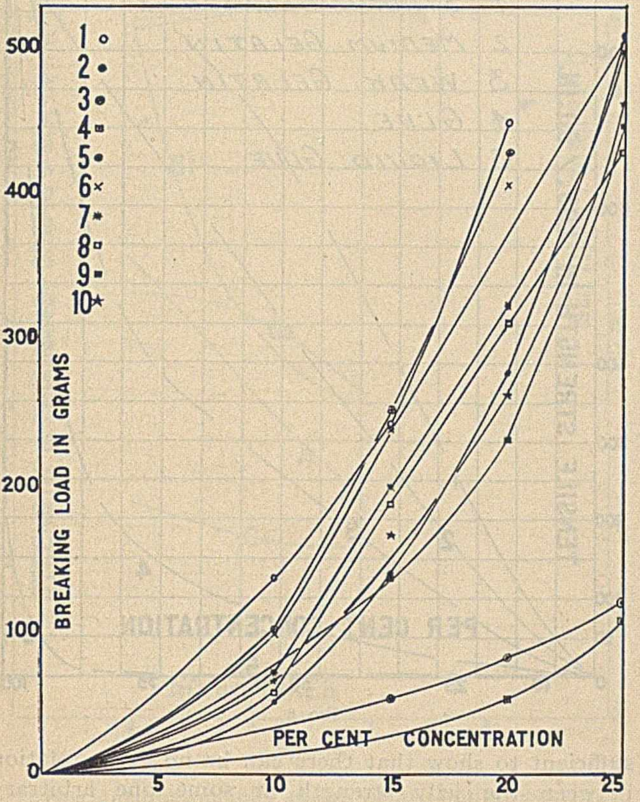

FIG. 6a—COMPARATIVE JELLY-STRENGTH TESTS
Samples 1, 2, 3, 4, 6, 7, 9 were American; 5, 8, 10, German gelatins

MAKING THE TEST—The entire mold is inserted in the lower clamp of the instrument, and the rotatable arm carrying the upper grip or clamp is swung around and fastened to the top of the mold by set screws. The Scales K, B, and I are all set at zero. The sides of the mold are then split off and the twisting started. This is stopped immediately on completion of a "break," and the angular difference K′—B′ read off, as also the breaking load on I. It is desirable to note also the character of the break. This should be a helical cleavage, of an angle of 45°, extending from the base to the upper end of the jelly column, with no sign of imperfect adhesion (Fig. 4).

Imperfect adhesion, which seldom occurs if proper precautions are taken, in filling and casting, should lead to rejection of the sample and repetition of the test. There are six molds in the set, but usually two or three check values are sufficient, allowing two or three different gelatins to be tested simultaneously. Apart from imperfect adhesion, however, a jelly may break off "short," corresponding to a low angle of twist and a brittle or crumbly structure.

EFFECT OF TEMPERATURE—Experiment showed that, after forming a jelly at 0° C. for 3 hrs., and then bringing it to a higher temperature and testing at that temperature, the "strength" did not alter materially till a temperature above 10° C. was reached. Above this point the jelly strength rapidly diminished (Fig. 5).

For experimental control of the temperature there is provided a water-tight jacket, revolving with the base and having transparent windows to facilitate observation, as shown in Fig. 2.

EFFECT OF CONCENTRATION—The relation of jelly strength to concentration is very important in making comparisons between different gelatins and glues. Although the jelly strength in any case increases more or less rapidly with the concentration, different gelatins differ considerably in this respect, as is shown in Fig. 6, where the curves of "breaking load" plotted against "concentration" frequently cut. Here concentration is based on air-dry gelatin. Consequently, according as comparisons were made below, at, or above the concentration where the curves cut, the one gelatin would be regarded as having lower, equal, or greater jelly strength than the other. For complete comparison it would be necessary to compare the areas enclosed by the breaking-load concentration curves from 0 to 100 per cent (based on dry gelatin). As this is not practicable, more or less arbitrary methods of comparison must be adopted. For some purposes we have taken the jelly-strength value of a photographic gelatin or paper gelatin as the slope $\Delta W/\Delta c$ between concentrations of 10 and 25 per cent (Fig. 7). As the actual expression for jelly strength instead of the breaking load, W, it appears better to use the value

$$S = \frac{\text{Breaking load} \times \text{per cent twist}}{\text{Cross-section area}},$$

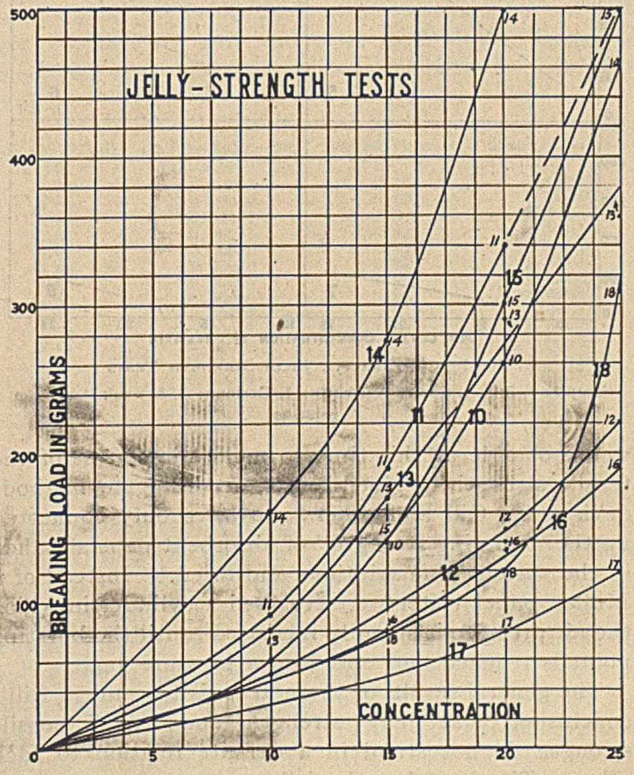

FIG. 6b—JELLY-STRENGTH TESTS
Sample 10, soft German; 11, hard German; 14, hard German (different brand); 15, English; 12, 13, American gelatins; 16, 17, 18, American glues

and we have for the present taken this value as measuring the jelly strength in our investigations of the effect of heat treatment, electrolytes and non-electrolytes, etc., upon the properties of gelatin jellies.

RELATION OF JELLY STRENGTH TO TENSILE STRENGTH OF GLUE JOINTS

While our investigation was principally directed to the study of gelatins, it appeared of interest to ascertain whether correlation exists between the jelly strength of a gelatin or glue, and the tensile strength of the dry gelatin or glue, particularly as used in glued joints. It has already been stated by Gill[1] that the viscosity, the jelly strength by the plunger method of Lipowitz, and the tensile strength of glues stand in no definite relation to each other. As we were not able at this time to make direct test of the tensile strength of glued joints, according to methods devised by Gill and others, we have only connected up the "bursting strength" of absorbent papers soaked in the various glue solutions and dried.[2] Instead of a Mullen paper tester we have used a cylinder in which the air pressure is steadily increased until the bursting point is reached and noted on a pressure gage.

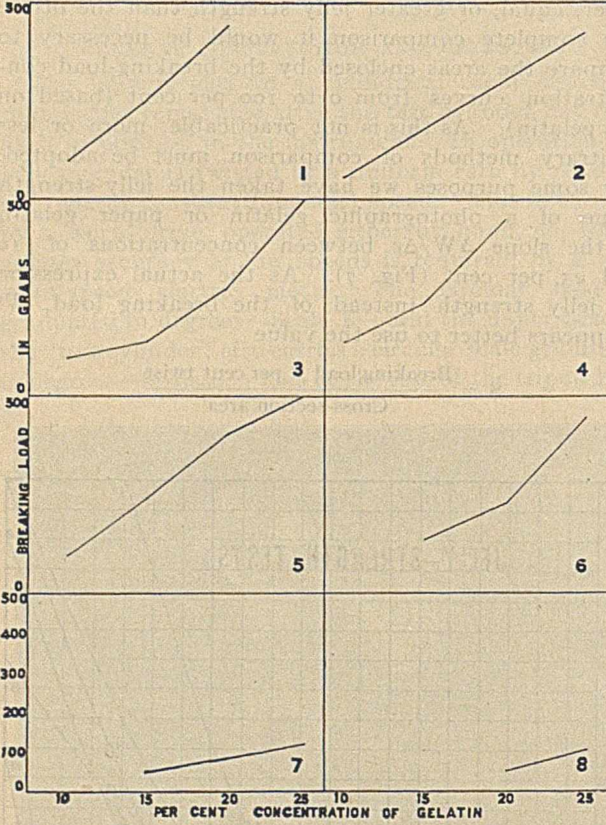

Fig. 7—Comparative Jelly-Strength Tests
Samples 1, 2, 3, 4, 6 were American; 5, German; 7, 8, weak American gelatins

The general result of these tests is to confirm Gill's conclusion that jelly strength and "dry" tensile strength do not stand in a definite relation to each other. The fact that the jelly strength-concentration curves of different gelatins and glues often cut each other even below 25 per cent concentration is already sufficient to show that there can be no exact relation between the jelly strength at some one arbitrary concentration of air-dry gelatin, *e. g.*, 10 per cent, and the strength of the 100 per cent air-dry material. This is brought out in a generalized diagrammatic form in Fig. 8, which includes the case of a non-setting or "liquid" glue, having practically no jelly strength at any concentration below the air-dry state. If one and the same gelatin or glue be subjected to hydrolysis, reducing the jelly strength, the glue strength (as in-

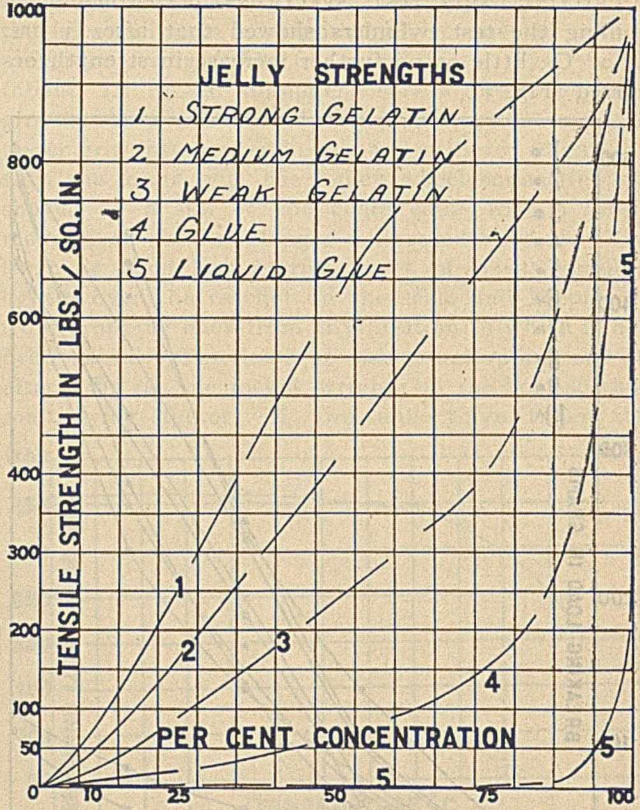

Fig. 8

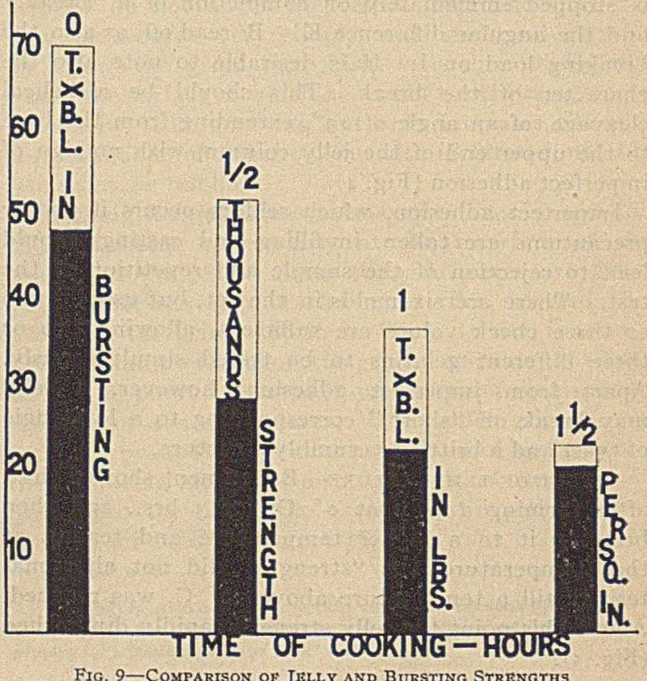

Fig. 9—Comparison of Jelly and Bursting Strengths

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[1] This Journal, 7 (1915), 102.

[2] Gill, *Loc. cit.*

dicated by the bursting load) is also diminished, but not in simple proportion, as illustrated in Fig. 9.

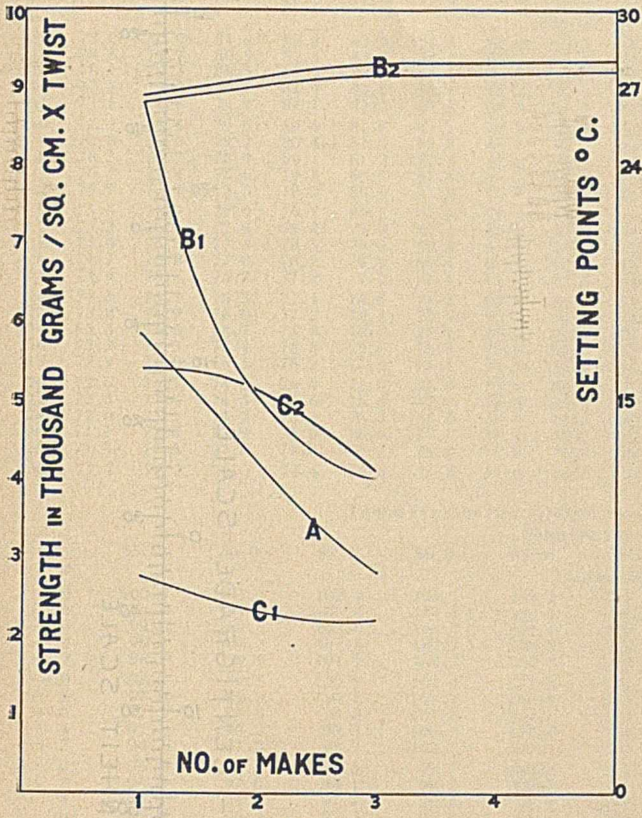

Fig. 10

Investigations on jelly strength are being continued with the object of obtaining satisfactory coefficients for testing of gelatins for photographic and other uses, and also of determining the influence of electrolytes, heat treatment, etc., on the jelly strength. It is known that the jellying powers of different gelatins are differently affected by remelting, and an example of this is given in Fig. 10. An automatic recording device is also in course of construction, so that determinations of the "elastic limit" and "proof resistance" may be measured from the *load twist* curves.

SUMMARY

1—A torsion dynamometer is described for determining the jelly strength of gelatin and glues under pure shear of molded cylindrical test pieces.

2—Both the "breaking load" and the percentage twist at break are determined; the product of breaking load × twist, divided by the cross section of the test piece, is taken as the jelly strength.

3—No simple relation holds between the concentration of gelatin and the jelly strength; furthermore, the curves relating these values for different commercial gelatins do not belong to a common family, and frequently cut each other. Hence, jelly-strength values determined for a single arbitrary concentration give a very arbitrary comparison of the jelly strengths.

4—There appears, consequently, to be no definite relation between the jelly strength, as a given concentration, and the glue-joint or tensile strength of a dry glue joint.

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GASOLINE FROM NATURAL GAS. IV—TEMPERATURE CORRECTION AND BLENDING CHARTS

By R. P. Anderson

United Natural Gas Company, Oil City, Pennsylvania

Received May 12, 1920

The topics discussed in the present article are:

(1) The correction of gasoline gravity and volume to a temperature base of 60° F.

(2) A chart for blending gasoline and naphtha.

COEFFICIENT OF EXPANSION OF GASOLINE

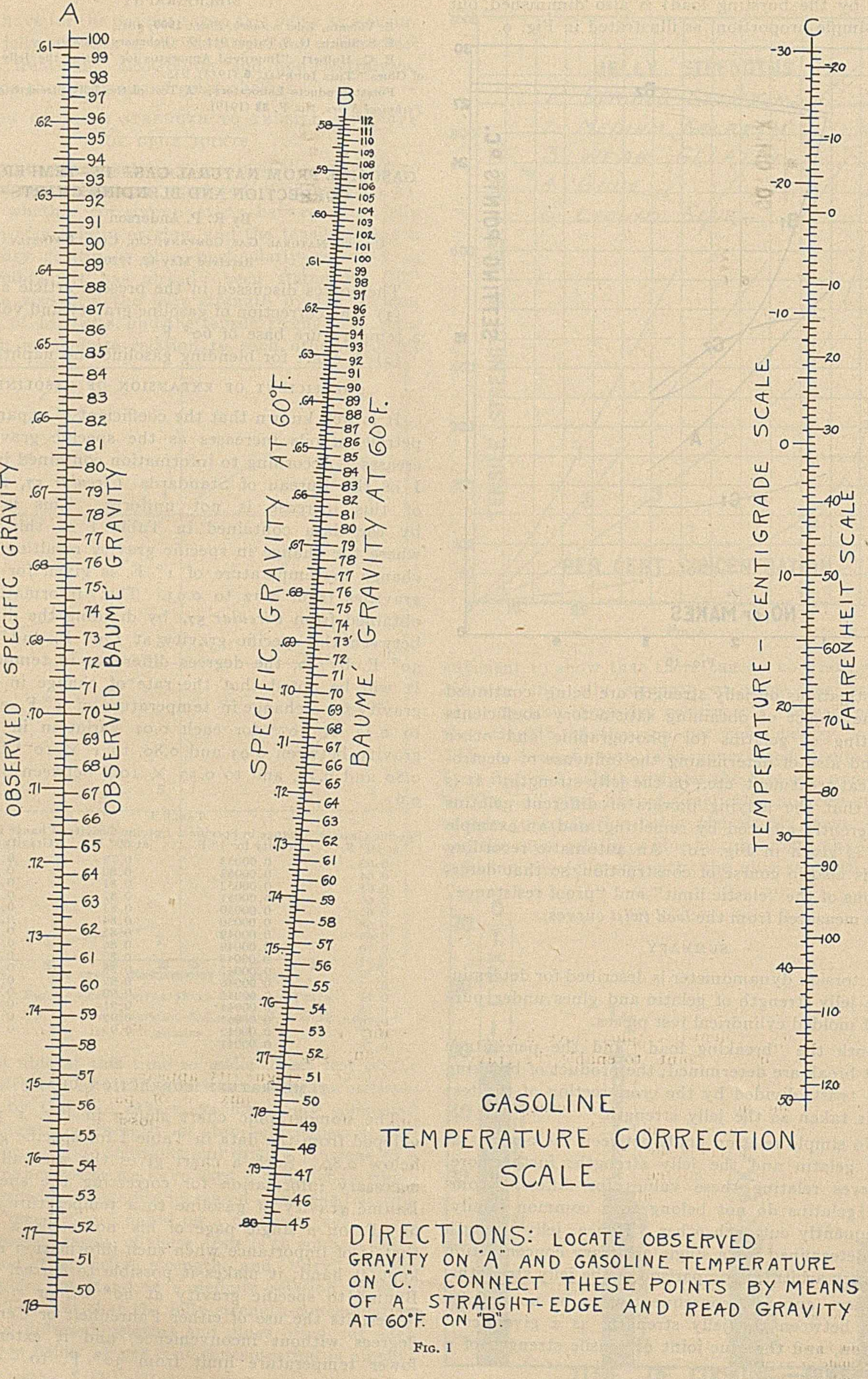
It is well known that the coefficient of expansion of petroleum oils increases as the specific gravity decreases. According to information contained in Table I of the Bureau of Standards *Circular* 57, the rate of this increase is not uniform. This is shown by the data contained in Table I of this article, where the change in specific gravity resulting from a change in temperature of 1° F. is given for specific gravities from 0.62 to 0.93. This information was obtained from *Circular* 57, by dividing the difference between the specific gravity at 120° F. and that at 30° F. by 90, the degrees difference in temperature. It will be noted that the rate of change in specific gravity for a change in temperature of 1° F. amounts to 0.23×10^{-5} for each 0.01 variation in specific gravity between 0.93 and 0.80, to 1×10^{-5} between 0.80 and 0.70, and to 0.57×10^{-5} between 0.70 and 0.63.

Table I

Specific Gravity at 60° F.	Change in Specific Gravity for 1° F.	Specific Gravity at 60° F.	Change in Specific Gravity for 1° F.
0.63	0.00053	0.79	0.00040
0.64	0.00052	0.80	0.00039
0.65	0.00052	0.81	0.00039
0.66	0.00051	0.82	0.00039
0.67	0.00050	0.83	0.00038
0.68	0.00050	0.84	0.00037
0.69	0.00049	0.85	0.00037
0.70	0.00049	0.86	0.00037
0.71	0.00048	0.87	0.00037
0.72	0.00047	0.88	0.00036
0.73	0.00046	0.89	0.00036
0.74	0.00045	0.90	0.00036
0.75	0.00044	0.91	0.00036
0.76	0.00043	0.92	0.00036
0.77	0.00042	0.93	0.00036
0.78	0.00041		

TEMPERATURE CORRECTION CHART

The nomographic chart shown in Fig. 1 was developed from the data in Table I for specific gravities below 0.80. Such a chart gives the user all of the necessary information for correcting the specific or Baumé gravity of gasoline to a temperature base of 60° F. on a single page of his notebook, a feature that is of importance when such information must be kept at hand; it makes it possible to correct degrees Baumé to specific gravity at 60° F., or *vice versa;* it permits the use of either Fahrenheit or Centigrade degrees without inconvenience, and it extends the lower temperature limit from 30° F. to —20° F.



GASOLINE
TEMPERATURE CORRECTION
SCALE

DIRECTIONS: LOCATE OBSERVED GRAVITY ON "A" AND GASOLINE TEMPERATURE ON "C". CONNECT THESE POINTS BY MEANS OF A STRAIGHT-EDGE AND READ GRAVITY AT 60°F. ON "B".

Fig. 1

TABLE II—GRAVITY CORRECTIONS AT LOW TEMPERATURES

	Observed Gravity Degrees Baumé																	
	67.0	68.0	69.0	70.0	71.0	72.0	73.0	74.0	75.0	76.0	77.0	78.0	79.0	80.0	81.0	82.0	83.0	84.0
° F.	Degrees Baumé at 60° F.																	
—20	78.8	80.0	81.2	82.4	83.6	84.8	86.0	87.2	88.4	89.6	90.8	92.0	93.2	94.4	95.6	96.8	98.0	99.3
—18	78.5	79.7	80.9	82.1	83.3	84.5	85.7	86.9	88.0	89.2	90.4	91.6	92.8	94.0	95.2	96.4	97.6	98.8
—16	78.1	79.3	80.5	81.7	82.9	84.1	85.3	86.5	87.6	88.8	90.0	91.2	92.4	93.6	94.8	96.0	97.2	98.4
—14	77.8	79.0	80.2	81.4	82.6	83.8	85.0	86.1	87.2	88.4	89.6	90.8	92.0	93.2	94.4	95.6	96.8	98.0
—12	77.5	78.7	79.9	81.1	82.2	83.4	84.6	85.7	86.9	88.0	89.2	90.4	91.6	92.8	94.0	95.2	96.4	97.6
—10	77.2	78.4	79.6	80.8	81.9	83.1	84.3	85.4	86.6	87.7	88.9	90.1	91.2	92.4	93.6	94.8	96.0	97.2
— 8	76.8	78.0	79.2	80.4	81.5	82.7	83.9	85.0	86.2	87.3	88.5	89.7	89.8	92.0	93.2	94.4	95.6	96.7
— 6	76.5	77.7	78.9	80.1	81.2	82.4	83.6	84.7	85.9	87.0	88.1	89.3	89.4	91.6	92.8	94.0	95.2	96.3
— 4	76.2	77.4	78.6	79.8	80.9	82.1	83.2	84.4	85.5	86.6	87.7	88.9	89.0	91.2	92.4	93.6	94.8	95.9
— 2	75.9	77.1	78.3	79.5	80.6	81.8	82.9	84.1	85.2	86.3	87.4	88.6	89.7	90.9	92.0	93.2	94.4	95.5
0	75.6	76.7	77.9	79.1	80.2	81.4	82.5	83.7	84.8	85.9	87.0	88.2	89.3	90.5	91.6	92.8	94.0	95.1
2	75.3	76.4	77.6	78.8	79.9	81.1	82.2	83.3	84.4	85.6	86.7	87.8	88.9	90.1	91.2	92.4	93.6	94.7
4	75.0	76.1	77.3	78.5	79.6	80.8	81.9	83.0	84.1	85.3	86.4	87.5	88.6	89.7	90.8	92.0	93.2	94.3
6	74.7	75.8	77.0	78.2	79.3	80.4	81.5	82.6	83.7	84.9	86.0	87.1	88.2	89.3	90.4	91.6	92.8	93.9
8	74.4	75.5	75.7	77.9	79.0	80.1	81.2	82.3	83.4	84.6	85.7	86.8	87.9	89.0	90.1	91.3	92.4	93.5
10	74.1	75.2	76.3	77.5	78.6	79.7	80.8	81.9	83.0	84.2	85.3	86.4	87.5	88.6	89.7	90.9	92.0	93.1
12	73.8	74.9	76.0	77.2	78.3	79.4	80.5	81.6	82.7	83.8	84.9	86.0	87.1	88.2	89.3	90.5	91.6	92.7
14	73.5	74.6	75.7	76.9	78.0	79.1	80.2	81.3	82.4	83.5	84.6	85.7	86.8	87.9	89.0	90.1	91.2	92.3
16	73.2	74.3	75.4	76.5	77.6	78.7	79.8	80.9	82.0	83.1	84.2	85.3	86.4	87.5	88.6	89.7	90.8	91.9
18	72.9	74.0	75.1	76.2	77.3	78.4	79.5	80.6	81.7	82.8	83.9	85.0	86.1	87.2	88.3	89.4	90.5	91.6
20	72.6	73.7	74.8	75.9	76.9	78.0	79.1	80.2	81.3	82.4	83.5	84.6	85.7	86.8	87.9	89.0	90.1	91.2
22	72.3	73.4	74.5	75.6	76.6	77.7	78.8	79.8	80.9	82.0	83.1	84.2	85.3	86.4	87.5	88.6	89.7	90.8
24	72.0	73.1	74.2	75.3	76.3	77.4	78.5	79.5	80.6	81.7	82.8	83.9	84.9	86.0	87.1	88.2	89.3	90.4
26	71.7	72.8	73.9	75.0	76.0	77.1	78.2	79.2	80.3	81.4	82.4	83.5	84.5	85.6	86.7	87.8	88.9	90.0
28	71.4	72.5	73.6	74.7	75.7	76.8	77.9	78.9	80.0	81.1	82.1	83.2	84.2	85.3	86.3	87.4	88.5	89.6
30	71.1	72.2	73.3	74.4	75.4	76.5	77.6	78.6	79.7	80.8	81.8	82.9	83.9	85.0	86.0	87.1	88.2	89.3

TABLE II—GRAVITY CORRECTIONS AT LOW TEMPERATURES (*Continued*)

	Observed Gravity Degrees Baumé											
	85.0	86.0	87.0	88.0	89.0	90.0	91.0	92.0	93.0	94.0	95.0	96.0
° F.	Degrees Baumé at 60° F.											
—20	100.5	101.7	102.9	104.1	105.3	106.5	107.7	108.9	110.1	111.4	112.7	114.0
—18	100.0	101.2	103.4	103.6	104.8	106.0	107.2	108.4	109.6	110.9	112.2	113.4
—16	99.6	100.8	102.0	103.2	104.3	105.5	106.7	107.9	109.1	110.4	111.6	112.9
—14	99.1	100.3	101.5	102.7	103.8	105.0	106.2	107.4	108.6	109.9	111.1	112.3
—12	98.7	99.9	101.1	102.3	103.4	104.6	105.7	106.9	108.1	109.4	110.6	111.8
—10	98.3	99.5	100.7	101.9	103.0	104.2	105.3	106.5	107.7	108.9	110.1	111.3
— 8	97.9	99.0	100.2	101.4	102.5	103.7	104.8	106.0	107.2	108.4	109.6	110.8
— 6	97.5	98.6	99.8	101.0	102.1	103.3	104.4	105.6	106.7	107.9	109.1	110.3
— 4	97.1	98.2	99.3	100.5	101.6	102.8	103.9	105.1	106.2	107.4	108.6	109.8
— 2	96.7	97.8	98.9	100.1	101.2	102.4	103.5	104.7	105.8	106.9	108.1	109.3
0	96.3	97.4	98.5	99.7	100.8	102.0	103.1	104.3	105.4	106.5	107.7	108.8
2	95.8	97.0	98.1	99.2	100.3	101.5	102.6	103.8	104.9	106.0	107.2	108.3
4	95.4	96.6	97.7	98.8	99.9	101.1	102.2	103.4	104.5	105.6	106.8	107.9
6	95.0	96.2	97.3	98.4	99.5	100.7	101.8	102.9	104.0	105.1	106.3	107.4
8	94.6	95.8	96.9	98.0	99.1	100.3	101.4	102.5	103.6	104.7	105.9	107.0
10	94.2	95.4	96.5	97.6	98.7	99.9	101.0	102.1	103.2	104.3	105.4	106.5
12	93.8	95.0	96.1	97.2	98.3	99.4	100.5	101.6	102.7	103.8	104.9	106.0
14	93.4	94.6	95.7	96.8	97.9	99.0	100.1	101.2	102.3	103.4	104.5	105.6
16	93.0	94.2	95.3	96.4	97.5	98.6	99.7	100.8	101.9	102.9	104.0	105.1
18	92.7	93.8	94.9	96.0	97.1	98.2	99.3	100.4	101.5	102.5	103.6	104.7
20	92.3	93.4	94.5	95.6	96.7	97.8	98.9	100.0	101.1	102.1	103.2	104.3
22	91.9	93.0	94.1	95.2	96.3	97.4	98.5	99.5	100.6	101.7	102.8	103.9
24	91.5	92.6	93.7	94.8	95.9	97.0	98.1	99.1	100.2	101.3	102.3	103.4
26	91.1	92.2	93.3	94.4	95.5	96.6	97.7	98.7	99.8	100.9	101.9	103.0
28	90.7	91.8	92.9	94.0	95.1	96.2	97.3	98.3	99.4	100.5	101.5	102.6
30	90.4	91.5	92.5	93.6	94.7	95.8	96.9	97.9	99.0	100.1	101.1	102.2
32	....	....	....	....	....	....	96.5	97.5	98.6	99.6	100.6	101.7
34	....	....	....	....	....	....	96.0	97.1	98.1	99.2	100.2	101.3
36	....	....	....	....	....	....	....	96.7	97.7	98.8	99.8	100.9
38	....	....	....	....	....	....	....	96.3	97.3	98.4	99.4	100.5
40	....	....	....	....	....	....	....	95.9	96.9	98.0	99.0	100.1
42	....	....	....	....	....	....	....	....	96.5	97.6	98.6	99.6
44	....	....	....	....	....	....	....	....	96.1	97.2	98.2	99.2
46	....	....	....	....	....	....	....	....	....	96.8	97.8	98.8
48	....	....	....	....	....	....	....	....	....	96.4	97.4	98.4
50	....	....	....	....	....	....	....	....	....	96.0	97.0	98.0
52	....	....	....	....	....	....	....	....	....	....	96.6	97.6
54	....	....	....	....	....	....	....	....	....	....	96.2	97.2
56	....	....	....	....	....	....	....	....	....	....	95.8	96.8
58	....	....	....	....	....	....	....	....	....	....	....	96.4
60	....	....	....	....	....	....	....	....	....	....	....	96.0

It is somewhat inconvenient to employ, since a straight edge must be set on two points to enable the gravity at 60° F. to be read.[1]

The bend in the middle line of the nomograph at sp. gr. 0.70 is, of course, the result of the change in the rate of increase of the coefficient of expansion. Had the nomograph been constructed to include the higher specific gravities, there would also be a bend at sp. gr. 0.80. There may be some connection between this latter bend and the fact that specific gravities of paraffin hydrocarbons higher than 0.78 are due to the solution of solid hydrocarbons in liquids of lower specific gravity. It seems difficult, however, to offer any explanation for the bend at sp. gr. 0.70. In fact, that irregularity appears anomalous as a characteristic of the mixture of paraffin hydrocarbons constituting gasoline. It is possible that, if the experimental work could be performed with a sufficient degree of accuracy, a gradual increase in the rate of change of the coefficient of expansion would be obtained, instead of the sudden variation at sp. gr. 0.70 portrayed by the nomograph.

TEMPERATURE CORRECTION TABLE FOR LOW TEMPERATURES

By the use of the nomographic chart, the Bureau of Standards tables for correcting gasoline gravity for temperature have been extended from 30° F. to —20° F. for gravities that are ordinarily met with in

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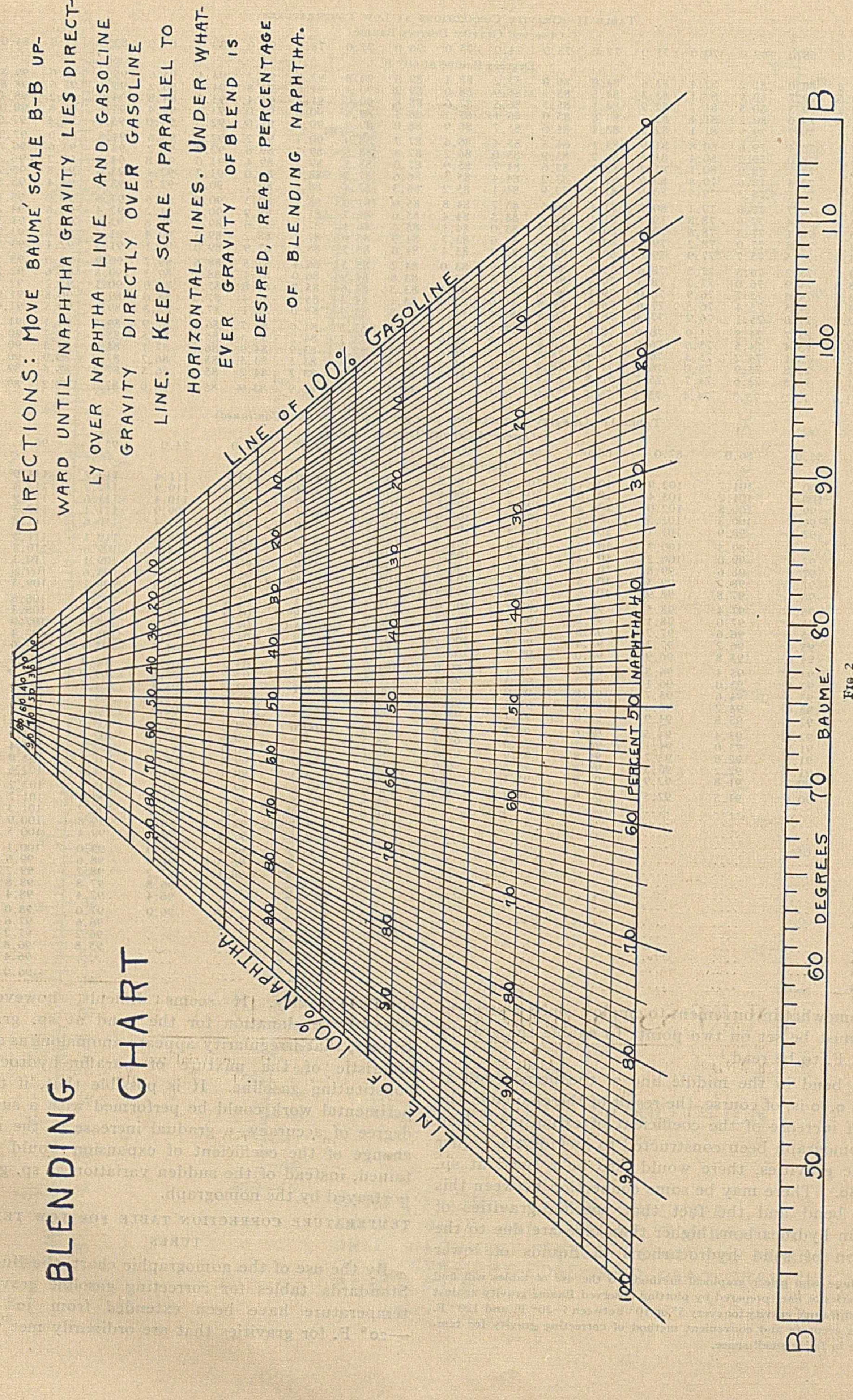
[1] Those who prfeer graphical methods to the use of tables will find that a series of lines prepared by plotting observed Baumé gravity against corrected Baumé gravity for every 5° or 10° between —20° F. and 120° F. gives an accurate and convenient method of correcting gravity for temperature in fairly small space.



BLENDING CHART

DIRECTIONS: MOVE BAUME' SCALE B-B UPWARD UNTIL NAPHTHA GRAVITY LIES DIRECTLY OVER NAPHTHA LINE AND GASOLINE GRAVITY DIRECTLY OVER GASOLINE LINE. KEEP SCALE PARALLEL TO HORIZONTAL LINES. UNDER WHATEVER GRAVITY OF BLEND IS DESIRED, READ PERCENTAGE OF BLENDING NAPHTHA.

Fig 2

TABLE III—GASOLINE VOLUME FACTORS (60° BASIS)

Observed Temp. ° F.	Observed Gravity									
	50	55	60	65	70	75	80	85	90	95
	Factor to Correct Volume to 60° F.									
120	0.9705	0.9685	0.9665	0.9640	0.9620	0.9600	0.9580	0.9560	0.9540	0.9525
110	0.9750	0.9730	0.9715	0.9695	0.9675	0.9660	0.9645	0.9630	0.9630	0.9600
100	0.9795	0.9780	0.9765	0.9750	0.9735	0.9725	0.9710	0.9700	0.9605	0.9675
90	0.9845	0.9835	0.9820	0.9810	0.9800	0.9790	0.9780	0.9770	0.9760	0.9755
80	0.9895	0.9890	0.9880	0.9870	0.9865	0.9860	0.9850	0.9845	0.9840	0.9835
70	0.9945	0.9945	0.9940	0.9935	0.9930	0.9930	0.9925	0.9920	0.9920	0.9915
60	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
50	1.0055	1.0055	1.0060	1.0065	1.0070	1.0075	1.0075	1.0080	1.0085	1.0085
40	1.0110	1.0115	1.0125	1.0135	1.0140	1.0150	1.0155	1.0165	1.0170	1.0175
30	1.0165	1.0180	1.0190	1.0205	1.0215	1.0225	1.0235	1.0250	1.0260	1.0265
20	1.0225	1.0245	1.0260	1.0275	1.0290	1.0305	1.0320	1.0335	1.0350	1.0360
10	1.0290	1.0310	1.0330	1.0350	1.0370	1.0390	1.0405	1.0425	1.0445	1.0460
0	1.0355	1.0380	1.0405	1.0425	1.0450	1.0475	1.0495	1.0520	1.0540	1.0560
—10	1.0420	1.0450	1.0480	1.0505	1.0530	1.0560	1.0585	1.0615	1.0640	1.0665
—20	1.0485	1.0520	1.0555	1.0585	1.0615	1.0650	1.0680	1.0710	1.0740	1.0770

dealing with natural-gas gasoline. Table II contains this information, which may be considered an extension of the tables on pages 46, 47, and 48 of *Circular* 57. Such tables are valuable throughout the entire year in the manufacture of natural-gas gasoline, on account of the low temperatures that result from the release of pressure from condensates containing butane and propane.[1]

TEMPERATURE CORRECTION TABLE FOR VOLUME

Table III contains correction factors to be employed in correcting gasoline volumes to a temperature base of 60° F. It differs from Table III of *Circular* 57 in that Baumé degrees are employed instead of specific gravity, and the lower temperature limit is extended from 30° F. to —20° F.

BLENDING GASOLINE AND NAPHTHA

The widespread use of the Baumé scale in the gasoline industry complicates the problem of blending two grades of gasoline, or gasoline and naphtha, to produce a blend of a certain grade, as a result of the fact that the equivalent of 1° Bé. in terms of specific gravity is not constant throughout the Baumé scale. Different grades of gasoline blend without appreciable increase or decrease in volume, and consequently the composition of a blend of a given specific gravity can easily be computed, provided the specific gravities of the two constituents be known. If Baumé degrees are employed, they must be converted to specific gravity before such a computation can be made.

The necessity for such a computation can be obviated by the use of a suitable blending chart, such as the one designed by Netzen and printed by the United States Geological Survey, or such as the one shown in Fig. 2. The scale BB represents a specific gravity scale calibrated in degrees Baumé. If such a scale be superimposed on a scale of 100 equal parts, the number of equal parts lying between the Baumé gravity of the blend and the Baumé gravity of the high-gravity gasoline represents the percentage of the low-gravity gasoline, or blending agent. The system of converging lines provides a scale of 100 equal parts of variable length, thus providing a convenient means for determining the composition of blends of various gravities, with various gravities of the two constituents of the blends.

SUMMARY

1—The relationship between the coefficient of expansion of gasoline and its specific gravity, as exemplified by Table I, Bureau of Standards *Circular* 57, has been studied, and a nomographic chart based upon this relationship has been developed.

2—Temperature correction tables for Baumé gravity and volume have been extended from 30° F. to —20° F. to meet the needs of the natural-gas gasoline industry.

3—A blending chart for use in blending two grades of gasoline, or gasoline and naphtha, has been described.

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[1] To simplify the temperature correction for gravity, combination hydrometers have been employed in which the thermometers are calibrated to —20° F., instead of to 30° F., which is the case with the customary stock article. These special hydrometers were made by the Taylor Instrument Company. In the opinion of the writer, combined hydrometers intended for use in the natural-gas gasoline industry should have the lower limit of the thermometer extended to —20° F., and the approximate correction in degrees Baumé marked on the temperature scale should be abolished on account of the large error introduced by its use.

ADDRESSES AND CONTRIBUTED ARTICLES

BONE-BLACK AND DECOLORIZING CARBONS[1]

By W. D. Horne

NATIONAL SUGAR REFINING CO. OF NEW JERSEY, YONKERS, N. Y.

Ever since Derosne introduced the use of bone-black in sugar refining in 1812, this agent has held a place of prime importance in the industry. The first cost of the material, which must be used in large quantity, the magnitude of the machinery necessary for handling it, and the complexity of the process have always been felt by those employing it, and have deterred from its use many who otherwise would be glad to avail themselves of this means of purifying and decolorizing juices, sirups, molasses, etc. Of late years the rapidly increasing price of bone-black, which has tripled in value, has further concentrated attention upon the need of rendering this material more efficient or of providing suitable substitutes. Many investigators have been active in making these attempts, in some cases without a sufficiently intimate acquaintance with the details of the requirements to enable them to work to the best advantage.

The object of the present paper is to direct attention to the desirable features of a decolorizing and purifying agent for use in sugar refineries and factories and to caution against undesirable properties.

BONE-BLACK AS A DECOLORIZER

The most desirable size of grain for bone-black in sugar refining is from about 16 to 30 mesh, and as it slowly wears down in use it is desirable not to allow more than 20 or 30 per cent of grains between 30 and 40 mesh to accumulate, or more than 5 per cent finer than 40 mesh. Artificial chars designed to be

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[1] Presented at the 59th Meeting of the American Chemical Society, St. Louis, Mo., April 12 to 16, 1920.

used in column filtration should conform to these sizes. Hardness is also very important, to enable the grains to resist the abrasion of continued use. A satisfactory method of testing, described by the writer about 1891, consists of shaking 25 g. of the bone-black in a covered round tin can, 4 in. in diameter, with 6 marbles weighing 12.5 g. each. After 200 rapid swirling revolutions the bone-black is sifted through a screen having round holes one-sixtieth of an inch in diameter. The increase of dust as compared with that before the test indicates the dust formed by the attrition, and should not exceed about 2 per cent.

Bone-black improves with use for a few treatments, due to elimination of empyreumatic matter. It slowly deteriorates from choking of pores by carbon and mineral matter and by shrinkage from heating. It loses $CaCO_3$ and its power to reduce chance acidity of liquors. Attrition slowly wears it down so that it packs too closely for filtering viscous solutions at the usual density. This result is partly compensated for by sifting out the finer grains and dust, as well as by running liquors at reduced densities.

Carbon can be kept from choking the pores by regulated partial oxidation in revivifying, as in air-vented cooler pipes, or in the Weinrich decarbonizer. Mineral matter may be lessened by washing with dilute HCl, 1 to 2 per cent, but this action has only a temporary effect. Carbon can be built up by diminishing the washing prior to burning in the kilns of decarbonizers.

MECHANISM OF ABSORPTION WITH BONE-BLACK

The action of bone-black is partly chemical and partly physical. The calcium carbonate neutralizes acidity. Considerable heat is developed, as bone-black absorbs the coloring and other organic matter and the salts from a sugar solution. This is particularly strong in the first part of the filtration, endangering the sugar by caramelization and inversion, if filtration be too slow. The greater part of the color absorption appears to be mechanical, through the entanglement of the large molecules of the colloidal coloring matter in the fine cellular structure of the carbon. A filter no more than an eighth of an inch thick, properly prepared of fine fibrous material containing a mere central wash of bone-black carbon, will remove the color instantly from methylene blue, claret, or a raw sugar solution, which can be explained only on physical grounds. Mineral salts are absorbed through surface action largely, and Sir J. J. Thompson has attributed the activity of bone-black to this cause, modified by the internal and surface tensions of the solvents and the substances dissolved.

Patterson[1] has shown that the color absorption of bone-black is lodged in a certain dark brown humus-like substance, not pure carbon, which is soluble in concentrated sulfuric acid. Nitrogen plays a part in this color absorption. All bone-black contains some nitrogen, especially abundant in new char, which gives off great quantities of ammonia when being burned. This nitrogenous compound resists the heat of the kilns very persistently. The first liquors coming from the bone-black contain considerable ammonia, as evidenced by alkalinity to litmus, a yellow precipitate with Nessler's solution, and the development of an intense yellow color on the addition of traces of ferric chloride.

Bone-black does not decolorize cane juice satisfactorily, and at times it yields an inky or even a pinkish filtrate in refineries, owing, apparently, in both cases to the presence of polyphenolic compounds of iron.

There is thus an apparent partial failure on the part of bone-black to remove iron salts from solution. Indeed, what little iron a char may accumulate in filtering high-grade liquors will slowly be removed under the action of low-grade sugar solutions, as though the mineral salts in the latter exercised a specific iron removal. Since it is very desirable to have as little iron as possible in sugar solutions, this is a point for investigators to develop.

In washing the char after filtration, the absorbed impurities can be almost completely removed, but owing to the large amount of water required and the length of time necessary, the final removal is accomplished by means of burning. Washing with soda or other chemicals is not commonly used.

Lately, efforts have been made to activate old bone-black by subjecting it to the action of steam under high pressure, taking advantage of experience gained during the war in the preparation of gas-mask carbon. One of these treated bone-blacks gave interesting results that are typical of the influence of reaction. When used freshly it gave considerable color absorption from a dark sirup. After washing out the sugar solution and boiling up with 1.0 per cent hydrochloric acid and again washing, it showed no color absorption from a washed sugar liquor, but after boiling out with water containing 10 per cent of a saturated sodium hydroxide solution, and washing out, it showed a very decided power to absorb color from a washed sugar liquor.

Similarly, a carbon prepared by the concentration and roasting of an industrial waste solution, actually darkened a raw sugar solution, but after boiling this carbon with dilute hydrochloric acid and washing, it showed a marked color-absorbing power. This particular carbon, acid-treated, removed a slightly increasing percentage of color when fresh carbon was added to the filtrate from the first treatment. Boiling the used carbon in soda solution effected a further increase in the percentage of color absorption.

OTHER DECOLORIZING AGENTS

Stimulated by the desirability of a cheap and easily handled substitute for bone-black, inventors have prepared many compounds, generally carbonaceous, to take its place. Porous mineral matters such as kieselguhr, fuller's earth, brick granules, and so on, impregnated with molasses, gelatin or other carbonaceous, or carbonaceous and nitrogenous substances and burned in kilns, have been tried, with varying success. None of these has yet been entirely successful. They are either deficient in power to absorb impurities, or break down too easily under the wear and tear of use.

Another class of decolorizers has been developed by the action of heat and reagents on organized vegetable substances. Sawdust, impregnated with earthy and mineral bases and salts and intensely heated, generally in presence of steam, has produced, in the laboratory, some excellent decolorizers. Norit, Eponite, etc., prepared on commercial scales by secret processes, are apparently made from vegetable fibrous materials and are low in ash. Norit, the most widely known of these preparations, comes in a finely powdered condition and weighs but 16 or 17 lbs. per cu. ft. In use it is mixed with the sugar solution, heated, and filter-pressed directly, even in liquors of very heavy density. Thus the cumbersome filters of the bone-black system are replaced by filter presses, possessing the advantages of less size, weight, and cost. These carbons are generally ten to twenty times as efficient as equal weights of bone-black, suggesting that the 10 per cent or so of carbon in the latter is the only decolorizing substance present. This conclusion would be wrong, however, as bone-black that has been almost entirely decarbonized by burning still possesses considerable color absorbing power.

Here we have the suggestion that substances entirely different from carbon, but possessed of very fine cellular structure, are capable of development for this purpose.

The affinity of these decolorizers varies for different substances and the same impurity may be taken up in very different degrees by the various absorbents. Thus, one of the carbons was found to take up 90 per cent of the color from a dark solution prepared by heating invert sugar with lime, while it took up only 23 per cent of the color from a caramel solution prepared

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[1] *J. Soc. Chem. Ind.*, **22** (1903), 608.

by heating sugar, and which, to the eye, exactly matched the lime-glucose solution. Some of the carbons, moreover, take up the dull grayish color from cane juice which bone-black fails to absorb, and their use is being urged for making refined sugar directly from cane juice.

SELECTIVE DECOLORIZING ACTION OF DIFFERENT AGENTS

Complete color removal is proportionally much more difficult than partial removal. For instance, a certain percentage of decolorizing carbon added to a raw sugar solution removed 50 per cent of the color, a similar percentage added to the filtrate removed only 25 per cent of original color, and a third treatment removed but 7 per cent. This suggests that in the complex of coloring substances present in a raw sugar there may be some which are more easily removed than others. Some further knowledge of this phase of the subject may be attainable through investigation of the effects of decolorizing agents on colors of different wave lengths. With this in view, a series of readings were made with the Hess-Ives tintometer on some specially prepared solutions, both before and after subjecting them to the absorbing action of two different decolorizing substances. The scale on the instrument was replaced by one devised by the writer to give a more exact index of the amount of light passing through the observed solutions. Having found that any particular amount of color solution gave a reading on the reversed scale of ten times the square root of the amount of color, the new scale was constructed with 1 coinciding with the original 10 (of the reversed scale) with 4 lying on 20, with 9 on 30, with 16 on 40, with 25 on 50, and so on, up to 100 on 100. Using this scale, the following results were obtained, expressed in terms of color transmitted, for 100 readings.

MATERIAL	100 Cc. Treated with					
	15 G. Bone-Black			0.5 G. Carbon		
Caramel	Red	Green	Blue	Red	Green	Blue
Original	97	78	25	97	78	25
Treated	99	95	80.5	96	88	62
Lime-Glucose						
Original	97	85	50	97	85	50
Treated	99.7	99.6	97.2	99.6	99.2	94

It is thus apparent that different colored substances require different decolorizing agents to yield the best results. It would seem, also, that successive treatments with different decolorizers might give greatly augmented decolorization, but thus far results have been disappointing. This field merits full investigation.

In refining, it is desirable to use about 100 lbs. of bone-black to 100 lbs. of raw sugar. This will remove about 25 to 35 per cent of the ash, about 35 to 45 per cent of the organic impurities, and about 75 per cent of the color. This involves several filtrations, and as the ash amounts to about 0.6 per cent of the raw sugar and the organic matter to about twice as much, while the weight of the coloring matter is but slight, the absolute amount of these substances taken up is always quite small. The decolorizing carbons in some cases succeed in removing as much color as 20 times their weight of bone-black will remove. The ash absorption is frequently not so good as in char work, slight as that is. Bone-black is used in filters 20 ft. deep, so that the liquor passing down comes successively into contact with numerous layers of fresh char, thus giving up all its color and producing for long periods a colorless filtrate, while a decolorizing carbon in powder added directly to colored liquor in a tank at once absorbs what color it can, and when this homogeneous mass is filter-pressed all the effluent is alike. For white sugar making, this is not so advantageous as the char method, and so we find a multiple decolorization and filtration coming into vogue.

Again, the wearing down of decolorizing carbon in use tends to give slow filtration, and, as it is not convenient to screen out the finer particles, a most ingenious contrivance has been developed by the General Norit Company to scrape off the accumulated deposit from the filter leaves continually, so that the filtration may continue in the most unobstructed manner.

Revivification can be carried on by chemical means in the case of carbons much more easily and safely than in the case of bone-black, and this field presents interesting undeveloped possibilities.

Decolorizing carbons of fine properties have been made from quite a number of waste materials and some very cheaply. The desideratum is one cheap enough to throw away after using once, and which will absorb ten to twenty times as much color as bone-black, and ash and organic impurities in proportion. This may not come, but the advance has been so rapid we may not unreasonably expect to see some approach to it in the not distant future.

RECENT WORK ON DECOLORIZING CARBONS

The subject of decolorizing carbons is a large field in itself, and although much very good work has been published on it of late it can only be touched upon here.

Chaney has shown[1] that all primary amorphous carbon consists essentially of a stabilized complex of hydrocarbons absorbed on a base of active carbon. These primary carbons as such do not possess a high specific absorptive power, the active carbon having been saturated by the hydrocarbon absorbed by it. The process of activation must, therefore, consist fundamentally in the separation and removal of the hydrocarbons from the active carbon. This active modification of carbon is formed whenever carbon is deposited at relatively low temperatures by chemical or thermal decomposition of carbon-bearing materials; in general, below 500° to 600° C.

Zerban has published in recent bulletins of the Louisiana Experiment Station most interesting results in regard to the preparation and properties of these carbons. Bradley[2] has recently published an excellent resumé of his results in the study of the properties of Norit. These and other pioneers have shown the way in beginning to develop this method of preparing and using decolorizing carbons. It remains for the subject to be followed up industriously to attain results that will amply repay all efforts in the investigations of these fascinating questions.

HISTORY OF THE PREPARATION AND PROPERTIES OF PURE PHTHALIC ANHYDRIDE

By H. D. Gibbs

E. I. du Pont de Nemours & Co., Wilmington, Delaware

Received July 1, 1920

A United States patent[3] recently granted, which claims *as an article of manufacture* "phthalic anhydride substantially chemically pure and having a melting point above 130° C., corrected" and "phthalic anhydride in the form of colorless, needle-like crystals substantially chemically pure and having a melting point above 130° C., corrected," raises the question of the history of the preparation and properties of pure phthalic anhydride, particularly of the melting point. As will be shown later in this article, phthalic anhydride of a degree of purity which undoubtedly exceeds that of the product described in this patent was prepared and described at least as early as 1902 by Van de Stadt,[4] and in 1919 (prior to the date of filing of the

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[1] *Chem. News*, **119** (1919), 283.

[2] *J. Soc. Chem. Ind.*, **38** (1919), 396.

[3] U. S. Patent 1,336,182, Phthalic Anhydride, issued April 6, 1920, to C. A. Andrews, assignor to the Selden Company of Pittsburgh, Pa. (Application filed October 14, 1919.)

[4] "Bernsteinsaüre und Phthalsaüre-anhydrid in ihrem Verhalten gegenüber Wasser," *Z. physik. Chem.*, **41** (1920), 353. Van de Stadt's excellent investigation carried out in Amsterdam in collaboration with Prof. Bakhuis Roozeboom has not received the attention which it deserves, since it has been overlooked by compilers of the standard organic treatises, such as Beilstein's "Organische Chemie," Richter's "Organic Chemistry," and Meyer and Jacobson's "Lehrbuch der Organischen Chemie," and also by the compilers of Landolt-Börnstein's "Physikalisch-Chemische Tabellen." It is, however, noted in a recent American treatise, Seidell's "Solubilities of Inorganic and Organic Compounds," 2nd Ed., D. Van Nostrand Co., New York, **1919**, p. 491.

application for U. S. Patent 1,336,182) by Monroe.[1] A process of manufacture by air oxidation (using vanadium and molybdenum oxides as catalysts) which yields a product in the form of "long, colorless, glistening needles,"[2] substantially chemically pure and having a melting point above 130° C. (corrected), has been described and patented by the author and C. Conover.[3]

It was early observed in the development of the air-oxidation process that the product melted above 130° C., and the author stated in an article published in THIS JOURNAL in 1919:[4] "It is interesting to note that phthalic anhydride produced by this process is of a remarkable degree of purity. Naturally, it is free from chlorine or sulfur compounds, common impurities in phthalic anhydride as formerly found on the market." Monroe's investigation was, indeed, carried out at my suggestion while we both were employed in the Color Laboratory of the Bureau of Chemistry, in view of the confusion which existed in the earlier literature and in the standard organic treatises in regard to the melting point of pure phthalic anhydride, and in the absence of knowledge concerning Van de Stadt's earlier investigation, to which Doctor Monroe has called my attention since the publication of his own article.

In view of these facts, the fallacy of the claims of Andrews to *pure phthalic anhydride as an article of manufacture* is very apparent. It is difficult to conceive the grounds upon which such a patent could have been granted. In order that the matter may be clarified, the following summary of chemical literature bearing on these topics is presented:

Phthalic anhydride was discovered at least as early as 1836 by Laurent,[5] who prepared the acid by oxidation of naphthalene with chromic acid, and obtained phthalic anhydride by sublimation of the acid. The melting point of the sublimed product recorded by this observer is 105°, concerning which Lossen[6] states:[7]

> 105° Réaumur corresponds to 131° Celsius (Centigrade). It appears, therefore, that Laurent carried out his observation with anhydride which contained some acid, and used a Réaumur thermometer....... I found the melting point of anhydride which was prepared by one sublimation of phthalic acid to be 131° C....... The large discrepancy between this and the value given by Laurent (105°) led me to repeat the determination. I used for these experiments phthalic acid prepared in various ways, which had been completely transferred into the anhydride by long-continued heating to the boiling point (of the anhydride) .... A large number of very careful determinations gave *consistently* 128° C. as the melting point.

Although conclusions of little value from the viewpoint of exact thermometry may be drawn, one may not altogether exclude the possibility that pure phthalic anhydride of substantially correct melting point (compare Van de Stadt and Monroe, *Loc. cit.*) was thus obtained even at this early date by its discoverer, and in one instance by Lossen.

Anschütz[8] prepared phthalic anhydride by the dehydration of phthalic acid with acetyl chloride, and found its melting point to be 127° C. No exact conclusions in regard to the melting point of pure anhydride may be drawn from this observation, however, since the crystals of anhydride were purified merely by pressing between filter paper after removal of acetyl chloride by absolute alcohol.

Lachowicz[1] prepared phthalic anhydride by warming phthalyl chloride with lead nitrate; the crude substance was purified by recrystallization from benzene. The melting point found (128° C.) agrees with the previous values of Lossen and Anschütz, although the method of purification is scarcely sufficient to eliminate all impurities.

Stohmann[2] prepared phthalic anhydride by distillation of commercial phthalic acid, and recrystallized the crude sublimate from benzene-ligroin mixture. The observed melting point (128° C.) is in agreement with that found by the previous investigators, but this work is open to the same criticism, the phthalic acid prepared by chromic or permanganic oxidation of naphthalene in sulfuric acid solution (with mercury sometimes present as a catalyst in large-scale operations) is well known frequently to contain sulfur and chlorine compounds[3] which are not readily removed by sublimation or recrystallization.

Indeed the first recorded investigation in which sufficient precautions were observed to insure a chemically pure anhydride, and in which the observations were recorded to have been taken, not in the capillary tube manner, but with thermometer immersed in the melt, is that of Van de Stadt,[4] who states:[5] "I determined the melting point (of phthalic anhydride purified by distillation) in a sealed tube with sealed-in thermometer, since the substance absorbs water readily, and in this manner obtained the value 131.2° C." Van de Stadt examined the melting points of various mixtures of anhydride and water, and also determined the eutectic temperature of phthalic anhydride and acid to be 129.6°. He describes the experimental procedure in some detail:

> A mixture of 95 molecular per cent anhydride and 5 molecular per cent water was heated in a small open tube and the point of a final solidification observed. In spite of constant stirring, a large portion of the mass remained liquid after copious crystallization had occurred until the temperature of 129.8° was reached, when a second crystallization occurred, during which the thermometer remained constant ± 8 minutes between 129.8° and 129.6°. Another mixture of 90 molecular per cent anhydride with 10 molecular per cent water also gave such a (eutectic) point at 129.7°, and the same phenomenon was observed very markedly with a mixture containing 70 and 30 molecular per cent.
>
> We see, therefore, that two distinctly different crystal forms appear (first acid and then anhydride). The first crystals may be agitated with the mother liquor without further crystallization occurring; they are, therefore, phthalic acid, which had been dissolved in the molten anhydride. Microscopic examination led to the same conclusion.

It is to be noted that the eutectic obtained by the very careful work of Monroe for the system phthalic anhydride–phthalic acid exactly checks the work of Van de Stadt, and the latter article was not discovered by Monroe until after the publication of his own work.

In view of the above statements of facts, it is evident that the purest phthalic anhydride is not a new product.

NEW FIELDS OF PHYTOCHEMICAL RESEARCH OPENED UP BY THE CULTIVATION OF MEDICINAL PLANTS ON AN ECONOMIC SCALE[6]

By Edward Kremers

UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN

The milling of half an acre of belladonna plants or the distillation of an acre of peppermint, when carried out by an ob-

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[1] THIS JOURNAL, **11** (1919), 1116. (Read before the Dye Section, 58th Meeting of the American Chemical Society, Philadelphia, Pa., September 2 to 6, 1919.)

[2] Monroe, *Loc. cit.*

[3] U. S. Patent 1,284,888. Process for the Manufacture of Phthalic Anhydride, Phthalic Acid, Benzoic Acid and Naphthoquinones, issued Nov. 12, 1918, to H. D. Gibbs and C. Conover (application filed May 12, 1917); U. S. Patent 1,285,117. Process for the Manufacture of Phthalic Anhydride, Phthalic Acid, Benzoic Acid and Naphthoquinones, issued November 19, 1918, to H. D. Gibbs and C. Conover (application filed February 17, 1917).

[4] "Phthalic Anhydride. I—Introduction," THIS JOURNAL, **11** (1919), 1034 (Received Aug. 19, 1919).

[5] *Rev. Scient.*, **14**, 560; *Compt. rend.*, **21**, 36; *Ann* , **19** (1836), 38.

[6] *Ann.*, **144** (1867), 76.

[7] Translated from the original German.

[8] *Ber.* **10** (1877), 326.

[1] *Ber.*, **17** (1884). 1283.

[2] *J. prakt. Chem.*, **40** (1889), 139.

[3] Gibbs, *Loc cit.*

[4] *Loc. cit.*; see also an earlier investigation by this author, *Z. physik. Chem.*, **31** (1899), 250; Bancroft, *J. Phys. Chem.*, **1899**, 93; Ramsay and Young, *Trans. Roy. Soc. London*, **117**, I 103.

[5] Translated from the original German.

[6] Presented at the 58th Meeting of the American Chemical Society, Philadelphia, Pa., September 2 to 6, 1919.

serving scientist, ought to be productive of results, new in more ways than one. To the scientist who has conducted his experiments on a relatively small laboratory scale, the problems which confront him in milling or distillation may result in solutions new to him although old to the technologist. The fact, however, that the technologist does not record his experiences for the benefit of the scientist may make the observations of value to others if recorded. It is not to fields, new in this sense, that the writer wishes to draw your attention. The cultivation of medicinal plants on a semi-economic scale and the working up of the harvest, whether fresh or cured, present to the observing scientist fields that are new in quite a different sense. To some of these, selected at random, and the lessons already learned from them, the writer desires to invite your attention.

DIGITALIS

At the meeting of the SOCIETY held at Urbana in April 1916, the writer presented to the Division of Pharmaceutical Chemistry specimens of digitalis that had been milled and sifted with a set of analytical sieves. Whereas the No. 20 powder prepared for an eastern hospital contained 10 per cent of ash, the No. 100 powder had an apparent content of nearly 80 per cent. The apparent ash content of the intermediate powders varied correspondingly according to the degree of fineness. This observation afforded a ready explanation of the greatly varying records of ash content of digitalis as found in literature.[1] Since that time a microscopical study of leaves with hairy surfaces and of the soil adhering to such leaves has been made by Tschirch.

The first lesson to be learned from this experience was a simple mechanical method of purifying digitalis and other leaves (hyoscyamus, sage, etc.). This method has already been adopted by others.

A second lesson is one for the analytical and government chemist. The Wisconsin Pharmaceutical Experiment Station certainly had no commercial motives when it gave some of its digitalis to eastern hospitals, yet, with all the care exercised in cultivation and curing, a so-called crude drug had been produced that yielded about 25 per cent of apparent ash. A high ash content—and ash standards have again come into greater prominence—does not necessarily indicate adulteration, not even carelessness. It may be largely a matter of the character of the soil on which the foxglove has been raised, or a question of rains, quite beyond the control of the grower.

A third lesson is revealed in the possibility of controlling the process of milling so as to yield the largest percentage of coarse powder, provided, naturally, that such is the object of the miller.

A fourth problem was suggested at the Urbana meeting by the late Mr. Wilbert, who pointed out that if the apparent ash consists largely of clay, the occluding effect of this admixture may be such as to interfere with the therapeutic effect of the active constituents. The solution of the problem will be a joint one for pharmacist and pharmacologist.

Still another problem is met in working up the by-products of the milling room for pharmaceutical preparations of desired strength or, better still, of definite chemical composition. These problems have been attacked and it is hoped may form the subjects for separate reports.

HYOSCYAMUS

When the milling experience worked out in connection with digitalis was applied to hyoscyamus by our pharmacognosist, Dr. W. O. Richtmann, and his assistant, Mr. F. Bacon, a striking observation was recorded. The ash determination happened to be made in the open laboratory rather than in the hood. In the assay of the fine powder there resulted a smoke which caused the occupants of the room to cough. No such result had occurred when the coarse powders had been incinerated. A microscopical examination of the fine powder revealed that it consisted not only of soil particles, but also of innumerable leaf hairs. Hence, aside from the lessons already learned from the milling experience with digitalis, we have several additional lessons to record.

The first of these is that in the milling of drugs we may have a very convenient means of separation of plant organs for special investigation, chemical or otherwise.

Second, Dr. Richtmann has been of the opinion, based on field observations, that the attraction of the plant for the potato beetle—this season all of the second year crop had to be harvested early in May because the potato beetle, finding no potato vines, threatened to devour every leaf—is due to a peculiar odor of the leaf. What more natural, therefore, than to infer that these leaf hairs are the reservoirs in which are stored the possible aldehydes, which on being heated in the crucible caused the irritation of the throat. Already a preliminary distillation with water vapor of the fine powder, rich in plant hairs, as well as soil particles, has been made. It is expected that after the 1919 crop has been milled a sufficient amount of this fine powder will have been separated to make possible a careful study of this problem.

Last and possibly not least, if the odoriferous substances of the hyoscyamus that attract the beetles can be identified, it may be possible to attract the beetles to traps containing these substances and to save the crop for further growth.

PEPPERMINT

The cultivation of an acre of peppermint during the season of 1917 enabled the Station to initiate a series of experiments[1] in distillation. Mr. Norbert Mueller, the government expert, distilled the fresh peppermint harvested late in the summer of that season and Professor E. R. Miller, at the time chemist of the Station, cohobated the aqueous distillate which had been saved for that purpose. Suffice it here to call attention to the following points:

First, the additional oil obtained by cohobation amounted to about 10 per cent of the oil obtained by the first separation. This oil differs materially, quantitatively if not qualitatively, from the regular crude, *i. e.*, non-rectified peppermint oil, and hence invites special study.

Second, for every liter of oil separated a liter of water-soluble constituents was obtained by repeated cohobation, or, to put it in other words: For a thousand-acre peppermint farm we have been throwing away from one to two thousand liters of organic chemicals.

Third, whether or not these observations prove of economic importance, their biochemical significance is in no way diminished.

Just as the commercial drug miller has kept his experiences largely to himself, so the distiller of peppermint and other aromatic herbs has not infrequently kept his observations to himself. For the most part he has not found the time in the rush of the season to interrupt his commercial production and to indulge in experiment. At times also he has not been in a position to interpret properly such observations as he has made.

The distillation of plants and parts of plants in the production of volatile oils has proven one of the most satisfactory methods of isolation in phytochemistry. Yet in comparatively few instances have the less striking water-soluble volatile constituents received any attention whatever.

The experiment with peppermint could not be repeated in 1918 because of the winter-killing of the mint. During the present season, however, the aqueous distillate is again being collected for cohobation. During the season of 1917 Professor Miller collected the aqueous products of a number of distillations, and his results are soon to be published as a Station circular.[2]

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[1] A compilation of ash determinations of vegetable drugs has been prepared by several students, but the voluminous manuscript has not yet been edited for publication.

[1] Wisconsin Pharmaceutical Experiment Station, *Circular* **9**.

[2] University of Wisconsin, *Bulletin* **1024**.

During the present season Roland E. Kremers, who carried out a number of distillations for the Station, has collected and cohobated the aqueous distillates of wormwood, tansy, peppermint, and milfoil. The aqueous distillates of *Monarda punctata* and *M. fistulosa* will be collected by D. C. L. Sherk, who will also supplement Professor Miller's study of *M. fistulosa* by a parallel examination of *M. punctata*.

If it required years of study to isolate and identify the oily constituents of plants, it will, no doubt, require years and years to study their water-soluble volatile constituents. If for years the writer has desired to devote to these latter constituents such attention as they seem to merit, he has also wanted, for the same length of time, to study those products which escape from the condenser and are not collected either in the separated oil or in the aqueous cohobate. The study of these escaping vapors will require, as experience has already shown, specially constructed condensers and absorbers. Thus will be trebled in size, as it were, this one field of phytochemistry.

In bringing to your attention some of our milling and distillation problems, the writer has not attempted to solve any milling or distillation difficulties from a technological point of view, but has desired to point out how large technological operations and the biochemical study of plants should work hand in hand for the advancement of plant chemistry.

A COMPARISON OF ACCURACY IN ANALYSIS OF METALLURGICAL MATERIALS DURING THE PAST TWENTY-FIVE YEARS

By E. D. Campbell and George F. Smith

University of Michigan, Ann Arbor, Michigan

Received June 5, 1920

It has been only a little more than 50 years since steel manufacturers realized the necessity of chemical control of their finished product, and the consequent necessity of knowing the composition of the various materials entering into the process, and the changes taking place during the various steps between the raw materials and the finished steel. During the 70's and 80's, chemists of many metallurgical companies developed a practice of exchanging carefully prepared and analyzed samples of steel and ores, in order to compare the accuracy of the results obtained by different chemists working on the same sample.

In February 1889, the late John W. Langley, in an address before the Engineering Society of Western Pennsylvania, advocated the preparation of a set of steels which should be analyzed by a number of leading chemists in different countries and should then constitute international standard steels. This idea Langley developed in a second paper.[1] Committees on analysis were formed in England, Sweden, the United States, France, and Germany. Some preliminary bulletins were prepared during the next three years and the results of the analyses, representing the work of the committees from the first three countries named, were published in the *Chemical News* for September 29, 1893.

It was the intention of the American committee, when the results of the analyses had been collected, to have the principal part of the American portion of the five international standard steels kept in some suitable depository, so that small samples could be distributed to such chemists as might be entitled to them. The chemical laboratory of the University of Michigan was selected as a suitable depository and the five standard steels were deposited there in September 1893.

Very little of this material was ever called for, and recently a large bottle of each of the five original international standard steels was sent to the Bureau of Standards to be kept because of their historic interest.

Although analytical chemists continued to feel the need of some means of determining the accuracy of analytical methods, and the variations which might be expected between different chemists working on the same material, it was nearly ten years later that the Bureau of Standards at Washington instituted a system of preparing carefully analyzed samples, which would cover a wider field than that of steel alone.

In the summer of 1895 one of the authors gave a paper before Section C of the A. A. A. S. on "A Proposed Schedule of Allowable Differences and of Probable Limits of Accuracy in Quantitative Analyses of Metallurgical Materials."[1] The following quotation outlines the object and method of arriving at the values shown in Table I, which are taken from a longer table in the original paper:

> Many methods for the determination of the various elements usually met with in metallurgical work have been proposed, each having its own claim for accuracy, or rapidity, or both, but as will be seen from the efforts of the international committee on the analysis of iron and steel, we are far from having perfect methods for metallurgical analysis.
>
> There are many sources of error in ordinary quantitative determinations, which, while they can be partially avoided, can never be wholly overcome. Among these may be mentioned such errors as arise from solubility of precipitates, solubility of apparatus in which operations are performed, impurities in chemicals, inaccurate graduation of volumetric apparatus, unavoidable error in accuracy of weighing, and last, but not least, errors due to what may be termed the personal equation, the presence or absence in the operator of that manipulative skill which distinguishes an expert from a clumsy worker. Since we cannot expect absolute agreement in results, it may be asked how close should quantitative determinations agree? This question cannot be answered by a single figure, since the unavoidable errors in the various determinations differ according to the element determined and the method used in the analysis. Just how great a difference between determinations should be allowed and what the probable limit of accuracy which may be hoped for, is largely a matter of judgment based upon the examination of the results obtained by different chemists, known to be careful operators, working upon the same material.
>
> Basing our judgment upon the usual errors of analysis, upon the commercial requirements of accuracy and upon the unavoidable sources of error we would propose the following schedule of allowable differences and of probable limits of accuracy for discussion in the section. In the table below the first column shows the element or constituent determined; the second, a formula for calculating the difference which might be reasonably expected between the results of two chemists working upon the same material, and the third column shows a formula for calculating the probable minimum error which may be hoped for.

TABLE I

ELEMENT OR CONSTITUENT	Allowable Difference of Per cent	Probable Limit of Accuracy
	Iron and Steel	
Graphitic carbon..	$\pm[0.050 + (0.02 \times Cg)]$	$\pm[0.005 + (0.005 \times Cg)]$
Combined carbon in cast iron.....	$\pm[0.050 + (0.02 \times Cc)]$	$\pm[0.005 + (0.005 \times Cc)]$
Carbon in steel....	$\pm[0.010 + (0.02 \times C)]$	$\pm[0.002 + (0.003 \times C)]$
Silicon...........	$\pm[0.005 + (0.02 \times Si)]$	$\pm[0.002 + (0.003 \times Si)]$
Sulfur...........	$\pm[0.003 + (0.03 \times S)]$	$\pm[0.0005 + (0.005 \times S)]$
Phosphorus.......	$\pm[0.002 + (0.02 \times P)]$	$\pm[0.0002 + (0.005 \times P)]$
Manganese in cast iron and steel...	$\pm[0.005 + (0.04 \times Mn)]$	$\pm[0.001 + (0.005 \times Mn)]$
Nickel...........	$\pm[0.050 + (0.02 \times Ni)]$	$\pm[0.005 + (0.005 \times Ni)]$
	Ores	
Silica...........	$\pm[0.050 + (0.006 \times SiO_2)]$	$\pm[0.005 + (0.001 \times SiO_2)]$
Alumina.........	$\pm[0.030+(0.003 \times Al_2O_3)]$	$\pm[0.005+(0.001 \times Al_2O_3)]$
Iron.............	$\pm[0.020 + (0.003 \times Fe)]$	$\pm[0.004 + (0.001 \times Fe)]$
Manganese.......	$\pm[0.050 + (0.003 \times Mn)]$	$\pm[0.005 + (0.001 \times Mn)]$
Calcium oxide....	$\pm[0.050 + (0.002 \times CaO)]$	$\pm[0.010 + (0.001 \times CaO)]$
Magnesia.........	$\pm[0.050+(0.010 \times MgO)]$	$\pm[0.005 + (0.002 \times MgO)]$
Phosphorus.......	$\pm[0.002 + (0.02 \times P)]$	$\pm[0.0002 + (0.005 \times P)]$
Phos. pentoxide...	$\pm[0.005 + (0.02 \times P_2O_5)]$	$\pm[0.0005+(0.005 \times P_2O_5)]$

The object of the present paper is to bring out, by a comparison of variations computed from the table with those actually found by skilled observers working on the same sample, the desirability of some such formulas for comparing the work of different analysts, and to emphasize the fact that the proportionate variations in the determination of elements, especially those occurring in small quantities, are larger than is generally realized.

Undoubtedly the most valuable data for such a comparison are those given in the certificates of analyses issued by the Bureau

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[1] "International Standards for the Analysis of Iron and Steel," *Trans. Am. Inst. Mining Eng.*, October 1890.

[1] *J Am. Chem. Soc.*, 18 (1896), 35.

Table II—Silicon Determination in Cast Iron

Allowable Difference of Per cent ± [0.005 + (0.02 × Si)]			Individual Observers Maximum + and — Deviation from Certificate Value						Probable Limit of Accuracy ± [0.002 + (0.003 × Si)]		
B. of S. Sample	B. of S. Certificate Value	Allowable Difference Formula Applied	Method A Drown's Method +	Method A Drown's Method —	No. Observers	Method B Other Methods +	Method B Other Methods —	No. Observers	Limit of Accuracy Formula Applied	Proportion Observers within Limit of Accuracy	Per cent within Limit of Accuracy
Iron B	1.267	±0.030	..	..	..	+0.045	—0.032[1]	5	±0.006	1/5	20
Iron B 4*b*	1.34	±0.032	+0.06	—0.07	4	+0.03	—0.04[2]	7	±0.006	4/11	36
Iron B 4*a*	1.37	±0.032	+0.056	—0.044	11	..	..	..	±0.006	5/11	45
Iron C	1.720	±0.039	..	..	..	+0.040	—0.020[1]	5	±0.007	3/5	60
Iron C 5*a*	1.84	±0.042	+0.03	—0.03	11	..	..	..	±0.008	4/11	36
Iron C 5*b*	1.84	±0.042	+0.04	—0.02	8	+0.04	—0.02[1]	5	±0.008	8/13	60
Iron C 5*c*	1.85	+0.042	+0.02	—0.03	4	+0.06	—0.06[2]	9	±0.008	2/13	15
Iron E	2.21	±0.049	+0.05	—0.03	7	+0.02	—0.03[1]	4	±0.009	6/11	55
Iron D 6*a*	2.57	±0.056	+0.05	—0.04	9	+0.06	—0.08[1]	6	±0.010	6/15	40
Iron D 6*b*	2.59	±0.057	+0.06	—0.06	6	+0.04	—0.04[1]	5	±0.010	2/11	18
Iron D	2.64	±0.058	..	..	..	+0.04	—0.03[1]	5	±0.010	1/5	20

[1] Method not stated.

[2] HCl dehydration.

Table III—Carbon Determination in Steel

Allowable Difference of Per cent ± [0.010 + (0.02 × C)]			Individual Observers Maximum + and — Deviation from Certificate Value						Probable Limit of Accuracy ± [0.002 + (0.003 × C)]		
B. of S. Sample	B. of S. Certificate Value	Allowable Difference Formula Applied	Method A Direct Combustion +	Method A Direct Combustion —	No. Observers	Method B Solution and Combustion +	Method B Solution and Combustion —	No. Observers	Limit of Accuracy Formula Applied	Proportion Observers within Limit of Accuracy	Per cent within Limit of Accuracy
Bessemer 8*b*	..	...	...	...	..	...	...	..	...	..	..
Bessemer 8*a*	0.084	±0.012	+0.003	—0.002	7	+0.007	—0.003	7	±0.002	8/14	57
Acid O. H. 0.1	0.103	±0.012	+0.003	—0.005	4	+0.021	—0.010	6	±0.002	3/10	30
Basic O. H. 15*a*	0.111	±0.012	+0.007	—0.003	6	+0.005	—0.007	6	±0.002	5/12	42
Bessemer 9*b*	0.184	±0.014	+0.015	—0.019	9	...	...	1	±0.003	1/ 9	11
Acid O. H. 19*a*	0.207	±0.014	+0.018	—0.010	9	+0.008	—0.012	4	±0.003	1/13	8
Acid O. H. 0.2	0.208	±0.014	+0.018	—0.007	4	+0.022	—0.017	6	±0.003	1/10	10
Basic O. H. 11*b*	0.211	±0.014	+0.014	—0.006	9	...	...	1	±0.003	7/ 9	77
Basic O. H. 11*a*	0.225	±0.014	+0.017	—0.003	6	+0.013	—0.017	6	±0.003	8/12	58
Basic O. H. 0.2	0.242	±0.015	+0.014	—0.013	3	+0.014	—0.015	8	±0.003	4/11	36
Bessemer 9*a*	0.254	±0.015	+0.006	—0.007	7	+0.006	—0.003	7	±0.003	10/14	71
Ni Steel 33	0.278	±0.016	+0.012	—0.012	7	+0.018	—0.010	4	±0.003	3/11	27
Cr-V Steel 30*a*	0.290	±0.016	+0.014	—0.016	10	...	...	..	±0.003	4/10	40
V Steel 24	0.350	±0.017	+0.024	—0.018	8	+0.009	—0.010	5	±0.003	3/13	23
Cr-Ni Steel 32	0.364	±0.017	+0.005	—0.003	6	+0.009	—0.009	7	±0.003	5/13	38
Basic O. H. 12*a*	0.372	±0.017	+0.015	—0.018	7	+0.010	—0.017	5	±0.003	5/12	42
Bessemer 10*b*	0.373	±0.017	+0.009	—0.015	8	+0.010	—0.006	7	±0.003	5/15	33
Cr-V Steel 30	0.373	±0.017	+0.013	—0.022	9	+0.010	—0.008	5	±0.003	3/14	21
Acid O. H. 0.4	0.377	±0.018	+0.012	—0.015	6	+0.013	—0.019	5	±0.003	2/11	18
Acid O. H. 20*a*	0.392	±0.018	+0.011	—0.013	9	...	...	1	±0.003	4/ 9	44
Basic O. H. 12*b*	0.409	±0.018	+0.005	—0.005	9	...	...	1	±0.003	6/ 9	67
Basic O. H. 0.4	0.436	±0.019	+0.021	—0.012	3	+0.023	—0.019	8	±0.003	3/11	27
Bessemer 0.4 Re.	0.453	±0.019	+0.014	—0.021	6	+0.018	—0.014	6	±0.003	1/12	8
Bessemer 22*a*	0.578	±0.022	+0.011	—0.011	8	...	...	1	±0.004	1/ 8	13
Basic O. H. 13*a*	0.581	±0.022	+0.010	—0.012	7	+0.009	—0.017	6	±0.004	2/13	15
Acid O. H. 0.6	0.591	±0.022	+0.016	—0.009	6	+0.011	—0.010	6	±0.004	4/12	33
Bessemer 22	0.592	±0.022	+0.019	—0.018	9	+0.005	—0.010	3	±0.004	4/12	33
Cr-W Steel 31	0.599	±0.022	+0.011	—0.014	10	...	...	..	±0.004	6/10	60
Acid O. H. 21*a*	0.617	±0.022	+0.008	—0.016	9	...	...	1	±0.004	6/ 9	67
Bessemer 23	0.805	±0.026	+0.011	—0.015	9	+0.006	—0.004	3	±0.004	4/12	33
Basic O. H. 14*a*	0.815	±0.026	+0.011	—0.012	7	+0.005	—0.014	6	±0.004	7/13	56
Acid O. H. 34	0.84	±0.027	+0.01	—0.01	8	+0.01	—0.01	6	±0.005	2/14	14
Basic O. H. 16*a*	0.998	±0.030	+0.021	—0.017	8	+0.010	—0.007	5	±0.005	4/13	31
Acid O. H. 35	1.03	±0.031	+0.01	—0.02	7	+0.01	—0.02	5	±0.005	1/12	8
Basic O. H. 1.0	1.049	±0.031	+0.011	—0.014	4	+0.026	—0.018	9	±0.005	5/13	46

of Standards. Through the courtesy of the director of the Bureau, a complete set of these certificates has been received by this laboratory. These certificates extend from 1906 to 1919, inclusive, and may fairly be taken as representing the best practice during these years. All certificates, to the certificate value of which five or more observers contributed, and which were applicable to the above table, were included in the comparisons following.

In order to make these comparisons, itemized tables were made out for each element: six for the elements in cast iron; six for those in steel; and eight for iron and manganese ores. Each itemized table represents from 2 to 34 different samples, with not less than five observers reporting on each sample, while in six cases reports were submitted by more than 20 observers. The reason for the absence in the original table of formulas for computing elements so commonly found in alloy steels is easily seen in the date of publication, since at that time nickel steels were about the only ones in general use. From the itemized tables, summarized tables were made up, the method of computing the average values and deviations being similar to that used by the Bureau of Standards in computing certificate values, since the number of observers reporting each value was taken into consideration.

The descriptive heading of each itemized table shows the element determined and the formula for computing the allowable difference of per cent and the probable limit of accuracy. The different columns of the table represent: first, the Bureau of Standards sample with number; second, the certificate value; third, the allowable difference computed by applying the formula to the certificate value. The next four columns show the maximum + and — deviation from the certificate value with the number of observers reporting on each method, where more than one method was employed. In general, when more than one method was used, that which was most popular, as shown by the number of observers, is designated "A," while the next in number of observers is called "B." The eighth column shows the probable limit of accuracy computed by applying the formulas to the certificate value. The ninth column shows the fractional proportion of the total observers whose values come within the probable limit of accuracy, while the last column expresses this same value in per cent.

As silicon in cast iron and carbon in steel are two of the most frequent determinations required of steel-works chemists, the itemized tables (Tables II and III) for these two determinations are given as being typically representative of all.

In Table IV are shown the summarized results of these values. The first column shows the number of samples included in the itemized table from which the summarized values are computed. The second column gives the element determined, the third the range of certificate values in per cent, the fourth the average value, and the fifth the average allowable deviation computed by applying the formula to the average per cent. The next four columns show the averages of the maximum + and — deviations from the averages, together with the average number of observers by Methods A and B, as defined in describing the itemized tables. In the tenth column is given the average

Table IV—Summarized Results for Cast Iron and Steel

No. Standards	Element Determined	Range of Certificate Values in Per cent	Mean Cert. Value	Allowable Difference Formula Applied to Cert. Value	Maximum + and — Deviations from Certificate Value						Limit of Accuracy Formula Applied to Mean	Proportion Observers within Limit of Accuracy	Per cent within Limit of Accuracy
					Method A		No. Observers	Method B		No. Observers			
					Cast Iron								
10	Graphite C	1.79 –3.27	2.27	±0.10	+0.05	—0.07	8	...	...	..	±0.016	31/ 83	37
10	Combined C	0.38 –0.67	0.55	±0.06	+0.05	—0.05	8	...	...	..	±0.008	27/ 82	33
11	Silicon	1.267–2.64	1.93	±0.04	+0.05	—0.04	7	+0.04	—0.04	6	±0.008	42/111	38
11	Sulfur	0.030–0.062	0.041	±0.004	+0.004	—0.004	9	+0.004	—0.004	6	±0.001	70/162	43
11	Phosphorus	0.092–0.862	0.331	±0.009	+0.010	—0.008	5	+0.006	—0.006	5	±0.002	37/ 98	38
11	Manganese	0.444–1.54	0.945	±0.042	+0.016	—0.012	7	+0.013	—0.023	4	±0.006	58/ 98	59
					Steel								
34	Carbon	0.084–1.049	0.453	±0.019	+0.012	—0.013	7	+0.012	—0.012	6	±0.003	138/395	35
35	Silicon	0.003–0.303	0.120	±0.007	+0.006	—0.006	6	+0.007	—0.007	6	±0.002	154/369	42
35	Sulfur	0.019–0.103	0.045	±0.004	+0.003	—0.003	7	+0.004	—0.004	7	±0.001	244/485	50
35	Phosphorus	0.006–0.120	0.053	±0.003	+0.002	—0.003	5	+0.002	—0.003	4	±0.0005	122/301	40
35	Manganese	0.154–0.918	0.647	±0.030	+0.011	—0.011	7	+0.027	—0.024	6	±0.004	97/313	31
2	Nickel	1.62– 3.33	2.475	±0.100	+0.035	—0.025	9	...	...	..	±0.017	13/ 18	72

Table V—Iron and Manganese Ores

B. of S. Sample	Determination	B. of S. Cert. Value	Allowable Difference Formula Applied	Individual Observers Maximum + and — Deviation from Certificate Value						Limit of Accuracy Formula Applied	Proportion Observers within Limit of Accuracy	Per cent of Observers within Limit of Accuracy
				Method A		No. Observers	Method B		No. Observers			
"Sibley" Iron Ore 27	SiO_2	0.75	±0.10	+0.11	—0.07	21	..	..	..	±0.006	9/21	43
Magnetite Ore 29	SiO_2	12.02	±0.12	+0.09	—0.06	5	..	..	..	±0.017	2/5	40
Crescent Iron Ore 2*b*	Al_2O_3	1.03	±0.03	+0.04	—0.03	9	+0.07	—0.03	17	±0.006	12/26	46
Magnetite Ore 29	Fe	55.75	±0.19	+0.08	—0.10	6	..	..	..	±0.06	3/6	50
"Sibley" Iron Ore 27	Fe	69.11	±0.23	+0.11	—0.26	9	+0.20	—0.18	19	±0.07	11/29	38
"Norrie" Iron Ore 28	Mn	0.484	±0.05	+0.036	—0.044	24	..	..	..	±0.005	4/24	16
Manganese Ore 25	Mn	56.36	±0.22	+0.09	—0.27	5	+0.27	—0.20	11	±0.06	4/16	25
Crescent Iron Ore 26	CaO	2.64	±0.06	+0.26	—0.19	25	..	..	..	±0.013	1/25	4
Crescent Iron Ore 26	MgO	3.44	±0.08	+0.32	—0.22	25	..	..	..	±0.011	2/25	8
"Sibley" Iron Ore 27	P	0.037	±0.003	+0.004	—0.002	22	..	..	..	±0.0004	4/22	20
Magnetite Iron Ore 29	P_2O_5	1.01	±0.025	+0.01	—0.00	5	..	..	..	±0.0055	5/5	100

probable limit of accuracy computed by applying the formula to the average per cent. Column 11 gives in fractional proportion the number of all observers coming within the probable limit of accuracy, while in the twelfth column is shown the same value in per cent.

As comparatively few iron and manganese ores have been analyzed and certificates issued, the results of those determinations on which five or more observers have reported are given in Table V, which has been prepared by substantially the same system as that used to show the values for iron and steel.

A study of the results given in Table IV shows a very satisfactory agreement between the computed allowable deviation and that actually found by skilled workers in the case of the carbon, silicon, phosphorus, and sulfur, and the fact that considerably less than half of these experienced chemists come within the probable limit of accuracy bears out the original conclusion that insistence on agreement inside the computed limit of accuracy would be unreasonable. The close agreement of the deviations actually found with those computed is dependent on an allowable difference of more than two per cent of the element determined, a larger experimental difference than chemists usually realize.

The two exceptions, manganese and nickel, indicate very clearly the result of the improvements which have been made since 1895 in the methods for determining these two elements. The bismuthate method for manganese was first published in 1895, while the dimethylglyoxime method for nickel is of much more recent origin.

In view of the largely increased number of elements which metallurgical chemists are called upon to determine, there seems to be need of a schedule somewhat similar to that given in Table I for computing allowable differences and probable limits of accuracy, but extended to take in all the elements determined, the formula being modified where necessary to bring the results in close accord with the best modern practice. If such a revised schedule were prepared under the supervision of the Bureau of Standards, and issued with the certificates accompanying the analyzed samples sent out, it would be of much service to chemists in checking up the accuracy of their own work and in interpreting chemical specifications.

SCIENTIFIC SOCIETIES

SIXTIETH MEETING AMERICAN CHEMICAL SOCIETY, CHICAGO, ILL., SEPTEMBER 6 TO 10, 1920

PROGRAM OF PAPERS

GENERAL SESSIONS

Julius Stieglitz, Honorary Chairman. Address of Welcome.

Joseph R. Noel, President of the Noel State Bank and Vice President, Chicago Association of Commerce. Address of Welcome.

W. A. Noyes, President, American Chemical Society. Response.

Thomas E. Wilson, President, Wilson & Co. The Value of Technical Training in the Reconstruction of Industries.

A. S. Loevenhart, Head of Department of Pharmacology of the University of Wisconsin. Chemistry's Contribution to the Life Sciences.

H. P. Talbot. Relation of Educational Institutions to the Industries.

W. A. Patrick. Some Uses of Silica Gels.

W. A. Noyes. President's Address—Chemical Publications.

AGRICULTURAL AND FOOD CHEMISTRY DIVISION

C. E. Coates, *Chairman* T. J. Bryan, *Secretary*

1. Edward Gudeman. Antitoxins as Food Preservatives.
2. Melvin De Groote. The Solubilities of Vanillin and Coumarin in Glycerol Solutions.
3. Henry A. Schuette and M. Josephine Prichett. A Study of the Determination of Fat in Casein.
4. R. H. Carr. Do Greens Aid the Growth of Chicks in Confinement?
5. C. H. Bailey. The Hydroscopic Moisture of Flour Exposed to Atmospheres of Different Humidities.
6. F. C. Cook. The Composition of the Tubers, Skins, and Sprouts of Three Varieties of Potatoes.
7. F. C. Cook. Pickering Bordeaux Sprays.
8. William Brinsmaid. A Test for Annatto in Fats and Oils. (By title.)

BIOLOGICAL CHEMISTRY DIVISION

R. A. Gortner, *Chairman* A. W. Dox, *Secretary*

1. Howard B. Lewis and Genevieve Stearns. Diet and Sex as Factors in Creatinuria in Man.
2. Carl O. Johns and A. J. Finks. Nutritive Value of the Proteins of Tomato Seed Press Cake. (Lantern.)
3. D. B. Jones and Carl O. Johns. Hydrolysis of the Globulin of the Coconut, *Cocos nucifera*. (Lantern.)
4. Carl O. Johns and Chas. E. F. Gersdorff. The Globulin of the Cohune Nut, *Attaleo cohune*. (Lantern.)
5. Carl O. Johns and Henry C. Waterman. Some Proteins of the Mung Bean, *Phaseolus aureus*. (Lantern.)

6. J. S. Hughes. The Effect of the Fat-soluble Vitamine Content of a Feed on the Fat-soluble Vitamine Content of Adipose Tissue. (Lantern.)
7. Arthur D. Hirschfelder, M. C. Hart and F. J. Kucera. The Local Anesthetic and Antiseptic Applications of Saligenin and Its Derivatives and Allied Compounds.
8. H. C. Gore. Occurrence of Diastase in the Sweet Potato in Relation to the Preparation of Sweet Potato Sirup.
9. A. D. Emmett. Polyneuritis as Influenced by the Amount of Protein and Carbohydrate Present.
10. A. R. Lamb. The Acid-Base Balance in Animal Nutrition. IV—The Tolerance of Rabbits to Acid Rations over Long Periods of Time.
11. V. E. Nelson and A. R. Lamb. Further Studies on the Effect of Fat-soluble Vitamine Deficiency.
12. J. F. McClendon. The Hydrogen-Ion Concentration of the Contents of the Small Intestine.
13. S. L. Jodidi, S. C. Moulton and K. S. Markley. A Mosaic Disease of Cabbage as Revealed by Its Nitrogen Constituents.
14. R. Adams Dutcher, Cornelia Kennedy and C. H. Eckles. The Influence of the Diet of the Cow upon the Fat-soluble and Water-soluble Vitamine of Cow's Milk.
15. R. Adams Dutcher, C. H. Eckles, C. D. Dahle, S. W. Mead and O. G. Schaefer. The Influence of the Diet of the Cow upon the Antiscorbutic and Nutritive Properties of Cow's Milk.
16. R. Adams Dutcher and S. D. Wilkins. The Influence of the Diet upon the Growth and Development of Testes and Adrenals in White Leghorn Cockerels.
17. R. Adams Dutcher, Geo. E. Holm and Harlow Bierman. Further Observations of the Antineuritic Properties of Chemical Substances.
18. Paul Francis Sharp and Ross Aiken Gortner. A Study of Certain Physicochemical and Colloidal Properties of the Glutens from Strong and Weak Flours.
19. C. H. Bailey and S. D. Wilkins. Further Observations on the Relation between the Imbibition of the Gluten and the Strength of Wheat Flour.
20. Geo. E. Holm and Walter F. Hoffman. Some Observations on the Isolation of Cystine from Keratin.
21. J. J. Willamann and M. Sandstrom. Biochemistry of Plant Diseases. III—Effect of the Brown Rot Organism on Plums.
22. Edgar J. Witzemann. The Apparently Specific Effect of Ammonia on the Oxidation of Butyric Acid with Hydrogen Peroxide.
23. F. M. Huntoon, Peter Masucci and E. Hannum. Antibody Studies. III—A Preliminary Report on the Chemical Nature of Bacterial Antibodies.
24. Sergius Morgulis and Victor E. Levine. The Non-catalase Decomposition of Hydrogen Peroxide by Aromatic Hydrocarbons and Their Derivatives.
25. Sergius Morgulis and Victor E. Levine. The Dynamics of the Catalase Reaction.
26. Victor E. Levine. The Action of Proteins on the Phenol Reagent of Folin and Dennis.
27. C. F. Langworthy and H. J. Deuel. Digestibility of Some Raw Starches.
28. Pauline M. Avery, R. R. Mellon and S. F. Acree. Uses in Biological Sciences for Standardized Sterile Buffer Tablets and for a Single Sterile Buffer Solution Covering All P_h Values.
29. Pauline M. Avery, R. R. Mellon and S. F. Acree. On the Ionization Constant of Glycerophosphoric Acid and the Use of Carbohydrate Phosphate as Buffers and Nutrients, Especially in Culture Media.
30. J. H. Hopfield, J. B. Halstead, Marguerite A. Brennan and S. F. Acree. Hydrogen Electrode Measurements of the Acid and Basic Ionization Constants of Asparaginic Acid and Its Value as a Buffer and Nutrient Material in Culture Media.
31. A. W. Homberger and B. Mathin. The Nitrogenous Constituents of Condensed Milk as Compared with Fresh Milk.
32. Chi Che Wang and Mamie Dentler. The Creatinine and the Creatine of the Blood of Normal Women.
33. Harper F. Zoller. The Buoying Up of the Equilibrium of Milk Salts during Heat Treatment.
34. Harper F. Zoller. Hydrogen-Electrode Study of the Curdling in Casein Solution at High Temperature.
35. H. C. Hamilton. Chemistry of Digitalis.

DYE CHEMISTRY DIVISION

Charles L. Reese, *Chairman* R. Norris Shreve, *Secretary*

1. A. S. Wheeler. New Naphthalene Dyes.
2. J. H. Carpenter. Applications of Maleic and Fumaric Acids and their Salts to the Textile Industry.
3. E. R. Brunskill. The Anilides of β-Oxynaphthoic Acid.
4. R. E. Rose. The Education of the Research Chemist.
5. Harry McCormack. Extraction of Resorcinol from the Alkali Melt.
6. Louis E. Wise. Photosensitizing Dyes. (Lantern.)
7. Louis A. Mikeska. The Preparation of Lepidine and Related Bases. (Lantern.)
8. E. Q. Adams and Herbert L. Haller. Isocyanine Dyes from Lepidine and Its Homologs. (Lantern.)
9. E. Q. Adams and H. L. Haller. Kryptocyanines: A New Series of Photosensitizing Dyes. (Lantern).
10. Louis A. Mikeska, Herbert L. Haller and Elliot Q. Adams. Synthesis of Photosensitizing Dyes. II—Dicyanine. (Lantern.)
11. Joseph A. Ambler. Naphthalene Sulfonic Acids. III—An Alternative Method for the Qualitative Detection of Naphthalene-2,7- and 1,6-Disulfonic Acids. (Lantern.)
12. D. F. J. Lynch. Substituted Naphthalene Sulfonic Acids. I. (Lantern.)
13. C. E. Senseman. Benzene Disulfonic Acid from Benzene Monosulfonic Acid. (Lantern.)
14. M. L. Crossley. Qualifications of Organic Chemists.
15. C. B. Ogilvie, G. S. Simpson and M. L. Crossley. Standard Laboratory Equipment.
16. M. L. Crossley. Actions of Sulfuric Acid on Nitro Carbocyclic Compounds.

FERTILIZER DIVISION

F. B. Carpenter, *Chairman* H. C. Moore, *Secretary*

I—Papers

1. J. W. Turrentine. Kelp as a Basis of an American Potash Industry.
2. C. H MacDowell. Relationships of Chemistry and the Fertilizer Industry.
3. E. G. Proulx. A Perfect Fertilizer Law.
4. J. E. Breckenridge. Boron in Relation of the Fertilizer Industry.
5. J. M. Bartlett. The Quantitative Estimation of Borax in Mixed Fertilizers.
6. F. B. Carpenter. Note on the Determination of Nitrogen in Fertilizers Containing Both Organic and Nitric Nitrogen.
7. Rolla N. Harger. Dicyanodiamide. A Rapid Direct Method for Its Determination in Cyanamid and Mixed Fertilizers.
8. Rolla N. Harger The Changes Taking Place in Cyanamid when Used in Mixed Fertilizers.
9. R. D. Caldwell and H. C. Moore. Some Results of Determination of Potash by the Lindo-Gladding Method Using Alcohol of Various Strengths in the Presence of Sodium Salts.
10. F. B. Carpenter. Injurious Effects of Borax on Field Crops.
11. B. F. Robertson. The "Blank" in the Kjeldahl Process; Its Analytical and Commercial Significance.
12. M. M. Austin and S. W. Parr. Potash Shales of Illinois.
13. H. A. Huston. Potash Situation in Germany.

II—Reports of Committees

1. Sampling. F. S. Lodge, *Chairman.*
2. Fertilizer Legislation. J. E. Breckenridge, *Chairman.*
3. Research and Analytical Methods. Paul Rudnick, *Chairman.*

INDUSTRIAL AND ENGINEERING CHEMISTRY DIVISION

H. D. Batchelor, *Chairman* H. E. Howe, *Secretary*

I—Symposium on Cellulose Chemistry

1. Chas. Baskerville and Clarence M. Joyce. Regenerating Book Stock.
2. Chas. Baskerville and Reston Stevenson. Recovering News Print.
3. Louis Kahlenberg. Cellulose Content of Various Compound Celluloses.
4. Harold Hibbert. The Constitution of Cellulose.
5. E. C. Sherrard and G. W. Blanco. Acid Hydrolysis of Sugar-cane Fiber and Cottonseed Hulls.
6. E. C. Sherrard and G W. Blanco. The Preparation and Analysis of a Cattle Food Consisting of Hydrolyzed Sawdust.
7. S. A. Mahood and D. E. Cable. A Comparison of Wood Cellulose and Cotton Cellulose.
8. Hugh P. Baker. Supply and Preparation of Wood for the Manufacture of Pulp.
9. J. E. Minor. Parchmentizing Paper and the Reaction of Mordants.
10. G. J. Esselen, Jr. Is It Feasible to Form a Section of Cellulose Chemistry?

II—Papers

11. Chas. Baskerville. Solvents for Phosgene.
12. Edward G. Mahin and R. E. Brewer. Electrometric Method for Detecting Segregation of Dissolved Impurities in Steel. (Lantern.)
13. Robt. E. Wilson. Soda Lime for Industrial Purposes. (Lantern.)
14. Robt. E. Wilson and M. Seltzer. Flow of Viscous Liquids through Pipes. (Lantern.)
15. H. K. Benson and A. L. Bennett. New Solvents for Rosin Extraction.
16. H. C. Howard. Comparative Study of Vibration Absorbers.
17. Hugo Schlatter. Catalysis in the Manufacture of Ether.
18. Harold Van Doren and James R. Withrow. Use of Platinum Crucibles in Electro-analysis. Copper Determination.
19. Rufus D. Reed and James R. Withrow. Use of Platinum Crucibles in Electro-analysis. Rapid Copper Determination.

20. H. McCormack. Estimation of Benzene in Admixture with Paraffin Hydrocarbons.
21. H. McCormack. Preparation of Manganates and Permanganates.
22. H. S. Coith and James R. Withrow. Permanganate Determination of Sulfur Dioxide.
23. F. C. Vilbrandt, Samuel L. Shenefield and James R. Withrow. Action of Permanganate upon Sulfur Dioxide and Sulfides.
24. Gordon D. Patterson and James R. Withrow. Iodimetric Determination of Sulfur Dioxide.
25. W. D. Collins. Uniform Packages for Reagent Chemicals.
26. R. M. Wilhelm. Uniform Specifications for Chemical Thermometers.
27. O. L. Barnebey. Recovery of Industrial Gases with Activated Charcoal.
28. H. V. Main. A Comfortable Dust Respirator.
29. O. R. Sweeney and Joseph Ellert. Evidences of Autocatalysis in the Hydrogenation of Cottonseed Oil.
30. Charles L. Parsons. The Use of Ammonia Oxidation *versus* Niter in Chamber Acid Production.
31. Harrison Hale and G. O. Burr. Separation of Iron from Aluminium by Precipitation as Prussian Blue. (By title.)

III—Fuel Symposium

32. S. W. Parr. Low Temperature Carbonization and Its Application to High Oxygen Coals.
33. Edgar Stansfield. Carbonization of Canadian Lignite.
34. Henry Kriesinger. By-product Coke, Anthracite, and Pittsburgh Coal as Fuel for Heating Houses.
35. F. W. Sperr, Jr. By-product Coking.
36. G. A. Burrell, G. G. Oberfell and C. L. Voress. The Charcoal Method of Gasoline Recovery.
37. S. E. Sheppard. Colloidal Fuels. Their Preparation and Properties.
38. A. C. Fieldner, G. W. Jones and A. A. Straub Gasoline Losses Due to Incomplete Combustion in Motor Vehicles.
39. J. B. Garner. Enrichment of Artificial Gas with Natural Gas.
40. Harry A. Curtis. Commercial Realization of Low-Temperature Carbonization of Coal.
41. Horace C. Porter. Fuel Conservation, Present and Future.
42. Alfred R. Powell. Some Factors Affecting the Sulfur Content of Coke and Gas in the Carbonization of Coal.
43. H. F. Yancey and Thomas Fraser. Distribution of the Forms of Sulfur in the Coal Bed. (Lantern.)

LEATHER CHEMISTRY SECTION

E. E. Marbaker, *Chairman* William Klaber, *Secretary*

1. John Arthur Wilson and Erwin J. Kern. Nature of the Hide-Tannin Compound and Its Bearing upon Tannin Analysis.
2. John Arthur Wilson. The Mechanism of Bating.
3. F. C. Orthmann. Chemical Control of the Tannery.
4. V. H. Kadish. A New Method for the Recovery of Nitrogenous Fertilizer Material from Tannery Waste Sulfide Liquors.
5. Alan A. Claflin. The Influence of Acids on the Tannin Content of Tan Liquors.
6. G. D. McLaughlin and R. E. Porter. The Swelling and Falling of White Hide in Vegetable Tan Liquors.
7. P. R. Roberts. Dyes as Used in the Leather Trade.
8. A. W. Thomas and Margaret W. Kelley. The Effect of Concentration of Chrome Liquors in the Adsorption of Its Constituents by Hide Substance.
9. A. W. Thomas and A. Frieden. The Determination of Hydrochloric Acid and Chlorides in Leather.
10. A. W. Thomas. Comment on Wilson and Kern's Recent Contribution to the Knowledge of Vegetable Tanning Agents.

ORGANIC CHEMISTRY DIVISION

E. Emmet Reid, *Chairman* Roger Adams, *Secretary*

1. W. L. Evans, J. E. Day and W. R. Stemen. The Oxidation of Propylene Glycol by Means of Alkaline Potassium Permanganate.
2. W. L. Evans and Lily Bell Sefton. The Oxidation of Isopropyl Alcohol and Acetone by Means of Alkaline Potassium Permanganate.
3. W. L. Evans and C. D. Looker. The Influence of Alkali on the Formation of Vinyl Alcohol from Acetaldehyde.
4. Thomas G. Thompson and Henry Odeen. The Solubility of Dichlorodiethyl Sulfide in Petroleum Hydrocarbons and Its Purification by Extraction with These Solvents.
5. Oliver Kamm and M. E. Dreyfus. Rearrangement of Unsaturated Acids.
6. Oliver Kamm and W. F. Day. The Reaction Velocity of Dealkylation of Tertiary Amines with Acyl Halides.
7. Rufus M. Kamm. The Alcoholysis of Esters with Amino Alcohols.
8. Roger Adams and Charles Shattuck Palmer. Reactions of the Arsines. Condensation of Primary Arsines with Aldehydes.
9. Ben. H. Nicolet. The Non-identity of Eleostearic Acid from Tung Oil with Ordinary Linolic Acid.
10. Ben. H. Nicolet and Imogene H. Willard. A New Type of Nitrogen-Sulfur Compounds; the Action of Chloramine-T on Alkyl Sulfides.
11. Hans T. Clarke. Report on the Progress of the Manufacture of Research Organic Chemicals.
12. Robert E. Wilson and Everett W. Fuller. The Production of Benzoic Acid and Benzophenone from Benzene and Phosgene.
13. Carleton E. Curran and C. E. Boord. The Nature of the Reactions of Anilines upon Nitrosophenol.
14. Chas. Raiford. Reduction of Polynitrophenols by Hydrogen Sulfide in the Presence of Ammonia.
15. F. B. Dains and E. Wertheim. The Action of Ammonia and Substituted Amines on Allophanic Ester.
16. H. L. Lochte and J. R. Bailey. Hydrazoisopropane.
17. J. B. Conant and E. L. Jackson. A Convenient Method for Preparing Certain Bromohydrins.
18. J. B. Conant. Addition Reactions Involving an Increase in Valence of a Single Atom.
19. D. S. L. Sherk and Edward Kremers. New Derivations of Thymol and Carvacrol.
20. Nellie A. Wakeman and Harlan G. Groffman. The Action of Amines upon Thymoquinone.
21. Frank C. Whitmore and E. B. Middleton. Organic Mercury Compounds of Phenol.

PHARMACEUTICAL CHEMISTRY DIVISION

Charles E. Caspari, *Chairman* Edgar B. Carter, *Secretary*

I—Papers

1. C. S. Leonard and Edward Kremers. A New Organic Arsenical and Related Compounds.
2. L. E. Sayre. Available Chlorine for Disinfectant Bath.
3. Chas. Baskerville and Myron Hirsch. Rate of Evaporation of Ethyl Chloride from Oils.
4. Chas. Baskerville. Experiences with and New Applications of Oil-Ether in Anesthesia.
5. E. H. Volwiler. Some Recent Anesthetics.
6. Hugh A. McGuigan. The Origin and Biological Significance of the Diastases.
7. H. A. Shonle and P. Q. Row. New Benzyl Esters Possessing Antispasmodic Action.
8. Mortimer Bye. Benzyl Succinate.
9. E. A. Wildman. Benzyl Derivatives of Salicylic Acid.
10. H. W. Rhodehamel and E. H. Stuart. Atropine Sulfate from *Datura stramonium*.
11. H. W. Rhodehamel and E. H. Stuart. Some New Compounds of Phenylcinchoninic Acid.
12. A. E. Stearn, H. V. Farr and N. P. Knowlton. An Investigation of the U. S. P. Assay of Phosphoric Acid and Soluble Phosphates.
13. S. A. Mahood. The Production of American Storax from the Red Gum Tree.

II—Symposium

The National Research Council and the Chemistry of Medicinal Products. A general discussion led by J. M. Francis on the possibilities to be found in the realm of the chemistry of medicinal products which may well be touched upon by the efforts of the National Research Council. The following members have been invited to participate in the symposium: Wilder D. Bancroft, Julius Stieglitz, Carl L. Alsberg, Chas. H. Herty, Frank R. Eldred, Chas. E. Caspari, H. V. Arny, and J. P. Snyder.

PHYSICAL AND INORGANIC CHEMISTRY

Wm. D. Harkins, *Chairman* H. N. Holmes, *Secretary*

1. W. J. Bently and Paul L. Stern. Preparation of Zinc Nitride.
2. H. V. Tarter. Hydrolysis of the Calcium Phosphates.
3. R. H. Bogue. On the Hydrolysis of the Silicates of Sodium.
4. H. H. Willard and R. K. McAlpine. A Revision of the Atomic Weight of Antimony. Final Report on the Analysis of the Tribromide.
5. Louis Kahlenberg. On the Separation of Crystalloids from One Another by Dialysis.
6. S. E. Sheppard, Felix A. Elliott, Harry D. Gideonse and (Miss) C. M. Godden. Investigations on Gelatins. Decay of Viscosity on Hydrolysis as a Function of Hydrogen-Ion Concentration.
7. (Miss) A. J. Benedict and Felix A. Elliott Investigations on Gelatins. Protein Errors of Indicators.
8. Harry N. Holmes and W. C. Child. Gelatin as an Emulsifying Agent.
9. Harry B. Weiser and Edmund B. Middleton. Adsorption of Precipitates. III—The Adsorption of Precipitating Ions by Hydrous Aluminium Oxide.
10. Farrington Daniels and Elmer Johnston. The Thermal Decomposition of Gaseous Nitrogen Pentoxide: A Monomolecular Reaction. (Lantern.)
11. S. A. Braley and R. F. Schneider. The Structure of Gold Amalgams. (Lantern.)
12. Robert E. Wilson. Some New Methods for Determining the Vapor Pressure of Hydrated Salts. (Lantern.)

13. Alan W. C. Menzies. Measuring Low Vapor Pressures.
14. H. S. Taylor and A. W. Gauger. Adsorption of Gases by Nickel Catalyst and the Mechanism of Hydrogenation.
15. Felix A. Elliott and S. F. Acree. A New Form of Titration Hydrogen Electrode.
16. W. S. Hendrixson. Electrometric Standardizing of Potassium Dichromate with Hydriodic Acid and the Asserted "Super-oxidizing Value" of the Former.
17. W. D. Harkins. The Isotopes of Lithium as Related to the Constitution of the Nuclei of Atoms. (Lantern.)
18. Arthur E. Hill. The Distribution of Strong Electrolytes between Benzene and Water.
19. A. F. O. Germann and H. S. Booth. I—The Cryoscopy of Boron Trifluoride Solutions: System with Hydrogen Sulfide.
20. James E. Wildish. The Dielectric Constant of Selenium Oxychloride.
21. D. A. McInnes. Ion Conductance of Strong Electrolytes.
22. Elliot Q. Adams. The Independent Origin of Acrinium.
23. Lloyd K. Riggs and C. Walter Eberlein. Nephelometric Estimation of Sulfur and Barium.
24. J. M. Bell, E. B. Cordon, F. H. Spry and W. White. Further Studies on the Freezing Points of the Nitrotoluenes.
25. Arthur E. Hill. The System Water-Benzene-Silver Perchlorate.
26. A. F. O. Germann and Vernon Jersey. II—The Cryoscopy of Boron Trifluoride Solutions: System with Phosgene. (Lantern.)
27. A. F. O. Germann and Wendell Phillips. III—The Cryoscopy of Boron Trifluoride Solutions: Systems with Sulfur Dioxide and with Nitric Oxide. (Lantern.)
28. A. F. O. Germann and Leland R. Smith. IV—The Cryoscopy of Boron Trifluoride Solutions: System with Hydrogen Chloride. (Lantern.)
29. Felix A. Elliott and S. F. Acree. Conductance Corrections and Ionic Mobilities from Hydrated-Ion Concentration Measurements.
30. (Miss) A. D. Dushak, Felix A. Elliott and S. F. Acree. Contact Potentials in Hydrogen-Ion Determinations.
31. (Miss) A. D. Dushak, Felix A. Elliott and S. F. Acree. Titration Curves of Some New Buffer Mixtures.
32. S. E. Sheppard and Felix A. Elliott. Investigations on Gelatins: The Gold Number.
33. H. S. Taylor and G. Dougherty. The Hydrogenation of Benzene.
34. Nathaniel H. Furman and Alan W. C. Menzies. Period of Induction Preceding Changes of Hydration in the Hydrates of Cupric Sulfate.
35. Alan W. C. Menzies. Certain Physical Properties of Three Oils.
36. Harry B. Weiser and Allen Garrison. The Oxidation and Luminescence of Phosphorus. I—The Behavior of Phosphorus in Pure Oxygen.
37. Farrington Daniels and Elmer Johnston. The Photochemical Decomposition of Gaseous Nitrogen Pentoxide. (Lantern.)
38. Henry C. Waterman and Curtis M. Parkhurst. An Improved Method for the Preparation of Cuprous Chloride and Cuprous Bromide. (By title.)
39. Irving Langmuir. Radiation as Factor in Chemical Action.
40. D. M. Dennison and Irving Langmuir. The Crystal Structure of Ice.

RUBBER DIVISION

W. K. Lewis, *Chairman* Arnold H. Smith, *Secretary*

1. Reports.
2. Discussion: Shall the Rubber Division Publish an Annual Volume of Reprints and Lengthy Abstracts of Everything of Interest to the Rubber Chemist Made Public during the Year?
3. Election of Officers.
4. W. B. Wiegand. Rubber Energy. (Lantern.)
5. New Jersey Zinc Co. Research Laboratories. The Aging of Some Rubber Compounds. (Lantern.)
6. New Jersey Zinc Co. Research Laboratories. Some Microsections Cut from Vulcanized Rubber Articles. (Lantern.)
7. G. D. Kratz, A. H. Flower and B. J. Shapiro. II—The Action of Certain Organic Accelerators in the Vulcanization of Rubber.
8. G. D. Kratz, A. H. Flower and B. J. Shapiro. III—The Action of Certain Organic Accelerators in the Vulcanization of Rubber.
9. J. F. Schufter. Method for the Determination of Free Sulfur and Antimony Tri- and Pentasulfides in Golden Antimony.
10. J. B. Tuttle. The Action of Heat and Light on Vulcanized Rubber.
11. C. W. Bedford and Winfield Scott. A Theory of Acceleration Based on the Formation of Polysulfides during Vulcanization.
12. Symposium: The Analysis of Rubber, led by W. W. Evans. There will be discussions of various topics by H. L. Fisher, A. H. Smith, J. B. Tuttle, H. E. Simmons, C. W. Sanderson, W. W. Harrison, H. B. Underwood, C. R. Boggs, P. A. Ritter, and others.
13. Round Table Discussion of Recent Developments. There will be samples on exhibit of rubber vulcanized by Peachey's nascent sulfur method.

SUGAR CHEMISTRY DIVISION

C. A. Browne, *Chairman* Fred. J. Bates, *Secretary*

1. Chas. A. Gamble. The Sugar Industry of Peru.
2. G. L. Spencer. Electric Oven for Rapid Moisture Tests.
3. C. E Coates. Refining Raw Sugars without Bone-black.
4. W. D. Horne. Recent Advances in Defecation.
5. Frederick Bates and Associates. Comparative Analyses of Refined Sugars.
6. C. A. Browne. Graphic Method for Estimating Reducing Sugars in the Presence of Sucrose.
7. W. B. Newkirk and C. F. Snyder. Commercial Production of *d*-Mannite.
8. G. L. Spencer. The Preservation of Bagasse in Sugar Cane Mill Control.
9. M. J. Proffitt. Glass Vacuum Pan for Laboratory Use.
10. A. F. Blake. Changes in the Polarizing Constants of Sugars during Refining.
11. T. H. Murphy. Report on the Sugar Industry of France since the War. (Lantern.)
12. R. F. Jackson and C. L. Gillis. The Composition and Preparation of a Sugar Sirup of Maximum Solubility.
13. C. A. Browne. Some Characteristics of Imported Cane Sugars.
14. Edmond H. Eitel. American Progress in Bacteriological Sugars.
15. Longfield Smith. Results of Sugar Cane Experiments in St. Croix.
16. H. S. Paine and C. F. Walton, Jr. Use of Kieselguhr in the Clarification of Cane Juice.
17. W. B. Newkirk. Determination of the Density of Molasses.
18. R. F. Jackson and C. L. Gillis. Determination of Sucrose and True Raffinose in Beet Products.

WATER, SEWAGE AND SANITATION DIVISION

J. W. Ellms, *Chairman* W. W. Skinner, *Secretary*

1. A. S. Behrman. Water Softening for the Manufacture of Raw Water Ice.
2. Harry E. Jordan. Specifications for Glassware for Waterworks Laboratories.
3. W D. Collins. Hardness of Surface Waters in the United States.
4. Edward Bartow. The New Sewage Testing Station of the Illinois State Water Survey Division.

THE CHEMICAL SOCIETIES IN NEW YORK CITY

1920-1921 SEASON—RUMFORD HALL, THE CHEMISTS' CLUB

October 1—Société de Chimie Industrielle.
October 8—Society of Chemical Industry. *Joint Meeting* with Société de Chimie Industrielle.
October 22—American Chemical Society. *Joint Meeting* with Société de Chimie Industrielle.
November 5—Society of Chemical Industry.
November 19—American Chemical Society.
December 10—American Chemical Society. *Joint Meeting* with Society of Chemical Industry, American Electrochemical Society, and Société de Chimie Industrielle.
January 7—American Chemical Society.
January 14—Society of Chemical Industry. *Perkin Medal Award.*
February 11—American Electrochemical Society. *Joint Meeting* with Society of Chemical Industry, American Chemical Society, and Société de Chimie Industrielle.
March 11—American Chemical Society. *Nichols Medal Award.*
March 25—Society of Chemical Industry.
April 22—Society of Chemical Industry. *Joint Meeting* with American Electrochemical Society, Société de Chimie Industrielle, and American Chemical Society.
May 6—American Chemical Society.
May 13—Société de Chimie Industrielle. *Joint Meeting* with American Chemical Society, Society of Chemical Industry, and American Electrochemical Society.
May 20—Society of Chemical Industry.
June 10—American Chemical Society.

NOTES AND CORRESPONDENCE

BETTER CHEMICAL NOMENCLATURE IN TRADE USAGE

Significant and very encouraging for the general use of better chemical nomenclature and orthography in America is the recent action of E. I. du Pont de Nemours & Co. in adopting names and spellings for its dyestuff intermediates which correspond with the usage considered best from a scientific point of view. The improved names are to be used by the Sales and Advertising Department and their use is being urged on others. Trade journals are showing a willingness to adopt these names, and every indication seems to be that the movement will assume a national aspect. In the past the greatest obstacle to the needed improvement in chemical nomenclature in this country has been the slowness of manufacturers of, and dealers in, chemical substances to change over to better names and spellings (better English, correct endings to designate class, etc.) from the frequently unsatisfactory ones which came into use in the early days when German business and influence were preponderant in our chemical trade. This has perhaps been natural enough but none the less unfortunate. The ice has been broken now, and it is to be hoped that the old reluctance to make changes will disappear. The dyestuff field is not the only one in which reform is needed.

The greatest appeal to the trade will very likely be from the point of view of standardization. There is a diversity of names and particularly of spellings in the case of many chemical substances. Accuracy and convenience will be promoted by the adoption and use of one name and spelling as a standard in each case. To avoid a new and added source of confusion caution is of course necessary in the establishment of standard forms. Standards cannot be multiplied. The American Dyes Institute has been suggested as the proper authority for the standardization of the names of compounds of interest to the dye industry. This institute or any other organization interested in chemical names will no doubt be willing to coöperate with the Committee of the American Chemical Society on Nomenclature, Spelling and Pronunciation, which committee in turn is coöperating with similar committees of the British chemical societies. Our committee is progressing, slowly of necessity, in the adoption of rules and forms, and I am sure that I can say for the committee that we will be glad to do all that we can to aid in the establishment of better usage in the trade. Such a movement has been on our program for a little later when further advanced in our work.

E. J. Crane, *Chairman,*
Committee on Nomenclature, Spelling
and Pronunciation

Columbus, Ohio
July 30, 1920

CHEMICAL READING COURSES

Editor of the Journal of Industrial and Engineering Chemistry:

In connection with the "Chemical Reading Courses" appearing in the July and August 1920 issues of the Journal, the attention of small libraries and general readers might profitably be called to two points not specifically mentioned, but, unfortunately, not always obvious to the layman who has an authoritative list at hand:

1—The constant output of new books makes it desirable to consider, also, the very latest literature for possible material supplementing the "Courses."

2—Since the "Courses" are brief lists selected from a large mass of literature, librarians should keep in mind the fact that there are available many other general works, and many works too special to be included, some of which may be of particular value in special cases.

Applying these suggestions to a single field—ferrous metallurgy—we find that "Electric Furnaces in the Iron and Steel Industry," by Rodenhauser *and others*, is available in a later edition than that mentioned.

Among the books *not* mentioned, "The Making, Shaping and Treating of Steel," by J. M. Camp and C. B. Francis, has appeared in a second edition (the first, published in 1919, was not widely distributed). It affords the best existing guide to modern American practice in iron and steel manufacture. "Iron and Steel," by H. P. Tiemann, is a dependable, encyclopedic guide to obsolete as well as modern processes. It is comprehensive in scope and, for the average library, it will furnish concise answers to more questions than will any other single work on ferrous metallurgy. La Verne W. Spring's "Non-technical Chats on Iron and Steel and Their Application to Modern Industry" is a popular, descriptive work of high value to the general reader.

The three books mentioned in the preceding paragraph are general in scope and the average library will find it advantageous to purchase them in addition to, *or instead of*, the works mentioned in the "Chemical Reading Courses." Specific problems, calling for books of a more special nature, will vary with each community and unlimited inclusion of such books is, of course, beyond the scope of these "Courses," but it is well to bear in mind that excellent American works are available, also, on many of the more specific problems of the iron and steel industry; for example, chemical analysis.

The "Chemical Reading Courses" are apparently not primarily intended to suggest reference literature, but perhaps a dozen of the titles listed are distinctively reference works. Since a beginning has been made, it might not be amiss to suggest to librarians the advisability of consulting some of the up-to-date reference lists, such as "Chemical Literature and Its Use," by Marion E. Sparks, 1919, and "Some Observations on Chemical Bibliographies," by Paul Escher, 1920.

Carnegie Library of Pittsburgh
Pittsburgh, Pa.
September 18, 1920

E. H. McClelland

EXPLOSION OF FLASHLIGHT POWDERS

Editor of the Journal of Industrial and Engineering Chemistry:

Recently a young student of my acquaintance, while experimenting with a "flashlight powder," which consisted of a mixture of potassium chlorate, sulfur, sodium carbonate, and red phosphorus, was so badly injured by an explosion that it was necessary to amputate his right hand.

In order to avoid repetition of such an explosion, or other explosions closely similar, students of elementary chemistry, particularly high-school students, ought to be emphatically warned against the danger existing in mixtures of oxidizing agents with either sulfur or red phosphorus, or with both. Furthermore, it is the duty of high-school chemistry teachers to discourage any attempt on the part of their pupils to experiment with flashlight powders, gunpowder, fireworks, semi-explosives, and the like.

Richard H. Kerbs

192 Wilkins Street
Rochester, N. Y.
August 21, 1920

COMPOSITION OF WATER-GLASS SOLUTIONS

Editor of the Journal of Industrial and Engineering Chemistry:

Whenever the results of scientific work involving sodium silicate solutions are published, care should be taken to record the composition of such solutions.

The appellation "water glass" covers materials which differ greatly in composition and properties. Mr. Vail's recent article[1] will give an excellent idea of these variations.

Attention was called to this matter by the article on "The Preservation of Eggs" by Jones and DuBois in the August 1920 number of THIS JOURNAL. The omission was particularly unfortunate in this case because the silicate solution was used as a standard. The more alkaline a solution is, the less satisfactory it is as an egg preservative. The presence of small amounts of sulfur compounds often causes spoilage.[2]

The confusion that exists in regard to sodium silicate is shown in two articles by Schurecht. In the first,[3] he states that the sodium silicate used "corresponded to the formula $Na_2O. 3.1SiO_3$," yet the lines in his graphs of the results were marked "Na_2SiO_3." In a later article,[4] he gives graphs with the lines marked "Na_2SiO_3" but no explanation is given. On account of the first article the question arises, what was the composition of the sodium silicate used in the later work?

All through the literature similar confusion is found. The value of the work done would be greatly exhanced by the inclusion of data sufficient to enable one to duplicate conditions. The gravity and the percentages of Na_2O and of SiO_2 should be determined.

One reason for the lack of analytical information may be the long procedure for analysis usually given in textbooks. The alkali may be determined by titration with standard acid with methyl orange as an indicator. A quick, fairly accurate method for water was devised by Ordway, in which the sample is added to an amount of ignited calcium sulfate equal to twice the weight of the Na_2O present. The mixture then is dried to constant weight. The percentage of silica is equal approximately to $100 - (\text{per cent } Na_2O + \text{per cent } H_2O)$.

WILLIAM STERICKER

MELLON INSTITUTE OF INDUSTRIAL RESEARCH
PITTSBURGH, PENNSYLVANIA
August 27, 1920

AUTOMATIC METHODS OF GAS ANALYSIS DEPENDING UPON THERMAL CONDUCTIVITY

Editor of the Journal of Industrial and Engineering Chemistry:

My attention has been called to an article in the April 1920 issue of the JOURNAL, by Messrs. Weaver, Palmer, Frantz, Ledig and Pickering, on automatic methods of gas analysis. May I be allowed to state one or two facts in reference to my katharometer which is referred to in the article?

In giving an historical account of thermal conductivity methods of gas analysis your contributors have referred to U. S. Patent 1,304,208 (1919) for details of my katharometer. They appear not to have known that the British patent was applied for in January 1916 and was granted after the instrument had been fully developed in its present form. The katharometer was devised in the Physics Department of the University of Birmingham in 1915 to meet a war emergency, under restrictions as to money, labor, and literature imposed by circumstances. I was, therefore, in ignorance of any previous work on the subject.

This greatly alters the history as given by your contributors. The successful commercial form of the katharometer is clearly earlier than the instruments of the Sperry Gyroscope Company, the Bureau of Standards, and the University of California, although it was unknown to those workers.

The instrument has been made and sold by the Cambridge Scientific Instrument Company for some years, and has given very satisfactory service in France and other theatres of the war, as well as in research work. Some results of this work have been communicated to the Advisory Committee for Aëronautics, from 1916 onwards.

In the summer of 1918 I presented to the Bureau of Standards a katharometer and balloon-fabric permeability tester.

The balanced bridge is no novelty; it was the first I tried and I still use it in research work. The patent specification purposely leaves this point open and covers the form described in the JOURNAL.

The balanced bridge form was shown to the British Admiralty in 1915, but as a fixed bridge proved much more useful for practically all commercial purposes and was most easily adapted for indicating and automatic recording, and for central reading of instruments at various distant points, it has been most generally used.

All the future work spoken of by the Bureau is already in hand here and much of it has already been finished. The Bureau will find as it proceeds with its experiments that the form which it has adopted has several disadvantages which are not at first sight apparent. These points cannot be satisfactorily dealt with in a letter, but those interested may find some information on the subject in a recent paper on the theory of the katharometer by Dr. H. A. Daynes in the *Proceedings of the Royal Society*.

I believe that the katharometer was the first instrument in which the effect of thermal conductivity was used in a practicable and remarkably accurate form for purposes of gas analysis.

THE UNIVERSITY G. A. SHAKESPEAR
BIRMINGHAM, ENGLAND
July 17, 1920

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Editor of the Journal of Industrial and Engineering Chemistry:

I do not wish to dispute any of the statements regarding the history of the thermal conductivity method of gas analysis contained in the preceding note by Professor Shakespear. Several of the facts stated by Professor Shakespear were not known to me, however. Accepting in full Professor Shakespear's statement of the facts, the only change which seems necessary in the article referred to is the description of the instrument developed at the University of California as "earlier" than Professor Shakespear's instrument. Since the former was known to us about a year before we heard of Shakespear's work, and since Shakespear's British patent was kept secret for military reasons, this mistake was only natural.

The first experimental work along this line was done at the Bureau of Standards in the late summer and autumn of 1915, following the work of Koepsel who was the real pioneer with this method; but as previously stated nothing practical was accomplished. The work had been resumed with every prospect of success and nearly the present form of apparatus had been evolved when we first heard of Professor Shakespear's work, through military channels, about the first of March 1918. The first intelligible description of the apparatus was not received until a month or more later. At that time we wrote to Professor Shakespear describing our own work and referring to the earlier investigators whose work was known to us. No reply was received to this or to at least one later letter. All correspondence was, however, through devious official channels, and our failure to get in direct communication with Professor Shakespear may have been due to no fault of his own.

The instruments developed by Professor Shakespear which are known to us, *viz.*, the "katharometer" and the "permeameter," are beautifully constructed instruments well adapted to the purposes for which they are intended.

The "katharometer" is designed to sample and determine the amount of air in balloon gas, and is certainly one of the best instruments ever devised for the purpose. The "permeameter" is designed to test the permeability of balloon fabrics and works well, although we do not regard it as a satisfactory substitute

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[1] THIS JOURNAL, 11 (1919), 1029.

[2] *Chem.-Ztg.*, 42, 195.

[3] *Trans. Am. Cer. Soc.*, 19 (1917), 460

[4] *J. Am. Cer. Soc.*, 1 (1918), 201.

for the methods employed at this Bureau. A great deal of credit is due to Professor Shakespear for his work in developing these instruments, the more so because he had no knowledge of the similar work of Koepsel and of Siemens and Halske, of which we took advantage.

There may be room for difference of opinion upon the relative merits of the balanced and unbalanced bridge in connection with this method. We stated our reasons for preferring the former, at least for certain classes of work, and there is nothing in Professor Shakespear's statement to modify our opinion.

The truly remarkable thing in connection with the history of this method is that a method capable of such great accuracy and such a wide variety of important applications should remain practically unknown to the technical world for at least ten years after its simplicity, accuracy, and some of its important applications were pointed out by Koepsel. This is especially strange in view of the fact that an instrument having useful properties is not at all hard to make, as shown by the five or six independent investigators who have obtained good results with apparatus of very different form.

Bureau of Standards
Washington, D. C.
August 26, 1920

E. R. Weaver

STOLEN PLATINUM

There were recently stolen from the laboratory of the North Dakota Agricultural College, Agricultural College, N. D., four platinum evaporating dishes and four platinum crucibles. The weights and markings on the evaporating dishes were as follows:

Marking	Weight Grams
Z-1	31.0580
S-2	32.6527
RH-1	20.8457
S-3	20.9213

The four platinum crucibles taken from the laboratory were marked and weighed as follows:

Marking	Weight Grams
I	19.3082
II	14.9760
III	15.8049
IV	14.8500

The total weight of the platinum stolen at this time was 170.4168 g. Two platinum dishes had previously been stolen from the laboratory at the Agricultural College.

NEW CHEMICAL LABORATORY FOR YALE UNIVERSITY

Plans are now being prepared for a new building for the Department of Chemistry of Yale University, which has hitherto carried on its work partly in the Kent Chemical Laboratory and partly in the Sheffield Chemical Laboratory. According to present plans, the new building will be located on the Pierson-Sage Square, just north of the Sloane Physics Laboratory, where ample space is available. It will have a total floor area of 100,000 square feet; and, in addition to the usual laboratories and recitation rooms, will include an ample number of rooms for research work, as well as space in which it will be possible to develop a process from the laboratory investigation up to a small-sized commercial scale.

NEW EXPERIMENT STATION OF THE BUREAU OF MINES

The Bureau of Mines is to open a new mining experiment station, with headquarters in St. Louis, Mo. The actual laboratory and investigational work will be done in coöperation with the Missouri School of Mines and Metallurgy at Rolla, Mo.

The new station will devote special attention to the problems of lead and zinc production in the Mississippi valley, and particularly to the development of a metallurgical process for the recovery of lead from the oxidized ores, which exist in large deposits in certain districts of Missouri.

GASOLINE FROM NATURAL GAS. III—HEATING VALUE, SPECIFIC GRAVITY, AND SPECIFIC HEAT—CORRECTION

In the article of the above title [This Journal, 12 (1920), 852] Equation 3 should read as follows:

$$\text{B. t. u. per lb.} = 1.8\left(\frac{158{,}650n + 53{,}200}{14.016n + 2.016}\right)$$

Oil City, Pa. R. P. Anderson

ALKALI FUSIONS. II—THE FUSION OF SODIUM BENZENE *m*-DISULFONATE WITH SODIUM HYDROXIDE FOR THE PRODUCTION OF RESORCINOL—CORRECTION

In the article of the above title [This Journal, 12 (1920), 857] the following correction should be made:

Page 859, first column, first sentence should read: "The total amount of sulfate sulfur in Solution B found by this determination was deducted from the total sulfur found by sodium peroxide fusion method, and the result calculated as $C_6H_4(SO_3Na)_2$."

Washington, D. C. Max Phillips and H. D. Gibbs

THE PREVENTION OF SUGAR DETERIORATION BY THE USE OF SUPERHEATED STEAM IN CENTRIFUGALS—CORRECTION

Through an error in printing, Fig. 1 of Dr. Kopeloff's article [This Journal, 12(1920), 860] was inverted.

WASHINGTON LETTER

By J. B. McDonnell, Union Trust Building, Washington, D. C.

TARIFF COMMISSION DYESTUFFS REPORT

The year 1919 witnessed considerable progress on the part of the American dye industry as compared with the previous year, as disclosed by the census of dyes and other coal-tar chemicals which is nearly ready for publication by the United States Tariff Commission. Total production during 1919 was 63,000,000 pounds, valued at $67,000,000. During 1918 production amounted to 57,000,000 pounds, valued at $61,000,000.

Publication of the report has been delayed this year beyond the date it was completed last year, when it appeared in June. While some few reports still have not reached the Tariff Commission, these are mostly from small concerns. These additional schedules may make some slight changes in the figures as shown at present, but it is safe to say that no very material change will be made in the present figures, which show clearly certain very interesting features.

Dr. Grinnell Jones, who has been in Washington recently in connection with completion of the census, will make public many of the details of the census in an address which he will deliver at the National Exposition of Chemical Industries in New York during the coming week.

CHEMICAL WARFARE SERVICE ADVISORY COMMITTEE

But little has been heard as yet of the appointment of a committee composed of some of the most eminent chemists in the country to act in an advisory capacity to the chief of the Chemical Warfare Service, General Amos A. Fries. The committee was appointed at the Chicago meeting of the AMERICAN CHEMICAL SOCIETY, and is headed by Dr. Chas. H. Herty, as chairman. Dr. Herty has conferred with General Fries regarding the work of the committee. There will be no public discussion of the work of the committee; it will be a great, all-powerful, if silent and but little heard-of, body working for the national defense.

Plans for inauguration of work of startling sweep now are in the making and may be announced within the next few weeks. While these do not have to do with the Chemical Warfare Service Advisory Committee, they are of intense interest not only to the chemists, but to every doctor of medicine in the country, and the general public. It is contemplated to utilize the Chemical Foundation to father this work, which will revolutionize the whole science of medicine giving.

SALE OF SURPLUS STOCKS OF GERMAN DYES

It is understood that efforts are now being made to establish workable machinery through which consumers who have found themselves with larger quantities of German dyestuffs than they actually need may dispose of their surplus and purchase from each other without disclosing to competitors just what they are doing. Investigation was recently inaugurated by the Department of Justice at the request of the War Trade Board Section of the Department of State into the offering for sale of German vat dyes by concerns which had made no application for selling permits to the War Trade Board. It was discovered that several consumers had on hand larger quantities of certain dyes than they expected to use and wished to dispose of some of them. Many of them apparently did not know that the regulations of the Board demanded issuance of a permit to sell such dyes. The matter has not yet been definitely settled, according to officials here, but establishment of a central office which shall act as a clearing house for such dyes has been suggested and discussed. Under the proposed arrangement names of consumers offering dyes for sale and those purchasing them would be kept secret.

THE INDUSTRIAL ALCOHOL SITUATION

Apparently there has been no change in the industrial alcohol situation here. The matter is officially in the status it has occupied since the conference held here some time ago with internal revenue officials. It was reported that Commissioner Williams has decided to ask Congress when it meets in December to entirely divorce industrial alcohol from the prohibition enforcement law, and to provide adequate machinery for handling the industrial alcohol question alone.

Among those interested in seeking relief for the hampered industry, however, it is contended that Commissioner of Internal Revenue Williams has ample authority under existing law to take steps which would relieve the industry from its burden. It is specifically provided in the present law, it is pointed out, that development of the industrial alcohol industry is to be fostered.

The United States has decided that it will not exercise its option on impounded German drugs and chemicals, it was announced recently by the War Trade Board, although the right to exercise its option on the daily production after July 1 still is maintained. The decision of the Board was announced just prior to the expiration of the time limit set for definite action, and was taken because of the lack of demand for these German goods in this country.

While the United States has no legal right to participate in the distribution of German dyes and chemicals under the treaty of peace, its moral right is such that it will be considered as having full rights in this direction, it has been decided by the interallied commission in Paris, according to reports reaching here.

Publication of the dyes and chemicals imported into this country, as shown by licenses granted by the War Trade Board, is a probability of the near future. Some discussion took place regarding the inclusion of this information in the dye census of the Tariff Commission, but the present decision is that this information shall be published by the War Trade Board. Such publication would afford very valuable statistics for purposes of comparison with pre-war import figures.

September 18, 1920

PARIS LETTER

By CHARLES LORMAND, 4 Avenue de l'Observatoire, Paris, France

The universities and research laboratories are just now closed for vacation, and news of pure science is scarce. However, I can announce in the realm of pure chemistry the work of M. Lacroix, perpetual secretary of the Académie des Sciences, who has found considerable amounts of scandium in Madagascan minerals of the same family as cymophane. Up to this time, this element has remained in the domain of spectroscopy. The high content in these minerals will permit a complete study by the simplest chemical means. It seems that it might be well for American geologists and chemists to search for scandium in the rocky regions of the West and the Far West (Colorado or Utah).

THE COAL AND IRON PROBLEM

The coal mines in northern France are not yet reconstructed, and the difficulties in the delivery of German coal are turning the manufacturer toward processes involving fuel economy.

The ferrous metallurgical industry is extremely interested in a new process which has caused much discussion. The process has not been reported before the Académie des Sciences or before any of the chemical societies. It consists solely of a series of patents, ten in number, taken out by the inventor of the process, M. Basset. These patents apply to the direct manufacture of iron and steel without the use of the blast furnace, or the Martin, Thomas, or electric furnaces. It is a direct transformation, in a single apparatus, from the mineral to the steel or iron.

A company with a capital of 60,000,000 francs (Société Française des Aciéries de Basset) has been formed, and the first tests have been made at Mantes, in an old cement factory, working with the rotating furnace there installed. The patents call for the rotating furnace of the present model. In these tests a daily production of 25 tons has been obtained.

It is planned to install 6 furnaces of 250 tons capacity at Longwy, near the Lorraine valley, given to France by the treaty of Versailles. A factory capable of producing 2,000 tons per day is also planned in Normandy near Caen, where during the last decade numerous new bearings of iron minerals have been discovered.

It would seem that the tests at Mantes have been entirely satisfactory and the general application of the process should bring about a considerable revolution in the siderurgical industry. A comparison of the heat balance of the old and the Basset processes shows that to produce a ton of cast iron 1400 to 1500 kilos of coal are needed for the old method and 900 kilos for the Basset. This saving seems slight, but the Basset process permits the use of any fuel. Moreover, the rotating furnace permits the use of powdered minerals, since the velocity of the air in the furnace is very slow and the great air pressure in the blower, necessary in the blast furnace, is replaced in the rotating furnace by an air injector of very low power.

The weakness of the process seems to lie in the necessity of using mineral of high iron content. The tests at Mantes were made with roasted pyrite. Nothing is known of how the minerals of Lorraine and Normandy will behave.

The originality of the process consists in the better utilization of the carbon monoxide or rather of the coal, since the coal is introduced into the center of the furnace in the form of dust by means of a current of air.

Opinions upon the value of the different patents covering the process are varied, but, neglecting this point, our attention will be fixed on the results at the Lorraine factory.

Along the same line I may mention the work done in the region of the Alps, where electric energy is obtained from the waterfalls, and where electrolytic iron is being produced by using the mineral in an appropriate solution. This is another very interesting attempt to escape from the coal problem. The factories producing electrolytic iron are situated in the region of Grenoble, and one of them has just ceded its process to Italian metallurgists on the other side of the Alps.

THE NITROGEN PROBLEM

The conference by M. Georges Claude, of which I spoke in my first letter, was a very great success. M. Claude showed the possibility of obtaining ammonia by the use of what he calls "hyperpressures," which reach 1,000 atmospheres. The obtaining of these hyperpressures does not seem to involve a very high net cost. The heat produced makes the reaction more smooth, and simplifies the extraction of the ammonia.

Granting these theoretical advantages, there is to be noted in the process the difficulty of obtaining tight joints, a difficulty which M. Claude has perfectly solved by the use of cup-leather joints. These joints, resistant to hyperpressures, will open to investigators a new field, for the use of hyperpressures is still in its infancy.

Since the starting material, nitrogen, is easily obtained by the liquefaction of air, the question of the other ingredient, hydrogen, must be considered. M. Claude mentions as a solution of the problem gas from coke ovens, illuminating gas, or water gas. Extraction of hydrogen from this gas seems to be practicable. However, we would note one point upon which M. Claude has not been very exact; that is, the economical extraction of the hydrogen. It is necessary to use very pure hydrogen in order not to diminish the efficiency of the catalyzer, which rapidly becomes exhausted; and such purification of hydrogen from these sources has not yet been completely realized.

September 9, 1920

INDUSTRIAL NOTES

According to a recent announcement the Bureau of Standards is in need of the services of several well-qualified young chemists for work in various lines. Candidates who have had graduate work or special experience in physical chemistry are especially desired. No examination is required. The entrance salaries will range from $1400 to $2400 per annum, depending upon the qualifications of the applicant. Applicants should write to the Civil Service Commission for Announcement 2236 and Form 1312, and should also communicate directly with the Bureau of Standards.

At the recent meeting of the American Dyes Institute the following committee on the nomenclature, spelling, and pronunciation of chemical products as applied to the dyestuffs industry was appointed: Mr. J. Warren Kinsman of E. I. du Pont de Nemours & Co., Dr. D. W. Jayne of The Barrett Co., Mr. J. R. M. Klotz of the Newport Chemical Works, Inc., Dr. J. M. Matthews of the Grasselli Chemical Co., and Mr. L. H. Cone of the National Aniline & Chemical Co. The Committee on Sanitation and Safety, composed of Mr. Victor L. King and Mr. Moses Crossley of the Calco Chemical Co., Mr. George B. Bradshaw of E. I. du Pont de Nemours & Co., and Albert G. Peterkin of The Barrett Co., made a report of its Philadelphia meeting, which included preliminary study of a plan outlined by Dr. Francis D. Patterson, chief of the Division of Industrial Hygiene and Engineering of the Department of Labor and Industry of the State of Pennsylvania.

The Bureau of Mines has completed arrangements for a coöperative research on the carbonization of lignite. $200,000 is to be supplied by private parties for the erection of a plant at New Salem, N. D. The Bureau of Mines will be in charge of the technical and experimental side of the investigation.

Because of the scarcity of limestone for use in the manufacture of sulfurous acid, on account of car shortage and other reasons, six of the largest paper companies in New York have organized the Richville Limestone Company to operate the limestone quarries at Richville, N. Y. A 38-year lease of the quarries has been taken, and the necessary machinery and equipment will be installed immediately. The corporations forming the combination are the Dexter Sulphite Pulp and Paper Co., of Watertown, the Newton Falls Paper Co., of Watertown, the Carthage Sulphite Pulp & Paper Co., of Carthage, the Oswego Falls Pulp & Paper Co., of Fulton, the De Grasse Paper Co., and the Gould Paper Co., of Lyons Falls.

The Newport Chemical Company is shortly to begin the erection of two large factory buildings in Passaic, N. J., which will cost in excess of $200,000. The present buildings will be abandoned when the new ones are completed.

The Honorary Advisory Council for Scientific and Industrial Research of Canada has awarded $5,000 to assist Prof. J. C. McLennan of Toronto University in investigations on helium, to determine its uses for lamps, amplifying values, high resistances, etc. One of the chief objects is to discover a method of conservation to prevent the present wastage which is estimated at 1,000,000 cu. ft. per month.

The Italy-America Society has announced that an American has secured from the Italian government a concession for the utilization of 800 h. p. of the waterfalls at Terni, 70 miles from Rome, for the production of nitrogenous plant food. Synthetic ammonia manufactured by water power at Terni has already been put on the market on a paying basis. With its present equipment the plant is capable of producing one ton of ammonia daily.

A new course in textile engineering is to be added at North Carolina College. This will make the fourth course offered by the textile department, as follows: Four-year course in textile manufacturing, four-year course in textile engineering, four-year course in textile chemistry and dyeing, and two-year course in textile manufacturing.

The Mathieson Alkali Works, Inc., has established a western district sales office at 327 South LaSalle St., Chicago, Ill.

The 1919 report of the English National Physical Laboratory, which has just been issued, contains the report of the executive committee for 1919, the statement of work proposed for 1920–21, a list of papers published by the laboratory during 1917, 1918, and 1919 or communicated by members of the staff to scientific societies or technical journals, and the report of the director for 1919.

The Netherlands Dyestuffs Factory has recently been established at Amsterdam with the coöperation of large industrial and banking concerns, to promote the manufacture of dyes and intermediates which were formerly chiefly imported from Germany. Attention has been particularly directed to the preparation of ethereal oils, essences and perfumes, inorganic and organic acids and salts, medicines, tar distillates and their derivatives, including aniline dyes.

The production of bituminous coal in the United States for the 199 working days ending August 21, 1920, as compared with corresponding periods in previous years was as follows:

	Tons
1917	352,011,000
1918	375,395,000
1919	287,270,000
1920	335,967,000

The production of anthracite up to August 21, 1920, was 55,712,000 tons, as compared with 52,678,000 in 1919. The coal production for the first three months in Canada was 4,126,523 tons in 1920, as compared with 3,735,654 in 1919.

The Commission appointed by Supreme Court Justice J. F. Minturn to investigate the damages to dyeing companies resulting from the diversion of water from the Passaic River has awarded $302,852 to the Wiedmann Silk Dyeing Company and the National Silk Dyeing Company. $97,351 are levied against Jersey City, $48,675 against Newark, and $5,400 against the Acquackanouck Water Company. Counsel for the municipalities has given notice that the case will be appealed from the award of the commissioners.

The report of the Commissioner of Patents shows that during the fiscal year ending June 30, 1920, 81,948 applications for inventions were filed, as compared with 62,755 during the previous year. The total number of applications of all kinds was 102,940, which is 27,283 more than in 1919. The cash receipts from all sources amounted to $2,615,697.33, and the total expenditures to $2,436,561.37, leaving a net surplus of $179,135.96.

The seven months' exports from London to the United States, January to July 1920, showed: Drugs and chemicals, $6,462,593 as against $3,574,541 in 1919; gums, $3,002,037, as against $997,604 in 1919.

At the August meeting of the American Institute of Fertilizer Chemists, which was organized at the annual meeting of the National Fertilizer Association in June, the details of the organization were discussed and the aims and purposes of the Institute were formulated.

The Canadian government has made experiments which prove the practicability of making paper from flax straw. The flax crop of Canada in 1919 would have produced 1,000,000 tons of straw which would have made 100,000 tons of pulp for paper, thus relieving the drain on the forests. Manufacturers have signified their intention of coöperating with the government.

During the last seven months of 1919 dyes were manufactured in France as follows:

	TONS
June	175
July	231
August	270
September	326
October	441
November	410
December	602

These were divided as follows: Acid colors, 121 tons; basic colors, 10 tons; direct colors, 48 tons; sulfur colors, 175 tons; indigo, 225 tons.

Exports of aniline dyes from the United States for the six months ending in June 1920 totaled $10,855,959, the totals per month being as follows:

	Dollars
January	917,574
February	1,850,662
March	2,648,401
April	1,829,771
May	2,120,606
June	2,389,515

The following table shows the distribution of dyes by countries for the months of May and June:

	May	June
Japan	$625,607	$680,215
China	109,503	622,345
Mexico	124,828	4,229
British India	133,155	199,036
Canada	193,211	188,731
France	112,375	134,705
Italy	72,020	40,803
Spain	155,293	110,340
England	136,659	128,353
Argentina	124,571	38,893
Brazil	51,492	43,840

One man was killed and several others injured by a fire which destroyed the percolating building of the Toledo Seed & Oil Company recently. The damage is estimated at $50,000.

The first factory for the manufacture of sulfuric acid in Uruguay has been established by the Instituto de Quimica Industrial at Capurro, and has already commenced production at the rate of 3,500 kilograms daily. Nitric, hydrochloric, and other acids are to be manufactured later.

The Stellar Company of Minnesota, organized to extract turpentine from pine stumps, is ready for operation. The plant is to run night and day and shipment of turpentine, creosote, pine oil, rosin oil, boiled tar, and charcoal is to begin at once. Three or four carloads of Norway pine will be used each week.

The creation of an All-India Chemical Service with a central research institute at Dehra Dun and laboratories in each province has been recommended by a committee presided over by Professor J. F. Thorpe of the Imperial College of Science and Technology, London. The object is to assist by scientific investigation in overcoming the difficulties and deficiencies in Indian industrial organization. It is intended that the research staffs shall be composed mainly of Indians, so far as those with adequate training are available.

A gas obtained from the destructive distillation of straw is being produced on a small scale at the experimental farm of the U. S. Department of Agriculture at Arlington, Va. The gas has been used for motor fuel, and for illuminating and cooking purposes, but its commercial value has not been determined. Fifty pounds of straw will produce about 300 cu. ft. of gas, and the Office of Development Work is working on the problem of liquefying or condensing the gas to enable it to be used practically as a motor fuel. Several valuable by-products are obtained in the process of manufacture.

About 106,000 tons of fuller's earth valued at $2,000,000 were produced in the United States in 1919. These figures show an increase of 217 per cent in quantity and of 563 per cent in value in 10 years, being an increase of 25 per cent in quantity and 74 per cent in value over 1918. Florida produced nearly nine-tenths of the 1919 output.

The mica mine at Blue Mountain, Stony Lake, Canada, has been purchased by American engineers who expect to start operations immediately, shipping 100 lbs. of mica a day.

Except for 6,000 tons of government guano per annum and a small supply of bone manure, the Union of South Africa is entirely dependent on foreign sources for artificial fertilizers. The total imports of manures and fertilizers in 1919 amounted to 12,617 tons.

PERSONAL NOTES

Mr. George A. Brewster, an active member of the AMERICAN CHEMICAL SOCIETY, the American Steel Treaters Society and the American Institute of Mining and Metallurgical Engineers, died August 17, 1920. Mr. Brewster was born in 1877, was educated at Ohio Northern University and held various positions in connection with the chemical industry, his last connection being with the American Radiator Co., of Buffalo, N. Y., as chief chemist.

Mr. John A. Dawson, one of the charter members of the California Section of the AMERICAN CHEMICAL SOCIETY and one of the oldest chemists on the Coast, died recently. Mr. Dawson was educated as a pharmaceutical chemist, and early in life became connected with the U. S. Customs House in San Francisco as examining chemist for foreign imports, serving in this capacity for thirty years.

Dr. Harmon N. Morse, professor of chemistry and director of the chemical laboratory at Johns Hopkins University, died recently at his summer home on Chebeague Island, Me. Dr. Morse was born in Cambridge, Vt., in 1848. After his graduation from Amherst College in 1873 he studied at the University of Göttingen and returned to Amherst as an assistant in chemistry in 1875. He went to Johns Hopkins as an associate professor in 1876.

Mr. Russell W. Moore, past president of the Chemists' Club, died on July 31 at his home, 44 West 77th St., New York City.

Mr. George P. Gray has resigned his position as assistant professor of entomology and chemist, insecticide laboratory, at the University of California, to become chief of the Division of Chemistry of the newly established Department of Agriculture of the State of California, Sacramento, Cal.

Mr. Daniel H. Simpson has resigned his position in the physical chemistry section of the Bureau of Standards, Washington, D. C., and is now in the sales division of the Edison Electric Appliance Co., Inc., Chicago, Ill.

Mr. A. J. Gailey has left the W. L. Cummings Chemical Co., Lansdowne, Pa., to accept the position of research chemical engineer for the Electrometallurgical Co., Niagara Falls, N. Y.

Mr. Florian A. Cajori, formerly Captain in the food section of the Sanitary Corps and on duty in Jugo-Slavia with the American Relief Administration, has completed his graduate work at Yale University and accepted a position as instructor in physiological chemistry at Leland Stanford, Jr., University, in California.

Mr. Thorwald A. Carlson has completed his work in connection with his Metallurgical Research Fellowship in the Department of Metallurgical Research, University of Utah, and is now in the testing department of the Anaconda Copper Mining Co., Anaconda, Mont.

Mr. G. E. Daibey has resigned his position as superintendent of the smelting plant of Benj. Harris & Co., Chicago, Ill., and is now with the Eastern Brass & Ingot Corporation of New York, Waterbury, Conn.

Mr. C. E. Vail has resigned his position as chemist with the Empire Refineries, Inc., Okmulgee, Okla., and is now assistant chemist on the staff of the Colorado Experiment Station, Fort Collins, Col.

Mr. R. T. Haslam has left the National Carbon Company, Cleveland, Ohio, to become director of the School of Chemical Engineering Practice of the Massachusetts Institute of Technology, Cambridge, Mass.

Dr. Harrison E. Patten, for several years research chemist with the Bureau of Chemistry of the Department of Agriculture, Washington, D. C., has accepted the position of chief chemist of the phosphate plant of the Provident Chemical Works, St. Louis, Mo.

Mr. Lewis C. Slater has resigned as assistant professor of industrial and engineeridg chemistry at Louisiana State University, and is now chemist for the Bogalusa Paper Co., Inc., Bogalusa, La.

Mr. DeWitt O. Jones, formerly in charge of the research laboratory of Armour Fertilizer Works, U. S. Yards, Chicago, Ill., has taken a position with the Newport Company, Carrollville, Wis.

Mr. Charles H. Breed, until recently metallurgist with the Crown Cork & Seal Co., Baltimore, Md., has joined the staff of Daniel M. Luehrs, industrial consulting engineers, Cleveland, Ohio, as consulting metallurgist in charge of the metallurgical laboratories.

Mr. F. L. Righter, for the past year a graduate student in the chemistry department of Cornell University, has joined the staff of the research laboratory of the Eastman Kodak Co., Rochester, N. Y.

Mr. David Jones, holder of an 1851 Exhibition Scholarship from London University at Johns Hopkins University, is at present with the chemical division of the Eastman Kodak Co. Rochester, N. Y.

Mr. Lester A. Buehler has accepted a position as assistant in the Department of Operative Pharmacy in the Philadelphia College of Pharmacy and Science, Philadelphia, Pa.

Mr. Kenneth A. Brownell, formerly assistant chemist for the Sayles Finishing Plants at Saylesville, R. I., has accepted a position as chemist for the Standard Bleaching Co., of Carlton Hill, N. J.

Mr. J. D. Brown has left the Johnson City High School, Johnson City, Tenn., to become supervisor of the aniline department of the Union Dye & Chemical Corporation, Kingsport, Tenn.

Mr. E. M. Heumann, until recently connected with the Crown Cork & Seal Co., Baltimore, Md., is in charge of the chemical laboratories of Daniel M. Luehrs, industrial consulting engineers, Cleveland, Ohio.

Mr. J. B. Ferguson has left the research laboratories of the Western Electric Co. of New York City to accept an appointment as associate professor of research chemistry at the University of Toronto, Toronto, Canada.

Mr. Arthur Bridge, for eight years chemist for the Central of Georgia Railway, Savannah, Ga., has accepted a position with the Newport Chemical Co., Carrollville, Wis., where he is engaged in the manufacture of coal-tar dyes.

Mr. Floyd K. Thayer has accepted a position as organic research chemist for the Abbot Laboratories, Chicago, Ill.

Mr. Lester Yoder, formerly assistant chemist in the Iowa State Experiment Station, is now assistant in the research division of Parke, Davis & Co., Detroit, Mich.

Mr. J. R. Ruby, for three years in charge of the rubber research work of the New Jersey Zinc Co., has associated himself with Mr. C. P. Hall at Akron, Ohio, dealing in pigments and chemicals for the rubber trade.

Mr. Wallace F. Super, who received the degree of B.S. in chemical engineering from the University of Pennsylvania in June 1920, is connected with the Atmospheric Nitrogen Corporation at Laurel Hill, Long Island, N. Y.

Mr. L. E. Elliott, formerly water engineer, Wabash R. R., Decatur, Ill., is at present employed in a similar capacity with the St. Louis-San Francisco R. R., Springfield, Mo.

Mr. B. I. Corson, chemical engineer, has severed his connection as chief chemist with the Durkee Atwood Co., Minneapolis, Minn., and has accepted a position in the research laboratory of Hemingway & Co., Bound Brook, N. J.

Mr. Morris A. Pozen has resigned as chief chemist, Health Department, Washington, D. C., to accept a similar position with the Schwarz Laboratories, analytical and consulting chemists, New York City.

Mr. Ewing C. Scott, having fully recovered from a siege of illness after his discharge from the Army, has accepted a position in the laboratory of the Phelps Dodge Corp., Morenci, Ariz.

Mr. Zoltan de Horvath resigned from the employ of E. I. du Pont de Nemours & Co., to become chief chemist of the Midland Chemical Co. of Argo, Ill.

Mr. Jason L. Russell, formerly chemist with the Swan-Myers Co., Indianapolis, Ind., is now connected with Frederick Stearns & Co., Detroit, Mich., where he has charge of the analytical work.

Mr. L. E. Jackson resigned as chemist and chemical engineer with the Empire Gas & Fuel Co., Bartlesville, Okla., and has accepted a fellowship with the Mellon Institute, Pittsburgh, Pa.

Mr. W. W. Peters, formerly chemist for Dow & Smith, consulting chemical engineers of New York City, has joined the forces of the Beacon Oil Co., Boston, Mass., as assistant chief chemist.

Mr. Lewis W. Armstrong has left the Wisconsin Chemical Products Co., Shawano, Wis., where he was chief chemist, and has become superintendent of laboratories of Kimberly-Clark Co., Niagara, Wis.

Dr. Walter T. Taggart, for many years professor of organic chemistry at the University of Pennsylvania, has been elected to succeed **Dr. Edgar Fahs Smith** as Blanchard Professor of Chemistry at that institution. Dr. Smith resigned as Provost and Professor of Chemistry last June. Professor Taggart is now the head of the chemical department of the University.

Dr. Nicholas Kopeloff has left the Sugar Experiment Station, Louisiana State University, and has accepted the position of associate in bacteriology at the Psychiatric Institute of the New York State Hospitals. He will conduct research on the possible correlation between bacterial infections and mental derangements.

Mr. D. C. Leander Sherk, Ph.D. University of Wisconsin, June 1920, is employed as research chemist with the Gillican-Chipley Co., Inc., New Orleans, La.

Mr. Herbert S. Bailey has resigned his position with E. I. du Pont de Nemours & Co., where he has been in charge of research paints, varnishes, lubricating, and heating oils, to accept a position as assistant chief chemist in charge of research work of the Southern Cotton Oil Co., Savannah, Ga. Mr. Bailey is editor of the Chemists' Section of the Cotton Oil Press.

Mr. Walter R. Kirner, M.S. University of Illinois, is now associated with the synthetic chemistry department of the Eastman Kodak Co.'s research laboratory, Rochester, N. Y.

GOVERNMENT PUBLICATIONS

By Nellie A. Parkinson, Bureau of Chemistry, Washington, D. C.

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

FEDERAL BOARD FOR VOCATIONAL EDUCATION

Coal Mine Ventilation. R. Z. VIRGIN. Bulletin 41. Trade and Industrial Series 11. 64 pp. Paper, 10 cents. 1920.

NATIONAL ACADEMY OF SCIENCES

Fourth Annual Report of National Research Council. 68 pp. 1920.

WAR DEPARTMENT

Airship and Balloon Gas Manual. Book 1. War Department Document 985. 160 pp. Paper, 25 cents. 1920.

Airship and Balloon Gas Manual. Book 2, Gas Plant Operation. War Department Document 985. 51 pp. Paper, 5 cents. 1920.

Comparative Test of Special Homogeneous Gasoline and Commercial Aëronautic Gasoline. Power Plants Report 85. 4 pp. 1920. Air Service Information Circular, Heavier-than-Air, Vol. I, No. 35.

PUBLIC HEALTH SERVICE

Prompt Shipment of Water Supply Chemicals Assured. 35, 2059. The Commission on Car Service of the American Railway Association, which is associated with the Interstate Commerce Commission, has instructed railroads to move promptly the following materials when they are to be used for the purification of public water supply, or when for movement to plants for the manufacture of chemicals to be used for such purposes: Aluminium, sulfate, bauxite, chlorine, calcium hypochlorite, soda ash, copperas, lime, and empty cylinders for chlorine shipment.

Botulism from Eating Canned Ripe Olives. CHAS. ARMSTRONG, R. V. STORY AND ERNEST SCOTT. Reprint No. 577 from the Public Health Reports. 31 pp. Paper, 5 cents. 1920.

Note on the Hygienic Laboratory Method of Standardizing Disinfectants. Reprint No. 567 from the Public Health Reports. 3 pp. Paper, 5 cents. 1920.

GENERAL LAND OFFICE

Regulations Concerning Phosphate Leases and Use of Permits under the Act of February 25, 1920. Public No. 146, approved May 22, 1920. Circular 696. 20 pp. 1920.

Regulations Concerning Sodium Mining Leases and Prospecting Permits under the Act of February 25, 1920. Public No. 146, approved May 28, 1920. Circular 699. 24 pp. 1920.

GEOLOGICAL SURVEY

Gold and Silver in 1918. General Report. J. P. DUNLOP. Separate from Mineral Resources of the United States, 1918, Part I. 55 pp. Published July 15, 1920.

Clay-Working Industries, Silica Brick and Building Operations in the Larger Cities in 1918. JEFFERSON MIDDLETON. Separate from Mineral Resources of the United States, 1918, Part II. 88 pp. Published July 14, 1920. This report deals with the products of the clay-working industries, as well as with clay mining, and the tables are made up to show the output in their first form of manufactured clay products as best expressing the production of clay.

Platinum and Allied Metals in 1919. J. M. HILL. Separate from Mineral Resources of the United States, 1919, Part I. 10 pp. Published July 30, 1920.

Reports received from refiners of platinum, gold bullion, nickel, and copper indicate that 45,109 troy ounces of refined new metals of the platinum group were recovered in 1919, a decrease of 14,644 ounces, or 25 per cent, from the new metals recovered in 1918. About 11,759 troy ounces of the new metals recovered in 1919 are believed to have been derived from domestic materials.

NEW PLATINUM AND ALLIED METALS RECOVERED BY REFINERS, 1915–1919, IN TROY OUNCES

YEAR	Platinum	Iridium	Iridosmine-osmiridium	Palladium	Rhodium
1915.......	6,495	274	355	1,541	...
1916.......	24,518	370	315	2,885	...
1917.......	33,009	210	833	4,779	...
1918.......	54,399	465	539	4,024	326
1919.......	40,220	401	402	3,807	279

Magnesium in 1919. R. W. STONE. Separate from Mineral Resources of the United States, 1919, Part I. 4 pp. Published August 11, 1920. There were 127,465 lbs. of metallic magnesium manufactured in the United States in 1919, a decrease of 55 per cent in quantity and 60 per cent in value from the output of 1918. The production in 1919, however, was greater than in any year before 1918 and shows that the peace-time demands are increasing.

Bauxite and Aluminium in 1919. J. M. HILL. Separate from Mineral Resources of the United States, 1919, Part I. 8 pp. Published August 30, 1920. The quantity of bauxite marketed in the United States in 1919 was 376,566 long tons, a decrease from the production of 1918 of about 38 per cent in quantity and about 36 per cent in value. The domestic consumption was about 38 per cent less than that in 1918.

The value of primary aluminium produced in the United States in 1919 was $38,558,000, a decrease of about 6 per cent from the value of the output in 1918. The decrease was due largely to curtailment in production forced by the accumulation of large stocks in the preceding year.

Thorium, Zirconium and Rare-Earth Minerals in 1919. W. T. SCHALLER. Separate from Mineral Resources of the United States, 1919, Part II. 32 pp. Published September 1, 1920. The report aims to set forth the world relations, as well as the domestic resources of these minerals.

Fuel-Briquetting in 1919. F. G. TYRON. Separate from Mineral Resources of the United States, 1919, Part II. 4 pp. Published August 13, 1920. The total production of briquets in 1919 was 295,734 net tons, a decrease, compared with 1918, of 181,501 tons, or 38 per cent. In fact, the output dropped back to the position occupied in 1916.

Lithium Minerals in 1919. HERBERT INSLEY. Separate from Mineral Resources of the United States, 1919, Part II. 4 pp. Published August 12, 1920. The output of lithium minerals in 1919 was ten times more than that in 1916. This marked increase is no doubt due to the increased use of lithium salts in storage batteries, and of lithium salts and lepidolite in the manufacture of glass.

The Mule Creek Oil Field, Wyoming. E. T. HANCOCK. Bulletin 716-C. Contributions to Economic Geology, 1920, Part II. 19 pp. Published July 27, 1920.

BUREAU OF MINES

Casing Troubles and Fishing Methods in Oil Wells. THOMAS CURTIN. Bulletin 182. Petroleum Technology 57. 48 pp. Paper, 15 cents. 1920. After expensive development work, many wells being drilled for oil have been abandoned, although the difficulties are sometimes susceptible of solution. This report attempts to classify these troubles and suggests solutions that will save the operator discouragement and expense.

Determination of Molybdenum. J. F. BONARDI AND E. P. BARRETT. Technical Paper 230. 35 pp. Paper, 5 cents. 1920. This report is the result of work done under coöperative agreements with the College of Mines, University of Washington, and the Colorado School of Mines. It points out certain disadvantages in the methods hitherto used when applied to low-grade ores, and describes improved methods of both volumetric and gravimetric analysis, perfected in the laboratories of the Bureau of Mines, that are more rapid and accurate than any previously devised. Also, comparison is made of the two methods, as regards their application and relative advantages.

The Properties of Some Stoneware Clays. H. G. SCHURECHT. Technical Paper 233. 41 pp. Paper, 10 cents. 1920. In connection with its investigations having to do with the utilization of high-grade clays in the United States, the Bureau of Mines has conducted, in coöperation with the Ohio Geological Survey, a study of the properties of some Ohio and Pennsylvania stoneware clays. The investigation had special reference to the possible use of these clays in making chemical stoneware, but many of the results brought out can be applied to a number of other ceramic industries.

BUREAU OF STANDARDS

Lime: Its Properties and Uses. Circular 30, 2nd edition, July 6, 1920. 25 pp. Paper, 5 cents.

Recommended Specifications for Green Paint—Semipaste and Ready-Mixed. Prepared and recommended by the United States Interdepartmental Committee on Paint Specification Standardization, June 28, 1920. Circular 97. 10 pp. Issued August 23, 1920. Specifications are outlined for the pigment, liquid, semipaste, and ready-mixed paint; and methods of sampling, laboratory examination of the semipaste, analysis of the pigment, laboratory examination of the mixed paint, and the reagents employed are described.

Measurement of Plasticity of Mortars and Plasters. W. E. EMLEY. Technologic Paper 169. 27 pp. Paper, 10 cents. 1920. Attention is directed to the enormous influence which the degree of plasticity has on the economic use of these materials. An instrument has been devised that will measure plasticity. Another instrument is now being built which is much simpler in design and on a much larger scale than the present instrument. It is proposed to use this new plasticimeter to attack the problem of the plasticity of concrete. The instrument is available for use in writing specifications for lime and gypsum.

DEPARTMENT OF AGRICULTURE

A Modified Boerner Sampler. E. G. BOERNER. Department Bulletin 857. 8 pp. Paper, 5 cents. Of interest to grain dealers and laboratory workers engaged in testing grain.

Pickering Sprays. F. C. COOK. Department Bulletin 866. 47 pp. Paper, 10 cents. Issued August 24, 1920.

Atmospheric Nitrogen for Fertilizers. R. O. E. DAVIS. Separate No. 803 from Yearbook of the Department of Agriculture, 1919. 7 pp. Paper, 5 cents.

COMMERCE REPORTS—AUGUST 1920

Domestic sales of **potash** have come to a complete standstill in Germany. (P. 612)

Oil is being used quite extensively as **fuel** in the Danish industrial plants. (P. 639)

The embargo on the exportation of **hides and leather** from Australia has been removed. (P. 641)

There is said to be a market for American **copper** in Manchuria. (P. 664)

The exportation from New Zealand of **kauri gum** that has been adulterated or mixed with other gum is prohibited. (Pp. 666–7)

A modification, increasing the import duties on **coal-tar dyes**, has been made in Spain. (P. 667)

The **tanning industry** in Spain is reviewed. (Pp. 677–9)

The rapid decrease in the output of **gold** in Australia continues. (P. 680)

The **salt** reserves in the Crimea are said to be unlimited. Large quantities of **sulfate of soda** and of **bromine** also are obtained, as well as substances for the production of high-grade cement. (P. 682)

The **vegetable oil industry** of Ceylon is flourishing, and in 1919 the United States received all of the **citronella oil**, 992,850 lbs., exported therefrom. (Pp. 698–9)

The **dyestuffs** trade in Japan is reviewed. (P. 710)

A corporation has been formed in London for placing in Spanish ports stocks of **mineral oils.** (P. 715)

Regulations governing the importation and sale of **chemical fertilizers** in Brazil are now in force. (P. 728)

Germany has revised her **export duties** on the *ad valorem* system and the new duties are given on hides and skins, products of oil mills, of the starch industry, mineral and fossilized raw materials, waxes, chemical and pharmaceutical products, leather, rubber goods, and metals. (Pp. 729–30)

It is now possible to purchase **purple ore** in Bordeaux. (Pp. 753–4)

The State of Sonora has planned to establish in Nogales, Sonora, a permanent exhibit of **agricultural, mining,** and **industrial** products of the state. (P. 759)

The **spelter industry** in South Wales has experienced a steady decline since the close of hostilities. (P. 764)

Fuel oil bunkering stations are being established in Australia, as the principal steamship lines trading there have decided to use oil instead of coal fuel. (P. 770)

Japanese authorities have decided to discontinue the allotment of **crude camphor** to camphor refiners in the United States and other countries foreign to Japan. The authorities have, however, decided to allot to refiners in the United States, at a special discount, 15,000 lbs. of refined camphor a month. (P. 783)

The **manganese industry** of Japan is reviewed. (P. 791)

The use of peat as fuel on Swedish railways so far shows favorable results. (P. 793)

Negotiations are pending between Germany and France with the object of coming to an agreement with respect to the Alsatian **potash** industry. (P. 802)

Papyrus in the Congo is to be exploited. It has been shown on analysis to contain 37.8 per cent of cellulose. After research and experiments, a process was discovered for bleaching the plants which had been vainly sought for 50 years. (P. 802)

The resumption of the German **chemical** trade is dependent upon the supply of coal. (Pp. 807–11)

The government of Manitoba is taking steps to construct a railway into the Manitoba mineral belt with a view to the exploitation of its **mineral resources.** (P. 827)

The prices for **camphor** in Foochow at present are unusually low, there are fairly good stocks on hand, and local firms are anxious and ready to do business with the United States. (Pp. 835–7)

The Italian **pumice** industry is reviewed. (Pp. 839–40)

The final estimate of India's 1919–20 **oil seed** crop is given as 1,174,000 long tons for rape and mustard and 433,000 long tons for linseed—an increase of 54 per cent for the former and 84 per cent for the latter. (Pp. 849–50)

Statistics are given showing the production, importation, and exportation of **fats and oils** in the United States for the three-month period ended June 30, 1920. (P. 851)

There appears to be a potential market for American **dyes** in Foochow. (P. 870)

The following table gives the output of Mexican **mines** during 1916, 1917, 1918, and 1919 (January to September), quantities being stated in kilos of 2,204 lbs. each:

METALS	1916 Kilos	1917 Kilos	1918 Kilos	1919 Kilos
Gold	11,748	23,543	25,313	22,944
Silver	926,142	1,306,988	1,944,542	1,949,673
Copper	28,411,248	50,985,923	70,223,454	50,893,612
Lead	19,970,986	64,124,752	98,837,154	67,378,353
Zinc	37,449,226	14,757,333	20,698,995	8,665,413
Antimony	828,767	2,646,544	3,268,546	627,704
Tin	292	9,214	13,537	2,117
Tungsten	12,250	187,637	149,486	29,292
Molybdenum	......	......	27,371	2,356
Manganese	......	73,387	2,878,383	2,849,979
Mercury	......	33,132	163,598	113,865
Arsenic	......	1,284,820	1,881,011	2,188,333
Amorphous graphite	470,343	420,046	6,190,819	5,011,619

(P. 883)

The president of the government Board of Trade has declared that the **dye-making** industry in the United Kingdom is regarded as a military necessity, and has pledged the government to bring in legislation which would make it possible thereafter to import synthetic dyestuffs under license only. (Pp. 884–5)

A concession has been granted for the extraction of **oil of liquid amber** in Honduras. (P. 887)

An American has secured a concession for the establishment of a **shark oil** industry in the Gulf of Fonseca. (P. 887)

Statistics relative to the **vegetable oil** supplies of the United Kingdom for the first six months of 1920 show that the imports of oil seeds, oil nuts, etc., from abroad were in the aggregate much in excess of the same period of last year and fast approaching pre-war level. A significant fact is the very considerable increase in the United Kingdom exports of refined oil, 10,161 tons, against only 632 tons in the same period last year, and the substantial reduction in the imports of refined oil from abroad, 23,717 tons, against 51,760 tons. Imports of refined cottonseed oil fell to 1,116 tons, compared with 20,785 tons a year ago. (P. 915)

The restriction on the importation of foreign **dyestuffs** into Jamaica has been suspended temporarily. (P. 929)

An **oil well** has been discovered at Kosenpo, Formosa, delivering oil of a very good quality at the rate of 1,700 gallons per day. (P. 940)

American chemical products are now well established in Japan, but whether they will be able to hold this trade will depend upon the maintenance of a high quality of goods at competitive prices. (Pp. 940–1)

An **oil** company has been organized in Rumania which will be under the control of the state, and all forms of petroleum products necessary for home consumption will be distributed by the state by means of the new company under the Ministry of Industry and Commerce. (P. 950)

It is suggested that the most profitable way of utilizing the Bassia flowers in India would be as a source of a mixed **motor spirit** of the "natalie" type for local use. That motor spirit can be produced on a manufacturing scale from Bassia flowers has already been demonstrated. (Pp. 953–4)

The Canadian **pulp** and **paper** industry is reviewed. (Pp. 968–9)

Important developments are anticipated in connection with the Tasmanian **iron ore** deposits. (P. 970)

A company has been formed to exploit the large **salt** deposits in South Australia for the purpose of manufacturing caustic soda and chlorine. (P. 971)

Requirements for the importation of **synthetic dyestuffs** into Persia are given. (P. 982)

The exportation from France of refined and unrefined **methanol** and **acetone** has been prohibited. (P. 993)

The demand for **sulfate of ammonia** in the Dutch East Indies is great and the present opportunity for the United States to gain a permanent hold on this trade is eminent. (Pp. 996–7)

Pulverized **lignite** is being used for fuel in Australia. (P. 1007)

Manganese ore is available for export from Argentina. (P. 1007)

SPECIAL SUPPLEMENTS ISSUED IN AUGUST

PARAGUAY—48*a*
PERU—49*a*
CHINA—55*c*
JAPAN—58*b*
AUSTRALIA—63*a*
ALGERIA—66*a*

STATISTICS OF EXPORTS TO THE UNITED STATES

BAHAI—(P. 847)
Chrome
Manganese
Rubber
Wax

FERNIE—(P. 734)
Copper
Fluorspar
Lead ore
Zinc ore

HANKOW—(P. 1032)
Antimony
Cottonseed oil
Rape-seed oil
Sesame-seed oil
Wood oil
Carbonate of potash
Sulfate of potash
Tallow

LONDON—(P. 1027)
Rubber .
Drugs and chemicals
Tin
Nitrogenous fertilizer
Creosote oil
Aluminium
Gums
Dynamite glycerol

HONGKONG—(P. 685)
Antimony
Camphor
Chemicals

ERITREA—(P. 647)
Gasoline
Gum arabic
Naphthalene
Paints
Potash

GREAT BRITAIN—(P. 742)
Tin plate
Black plate

MALAGA—(P. 699)
Tartar (crude)
Thymol
Grease and oils
Sulfur oil
Essential oils
Vegetable oils
Oxide of iron
Ocher

PERU—(P. 818)
Rubber

BRAZIL—(P. 818)
Rubber

BOOK REVIEWS

Explosives. By E. B. BARNETT. xv + 241 pp. D. Van Nostrand Co., New York, 1919. Price, $5.00 net.

This book, as stated in the preface, is designed to "give a clear but concise account of the manufacture of explosives, together with an outline of the methods used for investigating this class of substances," and this is quite satisfactorily accomplished. Owing to the conciseness of the work it was naturally impossible to go into details, but the whole field of explosives is covered in a general way. Especial attention is paid to safety coal-mine explosives, called permissible explosives in this country, and considerable space is given to methods of testing explosives, with some discussion of the theories on which the tests are based.

The principal objection to the book for the use of American readers is that it is based on English practice, which differs materially from the American in this subject. This is particularly noticeable in the remarks on nitrostarch, page 62, in which it is stated that nitrostarch has not been successfully manufactured and used in explosives. As a matter of fact, nitrostarch explosives have been used in this country for many years, and millions of pounds of these explosives have been manufactured.

There are a few minor errors, as is the case with practically every book published. For instance, the melting point of pure trinitrotoluene is given on page 56 as 81.9° C., whereas it has been determined by several independent investigators as 80.6–80.8°, and is so given in C. A. Marshall's large work on "Explosives," to which the author acknowledges his indebtedness.

ARTHUR M. COMEY

The Profession of Chemistry. By RICHARD B. PILCHER. xiv + 199 pp. D. Van Nostrand Co., New York, 1920. Price, $2.00 net.

In this little book of some two hundred pages, Mr. Pilcher gives a complete history of the development of chemistry in England from the point of view of the professional chemist. Beginning with the alchemists he describes the growth of the science, the differentiation between pharmacists and chemists, the origin of the various chemical societies and organizations of England, their aims and accomplishments, and their future possibilities. A considerable portion of the book is taken up with suggestions and advice as to the proper education and training of those who intend to take up chemistry as their profession, and repeatedly emphasizes the necessity of a broad foundation and thorough preparation in fundamentals. He thrashes out the old question of Latin requirements and reviews the arguments pro and con in a fair and judicial manner. The whole chapter on the education and training of chemists is sound.

While the book deals entirely with chemistry as practiced in England, and considerable of the space is devoted to description of the organization and duties of such societies as the Institute of Chemistry, the Society of Public Analysts, and others, the problems discussed are identical with those that exist in the United States, and the conclusions reached are the same. The importance of chemistry to civilization, the part played by chemistry in the welfare of the nation, the wonderful future promised, are truths, and truth is not confined to one section of the world. With the transposition of a few names, the volume might have been issued as an American publication, and would have had the endorsement of the majority of American chemists.

The book is written in a most delightful style and bears the evidence of first-hand knowledge. A great amount of information is presented in a clear and compact form. It should be read by every American chemist, partly as giving a vivid picture of chemistry and chemists in England, but mainly as a presentation of the problems of chemists in general, and common-sense methods of solving them.

EDMOND O'NEILL

Standards and Tests for Reagent Chemicals. By BENJAMIN L. MURRAY. x + 385 pp. D. Van Nostrand Co., New York, 1920. Price, $3.00 net.

It would be impossible to write a book on this subject which did not continue the series from the original Krauch to the 1914 translation of Merck. The present work has, however, enough new features to entitle it to consideration as much more than a mere revision of former books.

The descriptions of the chemicals are more complete, especially as to their uses. Information in regard to proper containers and conditions of storage, and warnings of the dangerous or unpleasant properties of many substances will prove valuable to chemists without wide experience along these lines.

The properties given are those of high-grade commercial reagent chemicals. Constants like boiling and melting points are on this basis, with results which have been reported for specially purified laboratory specimens stated as "theory," as under picric acid: "it melts between 121° and 123° C. (theory 122.5° C.)."

Practically all the tests for strength and purity have been established by long use. Those for special reagents follow the authoritative procedures published by the authors, institutions, and societies responsible for the standards. Some time-honored statements of standards for strength and purity have been changed to agree better with the facts, although further reduction might be advisable for some reagents like hydrochloric and sulfuric acids, which have been reduced from 37 and 95 per cent, respectively, to 36 and 94 per cent. The frequent use of 0.0000 per cent to mean failure to respond to the test for an impurity may be misleading, though it is stated: "The percentage figures in which the above limits are stated were in part determined by the customary quantitative tests, and to this extent are accurate; in part by qualitative tests in which the reactions in unknowns are compared with those in knowns. Such comparative tests have a real value in determining the usefulness of reagents, although they should not be regarded as exact. The tests will insure good reagents even though the stated percentages of impurities may not be entirely correct."

About 300 items are discussed, of which 40 are variations of others, such as solutions, different strengths of acids, or preparations for special purposes. More indicators are listed than in the former works. Potassium phosphate monobasic and sodium phosphate dibasic for use in measurement of hydrogen-ion concentration are tested according to the directions of Sorenson. Other newer reagents take the place of those less used which are omitted from former lists.

The following useful tables are included: Atomic weights (1918); calculation of acetic anhydride and acid from titrations of mixtures; congealing points of acetic acid of strengths from 98.00 to 100.00 per cent; percentages corresponding to specific gravities at 60°/60° F. for hydrochloric, nitric, and sulfuric acids, and ammonia; composition of fuming sulfuric acid corresponding to different percentages of total SO_3; specific gravity at 15°/15° C. for methyl alcohol of various percentages by volume.

The statement that the limits for impurities are "maxima permissible in chemicals for miscellaneous reagent purposes," and the corresponding principle in regard to strength should be kept in mind if the standards given are to be used in making purchases. For certain uses reagents of greater strength or purity can and must be obtained.

W. D. Collins

Treatise on General and Industrial Inorganic Chemistry. By Dr. Ettore Molinari, Professor of Industrial Chemistry at the Royal Milan Polytechnic. 2nd Edition, translated from the fourth revised and amplified Italian edition by Thomas H. Pope, B.Sc., F.I.C., A.C.G.I. xix + 876 pp., 328 illustrations + 2 phototype plates. P. Blakiston's Son & Co., Philadelphia, 1920. Price, $12.00.

The third edition of this chemistry, translated by Dr. Ernest Feilmann, appeared in 1913 and constituted the first English edition. This translation of the fourth edition by Pope constitutes the second English edition. Nearly 200 pages have been added. The war experiences of the author lead him to make the following remarks in the preface:

> The problem of the war, which in all countries has proved to be eminently chemical in character, shows how much the governments of certain nations are to blame for their past neglect of the development of the teaching of chemistry and of its modern applications. At the same time their fault would be none the less grave if their present experiences cause them to regard our science merely as an instrument for the preparation of monstrous devices destined to the work of destruction and carnage.
>
> When mankind, which is paying with its blood for the criminal follies of the ruling classes, ceases to be deceived by the attractive, idealistic veneer masking the true fundamental ends of every war, then will chemistry no longer be a tool of barbarism, but will direct its wonderful activity to the improvement of the material and intellectual welfare of man throughout the world, irrespective of race.

The book at first reminds one of Bloxam's well-known chemistry, so near are the two alike in mechanical details and in much of the subject matter. The difference lies mainly in the fact that the space devoted to organic chemistry in Bloxam is given to industrial chemistry in Molinari.

Molinari divides his book into three general parts: Part I embraces 111 pages, dealing with the laws of matter, chemical equations, solutions, and allied topics of a general nature. In Part II, 374 pages are given to a discussion of the non-metals and their compounds. The remainder of the book (Part III) is devoted to a study of the metals, following the general order of arrangement in the periodic table.

The book is distinctive in that it deals with both inorganic and industrial chemistry. Following the discussion of most of the elements and their important compounds, there is given a rather extended discussion of the commercial methods of preparation, often including statistics of production and cost of finished product. Unfortunately for the American student, the cost is given in the English system of coinage. It is a question whether or not it is advisable to attempt to give costs of various chemicals in such a treatise, especially at the present time when costs are so "out of joint." Nevertheless, the book serves to give approximate costs with some degree of accuracy, and it is advisable for a student to know whether, say, a pound of sulfuric acid is worth five cents or one dollar, and that is more than many of them do know—at least until they settle up their laboratory accounts. It is of interest to note that the Italian government paid as high as $10.00 a gram for platinum during the war.

It goes without saying that a book which attempts to be a treatise on both inorganic chemistry and industrial chemistry is likely to be unsatisfactory from either standpoint. Moreover, a book written on industrial chemistry by an Italian author is not likely to be extremely accurate from the standpoint of methods used in the United States. Accordingly, it is not difficult to find minor misstatements as to our practices. Nevertheless, the author has succeeded in bringing together into one easily handled, compact volume a vast amount of information of value to chemists. The reviewer has had the volume on his desk for some time and has found himself constantly turning to it for certain facts. It is hardly adapted as a textbook to our American needs, but it will find a place as a compact, handy reference book.

William McPherson

Annual Reports of the Society of Chemical Industry on the Progress of Applied Chemistry. Issued by the Society of Chemical Industry. Volume IV, 1919. 632 pp. Society of Chemical Industry, Central House, 46–47 Finsbury Square, London, E. C. 2, England, 1920. Price, to members, 5s. 6d.; non-members, 12s. 6d.

The various sections of these *Reports* now cover the entire range of subjects dealt with in the *Journal of the Society of Chemical Industry* in its industrial reviews, transactions, and abstracts, namely, plant and machinery; fuel; gas, destructive distillation, and tar products; mineral oils; coloring matters and dyes; fibers, textiles, cellulose, and paper; bleaching, dyeing, printing, and finishing; acids, alkalies, salts, etc.; glass; refractories; ceramics and building materials; iron and steel; metallurgy of the non-ferrous metals; electrochemistry; oils, fats, and waxes; paints, pigments, varnishes, and resins; India rubber; leather and glue; agricultural chemistry; sugars, starches, and gums; fermentation industries; foods; water and sewage purification; fine chemicals, medicinal substances, and essential oils; photographic materials and processes; explosives; and analytical chemistry. The reports on explosives (1914–1919) and on technochemical analysis appear for the first time; and the reports on ceramics and building materials, and on the fermentation industries for 1918, held over from Volume III, are also included, together with the reports on these subjects for 1919. In each of the 28 reports contained in Volume IV, the patent and journal literatures are critically reviewed by an expert, and each report serves as a concise resumé of the technical progress made during 1919 in the specific field to which it relates.

The period covered by these *Reports* was typically transitional: its outstanding feature was the transference of industry from war-time to peace conditions. In certain fields of chemical manufacture—especially in the "key" industries—technical difficulties were overshadowed by the continuous disagreements in the adjustment of affairs between different groups connected with the industries; but notwithstanding this necessary attention to economic considerations, the scientific progress made generally was very real. Then, too, technical matters of interest are contained in the reports of the enormous developments which resulted during and from four years of war.

This convenient, well-indexed, and authoritative compend constitutes a digest of the literature of industrial chemistry for the year 1919. The volume and its three foregoing companions should be in the library of every chemist or chemical engineer who reads much, but not many words. Summaries of this type, properly used, induce creative reading and furnish materials for research. W. A. HAMOR

Standard Methods for the Examination of Water and Sewage. 4th Edition. vii + 115 pp. American Public Health Association, Boston, 1920. Price, $1.25 (waterproof cloth); $0.60 (flexible paper cover).

The present edition is practically a reprinting of the third edition of this standard work. No changes whatever have been made in the portion of the book devoted to chemical methods of analysis, even the numbering of the pages remaining the same. In the bacteriological section the changes are comparatively slight. Witte's peptone is no longer the standard, improvements in American brands, aided by war conditions, having replaced it by the domestic product. The only important changes in procedure consist in a modification of the method of testing the reaction of media by adjusting them to a somewhat precise hydrogen-ion concentration through the use of phenol red, a slight change in the fuchsin-sulfite reagent for Endo's medium, and the introduction of a synthetic medium for the methyl red test.

The use of thinner paper renders the volume somewhat handier to use, and, as before, it will find widespread laboratory application, as representing in official form the selected methods of American water analysts. A. G. WOODMAN

The Organization of Industrial Scientific Research. By C. E. KENNETH MEES, D.Sc., Director of the Research Laboratory of the Eastman Kodak Company, Rochester, N. Y. 8vo. 175 pp. McGraw-Hill Book Co., Inc., New York, 1920. Price, $2.00 net.

During the past five years there has been a veritable deluge of papers and addresses dealing with the value of industrial research and its relation to manufacturing. Dr. Mees deals with such material only by title in a bibliography, passing directly to the problem of organizing and operating industrial research laboratories. Following four introductory chapters, Chapters V to VIII deal, respectively, with the internal organization, the staff, the building and equipment, and the direction of industrial research laboratories. The final chapter deals in some detail with the design of laboratories for specific industries. A classified bibliography of over 150 titles of papers dealing with research, in addition to footnote references throughout the text, adds to the value of the book as a work of reference. There are also indexes to authors and specific laboratories cited in the text.

Major differences of opinion being practically absent, this field of exposition is free from both argument and rebuttal. Each paper or address on the subject of research reflects chiefly the author's limitations in experience and in expression. It would be a great service indeed should some supermind reduce the complex mass of facts to a firm, well-ordered whole, crystal-clear, and firm. But the mass is palpably colloidal in its nature, and thus far resistant to all attempts to filter and centrifuge. Most attempts at desiccation and fusion have but resulted in oxidation to impalpable powder! Dr. Mees has shown wisdom in not attempting the impossible, he has treated a single phase of the subject with all his well-known lucidity of thought and expression. There is in no instance any doubt as to his meaning. He conveys the general impression that the general problem of organizing and operating a laboratory is a simple one.

If criticism must be offered, it should be directed perhaps (1) to the lack of discussion of some of the greatest unsolved problems in research organization, and (2) to the somewhat limited perspective of the author. Among the larger unsolved problems still under investigation is the psychological one of securing the best flow of the most valuable ideas from research men. With too great isolation, they run dry of ideas or tend to run off on tangents. With too close association there is too little continuity of effort. Periodical conferences of from four to eight men meeting about twice a month appears to be the best arrangement yet devised, but it is by no means entirely satisfactory. Another, and one of the greatest outstanding problems in large manufacturing organizations is that of properly utilizing the results of investigations. Dr. Mees mentions small-scale manufacturing as an intermediate phase in development, but this obviously does not apply to improvements in processes and materials employed on a large scale. In all large-scale manufacturing, it is usual to find the superintendents in charge quite indifferent to all but the most radical improvements. Some of the larger concerns are now experimenting with an intermediate department of internal information, close to high authority on the one hand, and in close touch with all new developments in certain fields.

Dr. Mees writes of industrial research as though it were a discrete entity appropriate to all manufacturing concerns above a certain minimum size and grade, whereas it is applicable to manufacturing of all sizes and degrees of complexity. Even a wagon factory, making but a single style and size of wagon, is concerned with the quality of the wood and iron purchased, the wearing and weathering properties of these materials, and with their heat treatment, impregnation and covering, as well as in improved machinery and methods of handling. In a larger concern in keener competition with its rivals, these functions are simply more highly differentiated, and are handled by larger corps of experts. As a rule, industrial research laboratories are not established to care for new lines of work but rather provided separate quarters when crowded out of manufacturing establishments. Objection may well be raised also to Dr. Mees' classification of laboratories into two distinct types, the "convergent" and "divergent," since laboratories exist of all intermediate diversities of field covered; it is difficult, in fact, to place his types even as extremes.

The time is not far distant, we trust, when we shall have done with experimenting on research organization and methods; when some master mind shall assemble all that is best of what is known in one master work, outlining the ideal and marshaling in united effort the combined forces of educational, industrial, engineering, and governmental organizations in logical effective research. P. G. NUTTING

NEW PUBLICATIONS

Chemistry: Textbook of Chemistry for Nurses and Students of Home Economics. Annie Louise MacLeod. 180 pp. Illustrated. Price, $2.25. McGraw-Hill Book Co., Inc., New York.

Drugs: Practical Standardization by Chemical Assay of Organic Drugs and Galenicals. A. B. Lyons. 397 pp. Price, $3.50. Nelson, Baker & Co., Detroit, Mich.

Fuel Analysis: Technical Gas and Fuel Analysis. Alfred H. White. 2d Ed., revised and enlarged. 319 pp. Price, $3.00. McGraw-Hill Book Co., Inc., New York.

Fuel Oil in Industry. Stephen O. Andros. 274 pp. Price, $3.75. The Shaw Publishing Co., Chicago, Ill.

Mésures Electrotechniques. Albert Turpain. 183 pp. 105 figs. Price, 20 fr. Dunod, Paris.

Molasses: Reading List on Molasses. Compiled by Clarence J. West. Bibliographic Series No. 5. 52 pp. Arthur D. Little, Inc., Cambridge, Mass.

Nature of Animal Light. E. Newton Harvey. 182 pp. Illustrated. Price, $2.50. J. B. Lippincott Co., Philadelphia, Pa.

Paper: Chemistry of Pulp and Paper Making. Edwin Sutermeister. 250 pp. $5^1/_2 \times 8^1/_2$. Illustrated. Price, $3.00. John Wiley & Sons, Inc., New York.

Resins: Analysis of Resins, Balsams and Gum-Resins. Karl Dieterich. Translated from the German. 2d English Ed., revised and enlarged. 432 pp. Price, 17s. 6d. net. Scott, Greenwood & Son, London.

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MARKET REPORT—SEPTEMBER, 1920

FIRST-HAND PRICES FOR GOODS IN ORIGINAL PACKAGES PREVAILING IN THE NEW YORK MARKET

INORGANIC CHEMICALS

		Sept. 1	Sept. 15
Acid, Boric, cryst., bbls.	lb.	.18	.18
Hydrochloric, com'l, 22°	lb.	.03¼	.03¼
Hydriodic	oz.	.19	.19
Nitric, 42°	lb.	.08½	.08½
Phosphoric, 50% tech.	lb.	.25	.25
Sulfuric, C. P.	lb.	.07	.07
Chamber, 66°	ton	22.00	22.00
Oleum	ton	25.00	25.00
Alum, ammonia, lump	lb.	.04¾	.04¾
Aluminium Sulfate (iron-free)	lb.	.05½	.05½
Ammonium Carbonate, pwd.	lb.	.16	.16
Ammonium Chloride, gran.	lb.	.15	.15
Ammonia Water, carboys, 26°	lb.	.11	.11
Arsenic, white	lb.	.14	.14
Barium Chloride	ton	140.00	140.00
Nitrate	lb.	.11	.11
Barytes, white	ton	30.00	30.00
Bleaching Powd., 35%, Works,	100 lbs.	6.50	7.00
Borax, cryst., bbls.	lb.	.10	.10
Bromine, tech.	lb.	.75	.75
Calcium Chloride, fused	ton	33.00	33.50
Chalk, precipitated, light	lb.	.05	.05
China Clay, imported	ton	18.00	18.00
Copper Sulfate	100 lbs.	8.25	8.25
Feldspar	ton	8.00	8.00
Fuller's Earth	100 lbs.	1.00	1.00
Iodine, resublimed	lb.	4.35	4.35
Lead Acetate, white crystals	lb.	.16	.13
Nitrate	lb.	.15	.15
Red American	100 lbs.	.12¼	.12¼
White American	100 lbs.	.10½	.10½
Lime Acetate	100 lbs.	3.50	3.50
Lithium Carbonate	lb.	1.50	1.50
Magnesium Carbonate, Tech.	lb.	.13	.13
Magnesite	ton	65.00	65.00
Mercury flask	75 lbs.	75.00	75.00
Phosphorus, yellow	lb.	.35	.35
Plaster of Paris	100 lbs.	1.50	1.50
Potassium Bichromate	lb.	.32	.34
Bromide, Cryst.	lb.	.75	.75
Carbonate, calc., 80–85%	lb.	.18	.20
Chlorate, cryst.	lb.	.16	.18
Cyanide, bulk, 98–99%	lb.	.50	.50
Hydroxide, 88–92%	lb.	.23	.28
Iodide, bulk	lb.	3.35	3.35
Nitrate	lb.	.15	.15
Permanganate, U. S. P.	lb.	.75	.75
Salt Cake	ton	Nominal	Nominal
Silver Nitrate	oz.	.62	.61
Soapstone, in bags	ton	12.00	12.00
Soda Ash, 58%, bags	100 lbs.	3.00	2.75
Caustic, 76%	100 lbs.	4.80	4.40
Sodium Acetate	lb.	.12	.12
Bicarbonate	100 lbs.	3.00	3.00
Bichromate	lb.	.20½	.19½
Chlorate	lb.	.10	.10
Cyanide	lb.	.50	.50
Fluoride, technical	lb.	.28	.22
Hyposulfite, bbls.	100 lbs.	4.00	4.00
Nitrate, 95%	100 lbs.	3.60	3.50
Silicate, 40°	lb.	.02	.01½
Sulfide	lb.	.10¼	.10¼
Bisulfite, powdered	lb.	.06½	.06½
Strontium Nitrate	lb.	.15	.15
Sulfur, flowers	100 lbs.	3.75	4.00
Crude	long ton	25.00	25.00
Talc, American, white	ton	20.00	20.00
Tin Bichloride	lb.	.21½	.21½
Oxide	lb.	.60	.60
Zinc Chloride, U. S. P.	lb	.50	.50
Oxide, bbls.	lb.	.12	.12

ORGANIC CHEMICALS

		Sept. 1	Sept. 15
Acetanilide	lb.	.60	.65
Acid, Acetic, 28 p. c.	100 lbs.	4.00	3.75
Glacial	lb.	.12	.12
Acetylsalicylic	lb.	.88	.88
Benzoic, U. S. P., ex-toluene	lb.	.85	.85
Carbolic, cryst., U. S. P., drs.	lb.	.15	.15
50- to 110-lb. tins	lb.	.23	.23
Acid (*Concluded*)			
Citric, crystals, bbls.	lb.	.72	.67
Oxalic, cryst., bbls.	lb.	.50	.38
Pyrogallic, resublimed	lb.	2.35	2.35
Salicylic, bulk, U. S. P.	lb.	.50	.45
Tartaric, crystals, U. S. P.	lb.	.70	.65
Trichloroacetic, U. S. P.	lb.	4.40	4.40
Acetone, drums	lb.	.22	.22
Alcohol, denatured, 190 proof	gal.	1.13	1.13
Ethyl, 190 proof	gal.	7.00	7.00
Wood, Pure	gal.	4.40	4.40
Amyl Acetate	gal.	4.00	4.00
Camphor, Jap. refined	lb.	1.35	1.32½
Carbon Bisulfide	lb.	.08	.08
Tetrachloride	lb.	.14½	.14½
Chloroform, U. S. P.	lb.	.40	.40
Creosote, U. S. P.	lb.	.70	.70
Cresol, U. S. P.	lb.	.18	.18
Dextrin, corn	lb.	.07¼	.06½
Imported Potato	lb.	.12	.12
Ether, U. S. P., conc., 100 lbs.	lb.	.24	.24
Formaldehyde	lb.	.48	.44
Glycerol, dynamite, drums	lb.	.28	.28
Pyridine	gal.	2.75	2.75
Starch, corn	100 lbs.	5.12	4.73
Potato, Jap.	lb.	.06½	.06½
Rice	lb.	.25	.25
Sago	lb.	.05	.05

OILS, WAXES, ETC.

		Sept. 1	Sept. 15
Beeswax, pure, white	lb.	.60	.60
Black Mineral Oil, 29 gravity	gal.	.22	.22
Castor Oil, No. 3	lb.	.16	.16
Ceresin, yellow	lb.	.16	.16
Corn Oil, crude	lb.	.08½	.08½
Cottonseed Oil, crude, f. o. b. mill	lb.	.10	.10
Menhaden Oil, crude (southern)	gal.	.55	.55
Neat's-foot Oil, 20°	gal.	1.65	1.65
Paraffin, 128–130 m. p., ref.	lb.	.11½	.11½
Paraffin Oil, high viscosity	gal.	.45	.45
Rosin, "F" Grade, 280 lbs.	bbl.	15.25	13.90
Rosin Oil, first run	gal.	.78	.74
Shellac, T. N.	lb.	1.10	1.05
Spermaceti, cake	lb.	.30	.30
Sperm Oil, bleached winter, 38°	gal.	1.85	1.85
Stearic Acid, double-pressed	lb.	.22½	.19½
Tallow Oil, acidless	gal.	1.25	1.25
Tar Oil, distilled	gal.	.60	.60
Turpentine, spirits of	gal.	1.55	1.49

METALS

		Sept. 1	Sept. 15
Aluminium, No. 1, ingots	lb.	.32	.32
Antimony, ordinary	100 lbs.	7.50	7.25
Bismuth	lb.	2.72	2.72
Copper, electrolytic	lb.	.19	.18¾
Lake	lb.	.18¾	.18¾
Lead, N. Y.	lb.	.08¾	.08½
Nickel, electrolytic	lb.	.45	.45
Platinum, refined, soft	oz.	95.00	115.00
Quicksilver, flask	75 lbs ea.	75.00	75.00
Silver	oz.	1.00	1.00
Tin	lb.	.47½	.45½
Tungsten Wolframite	per unit	6.50	6.50
Zinc, N. Y.	100 lbs.	8.40	8.15

FERTILIZER MATERIALS

		Sept. 1	Sept. 15
Ammonium Sulfate	100 lbs.	5.35	5.35
Blood, dried, f. o. b. N. Y.	unit	8.00	8.00
Bone, 3 and 50, ground, raw	ton	48.00	48.00
Calcium Cyanamide, unit of Ammonia		4.00	4.00
Fish Scrap, domestic, dried, f. o. b. works	unit	7.25	7.25
Phosphate Rock, f. o. b. mine:			
Florida Pebble, 68%	ton	6.85	6.85
Tennessee, 78–80%	ton	11.00	11.00
Potassium Muriate, 80%	unit	2.40	2.25
Pyrites, furnace size, imported	unit	.18	.18
Tankage, high-grade, f. o. b. Chicago	unit	7.75	7.75

COAL-TAR CHEMICALS

		Sept. 1	Sept. 15
Crudes			
Benzene, C. P.	gal.	.30	.30
Cresol, U. S. P.	lb.	.18	.18
Naphthalene, flake	lb.	.16½	.14
Phenol, drums	lb.	.15	.15
Toluene, 90%	gal.	.35	.35
Xylene, 2 deg. dist. range	gal.	.60	.60
Intermediates			
Acids:			
Anthranilic	lb.	2.20	2.20
B	lb.	2.25	2.25
Benzoic	lb.	.80	.80
Broenner's	lb.	1.75	1.75
Cleves	lb.	2.00	2.00
Cresylic, 97–99%	gal.	1.20	1.20
Gamma	lb.	5.75	5.75
H	lb.	2.00	1.90
Metanilic	lb.	1.70	1.70
Monosulfonic F	lb.	3.50	3.50
Napthionic, crude	lb.	.85	.85
Nevile & Winther's	lb.	1.90	1.90
Phthalic	lb.	.60	.60
Picric	lb.	.25	.25
Sulfanilic	lb.	.37	.37
Tobias	lb.	2.25	2.25
Amino Azo Benzene	lb.	1.15	1.15
Aniline Oil	lb.	.27½	.27½
For Red	lb.	.65	.65
Aniline Salt	lb.	.33	.33
Anthracene, 80–85%	lb.	.75	.75
Anthraquinone	lb.	4.50	4.50
Benzaldehyde, tech	lb.	.65	.65
U. S. P.	lb.	1.00	1.00
Benzidine Base	lb.	1.25	1.25
Benzidine Sulfate	lb.	1.05	1.05
Diaminophenol	lb.	6.00	6.00
Dianisidine	lb.	9.00	9.00
p-Dichlorobenzene	lb.	.10	.10
Diethylaniline	lb.	1.65	1.65
Dimethylaniline	lb.	.80	.95
Dinitrobenzene	lb.	.36	.36
Dinitrotoluene	lb.	.43	.43
Diphenylamine	lb.	.80	.80
G Salt	lb.	.90	.90
Hydroquinol	lb.	2.25	2.25
Metol (Rhodol)	lb.	6.75	6.75
Monochlorobenzene	lb.	.15	.15
Monoethylaniline	lb.	2.15	2.15
a-Naphthylamine	lb.	.50	.45
b-Naphthylamine (Sublimed)	lb.	2.25	2.25
b-Naphthol, dist.	lb.	.80	.80
m-Nitroaniline	lb.	1.05	1.05
p-Nitroaniline	lb.	1.10	1.10
Nitrobenzene, crude	lb.	.14	.14
Rectified (Oil Mirbane)	lb.	.16	.16
p-Nitrophenol	lb.	.80	.80
p-Nitrosodimethylaniline	lb.	2.90	2.90
o-Nitrotoluene	lb.	.25	.25
p-Nitrotoluene	lb.	1.50	1.50
m-Phenylenediamine	lb.	1.45	1.45
p-Phenylenediamine	lb.	2.55	2.55
Phthalic Anhydride	lb.	.50	.50
Primuline Base	lb.	3.00	3.00
R Salt	lb.	.90	.90
Resorcinol, tech	lb.	3.50	3.50
U. S. P.	lb.	5.50	5.25
Schaeffer Salt	lb.	.75	.75
Sodium Naphthionate	lb.	1.10	1.10
Thiocarbanilide	lb.	.60	.60
Tolidine, Base	lb.	1.75	1.75
Toluidine, mixed	lb.	.44	.44
o-Toluidine	lb.	.33	.33
m-Toluylenediamine	lb.	1.40	1.40
p-Toluidine	lb.	1.75	1.75
Xylidene, crude	lb.	.50	.50

COAL-TAR COLORS

		Sept. 1	Sept. 15
Acid Colors			
Black	lb.	1.25	1.25
Blue	lb.	3.00	3.00
Acid Colors (*Concluded*)			
Fuchsin	lb.	2.50	2.50
Orange III	lb.	1.00	1.00
Red	lb.	1.30	1.30
Violet 10B	lb.	6.50	6.50
Alkali Blue, domestic	lb.	5.50	5.50
Imported	lb.	8.00	8.00
Azo Carmine	lb.	4.00	4.00
Azo Yellow	lb.	2.00	2.00
Erythrosin	lb.	12.00	12.00
Indigotin, conc.	lb.	3.00	3.00
Paste	lb.	1.50	1.50
Naphthol Green	lb.	1.95	1.95
Ponceau	lb.	1.25	1.25
Scarlet 2R	lb.	1.00	1.00
Direct Colors			
Black	lb.	1.00	1.00
Blue 2B	lb.	.70	.70
Brown R	lb.	1.65	1.65
Fast Red	lb.	3.50	3.50
Yellow	lb.	2.00	2.00
Violet, con't	lb.	2.20	2.20
Chrysaphenine, domestic	lb.	2.25	2.25
Imported	lb.	3.80	3.80
Congo Red, 4B Type	lb.	.90	.90
Primuline, domestic	lb.	3.00	3.00
Oil Colors			
Black	lb.	.70	.70
Blue	lb.	1.65	1.65
Orange	lb.	1.40	1.40
Red III	lb.	1.65	1.65
Scarlet	lb.	1.75	1.75
Yellow	lb.	1.70	1.70
Nigrosine Oil, soluble	lb.	.90	.90
Sulfur Colors			
Black	lb.	.20	.20
Blue, domestic	lb.	.70	.70
Brown	lb.	.35	.35
Green	lb.	1.00	1.00
Yellow	lb.	.90	.90
Chrome Colors			
Alizarin Blue, bright	lb.	7.75	7.75
Alizarin Red, 20% Paste	lb.	1.10	1.10
Alizarin Yellow G	lb.	1.00	1.00
Chrome Black, domestic	lb.	1.25	1.25
Imported	lb.	2.20	2.20
Chrome Blue	lb.	2.50	2.50
Chrome Green, domestic	lb.	2.00	2.00
Chrome Red	lb.	2.00	2.00
Gallocyanin	lb.	3.25	3.25
Basic Colors			
Auramine, O, domestic	lb.	2.50	2.50
Auramine, OO.	lb.	4.15	4.15
Bismarck Brown Y	lb.	.90	.90
Bismarck Brown R	lb.	1.20	1.20
Chrysoidine R	lb.	.75	.75
Chrysoidine Y	lb.	.75	.75
Green Crystals, Brilliant	lb.	6.00	6.00
Indigo, 20 p. c. paste	lb.	.85	.85
Fuchsin Crystals, domestic	lb.	6.50	6.50
Imported	lb.	12.00	12.00
Magenta Acid, domestic	lb.	4.25	4.25
Malachite Green, crystals	lb.	4.50	4.50
Methylene Blue, tech	lb	2.75	2.75
Methyl Violet 3 B	lb	3.00	3.50
Nigrosine, spts. sol.	lb.	.85	.85
Water sol., blue	lb.	.70	.70
Jet	lb.	.90	.90
Phosphine G., domestic	lb.	7.00	7.00
Rhodamine B, extra conc'd	lb.	40.00	40.00
Victoria Blue, base, domestic	lb.	6.00	6.00
Victoria Green	lb	6.00	6.00
Victoria Red	lb.	7.00	7.00
Victoria Yellow	lb.	7.00	7.00

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For Alphabetical Index See Last Page

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Commercial Solvents Corp'n.
Du Pont de Nemours, E. I., & Co.
Merck & Co.
Miner-Edgar Company.
Roessler & Hasslacher Chemical Co.

Acids
Atlas Powder Co.
Baker, J. T., Chemical Co.
Dow Chemical Co.
Du Pont de Nemours, E. I., & Co.
General Chemical Co.
Merck & Co.
Monsanto Chemical Works
Roessler & Hasslacher Chem. Co.
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Badger, E. B. & Sons Co.
General Ceramics Co.
Knight, Maurice A.
Thermal Syndicate, Ltd.

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General Ceramics Co.
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Elyria Enameled Products Co.
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Sowers Mfg. Co.
Sperry, D. R., & Co.
Stevens Brothers
Technical Products Co.
Werner & Pfleiderer Division, Joseph Baker Sons & Perkins, Inc.

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Technical Products Co.
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Alcohol, Butyl
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Eimer & Amend
Merck & Co.
Miner-Edgar Company

Alcohol, Methyl
Miner-Edgar Company

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Badger, E. B. & Sons Co.
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Alkali Plants
Buffalo Foundry & Machine Co.
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Alkalis, Caustic Soda, Caustic Potash, Soda Ash, Etc.
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Autoclaves, Industrial
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Bags, Cottsn
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General Bakelite Co.

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Schaar & Co.
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Scientific Utilities Co.
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Chemical Catalog Co., Inc.
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Stechert, G. E., & Co.
Van Nostrand D. Co.
Wiley, John, & Sons, Inc.

Borings, Iron
Briggs & Turivas

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Brick, Acid-Proof
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General Ceramics Co.
Knight, Maurice A.

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Liquid Carbonic Co.
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Carbon Dioxide Plants
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Buffalo Foundry & Machine Co.
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Jacoby, Henry E.
Sowers Mfg. Co.
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Ferguson & Lange Foundry Co
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International Equipment Co
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Powers - Weightman - Rosengarten Co.
Rovey Instrument & Chemical Co. Inc.
Southern Laboratory Supply Co.
Synthetical Laboratories of Chicago.
Will Corporation
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Dow Chemical Co.
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Heil, Henry, Chemical Co.
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Kauffman-Lattimer Co.
Kenart Synthetic Products Co.
Mathieson Alkali Works
Merck & Co.
Miner-Edgar Company
Monsanto Chemical Works
National Aniline & Chemical Co.
Newport Chemical Works
Orbis Products Trading Co.
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Roessler & Hasslacher Chem. Co.
Semet-Solvay Company
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United Filters Corp.

Cloths, Filter, Metallic
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Multi Metal Co., Inc.
United Filters Corp.

Coal-Tar Products
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Cocks, Acid Proof
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Dorr Co., The

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Buffalo Foundry & Machine Co.
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Metz, H. A., & Co.
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Electric Heating Devices
General Electric Co.
Hoskins Mfg. Co.
Thermo Electric Instrument Co.
Westinghouse Elect. & Mfg. Co.
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Electric Measuring Instruments
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Electrical Supplies
General Electric Co.
Westinghouse Elect. & Mfg. Co.

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Elevators
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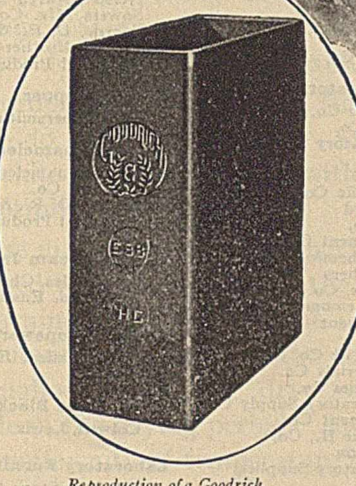
Enameled Apparatus, Acid Resisting
Elyria Enameled Products Co.
Pfaudler Co.

Engines, Steam, Gas or Oil
Technical Products Co.

Ether
Du Pont de Nemours, E. I., & Co
Merck & Co.
Miner-Edgar Company
Powers - Weightman - Rosengarten Co.

Ether Plants
Badger, E. B. & Sons Co
Hercules Engineering Corp.
Mantius Engineering Co.



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Evaporators
Badger, E. B. & Sons Co.
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Jacoby Henry E.
Kestner Evaporator Co.
Mantius Engineering Co.
Sowers Mfg. Co
Sperry, D. R., & Co.
Stokes, F. J., Mach. Co.
Swenson Evaporator Co.
Wheeler Condenser & Eng. Co.
Zaremba Company

Evaporators, Glass Enameled
Elyria Enameled Products Co.
Pfaudler Company

Evaporators, Single and Multiple Effect
Badger, E. B. & Sons Co.
Buffalo Foundry & Mach. Co.
Devine, J. P., Co.
Garrigue, Wm., & Co.
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Jacoby, Henry E.
Kestner Evaporator Co.
Mantius Engineering Co.
Sperry, D. R., & Co.
Stokes F. J., Mach. Co
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Technical Products Co.
Wheeler Condenser & Eng. Co.
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Badger, E. B. & Sons Co.
Buffalo Foundry & Mach. Co.
Garrigue, Wm., & Co.
General Ceramics Co.
Hercules Engineering Corp.
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Stevens Brothers
Wheeler Condenser & Eng. Co.

Extraction Plants, Solvent Process
Badger, E. B. & Sons Co.
Garrigue Wm & Co
Hercules Engineering Corp.

Extractors and Extracting Batteries
Badger, E. B. & Sons Co.
Devine, J. P., Co.
Garrigue, Wm., & Co.
Hercules Engineering Corp.

Fado-Meter, Color
Atlas Electric Devices Co.

Fans
Bethlehem Foundry & Mach. Co.
Duriron Company
General Ceramics Co.
General Electric Co.
Proctor & Schwartz, Inc.
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Westinghouse Elect. & Mfg. Co.

Faucets, Acid Proof
Duriron Company
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Knight, Maurice A.

Felts, Dryer
Hooper, Wm. E., & Sons Co.

Feeders
Caldwell, H. W., & Sons Co.

Fillers, Cement
Toch Brothers

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Celite Products Co.

Filter Presses
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Beach-Russ Co.
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Kelly Filter Press Co.
Shriver, T., & Co.
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United Filters Corp.

Filters, Clarifying
De Laval Separator Co.
Industrial Filtration Corp.
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Shriver, T., & Co.
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Furnaces, Electric Laboratory
Central Scientific Co.
Eimer & Amend
General Electric Co.
Hanovia Chemical & Mfg. Co.
Hoskins Mfg. Co.
Rohde Laboratory Supply Co.
Rovey Instrument & Chemical Co., Inc.
Scientific Utilities Co.
Southern Laboratory Supply Co.
Thermo Electric Instrument Co.
See also Laboratory Supplies

Furnaces, Industrial, Gas, Oil and Solid Fuel
Beach-Russ Co.
Denver Fire Clay Co.

Furnaces, Muffle
See Laboratory Supplies

Gages
Brown Instrument Co.
Eimer & Amend
Heil, Henry Chemical Co.
Taylor Instrument Cos.
See also Laboratory Supplies

Gas Analyzers
See Laboratory Supplies

Gas Machines
Tirrill Gas Mach. Ltg. Co.

Gas Masks
Hygeia Respirator Co., Inc.
Mines Safety Appliances Co

Gas Purifying Material
Alpha-Lux Co., Inc.

Gaskets
Sarco Co., Inc.

Generators, Chlorine
General Ceramics Co.
Knight, Maurice A.
Thermal Syndicate, Ltd.

Generators, Electric
See Dynamos and Motors

Glass Blowing
See Laboratory Supplies

Glass Enameled Apparatus
Elyria Enameled Products Co.
Pfaudler Company
Technical Products Co.

Glassware, Chemical
Braun Corpn.
Braun-Knecht-Heimann-Co.
Central Scientific Co.
Corning Glass Works
Daigger, A. & Co.
Denver Fire Clay Co.
Eimer & Amend
Glass Specialty Co.
Griebel Instrument Co.
Heil, Henry, Chemical Co.
Hiergesell Brothers
Mojonnier Bros. Co.
Palo Company
Rovey Instrument & Chemical Co, Inc.
Sargent, E. H., & Co.
Scientific Materials Co.
Scientific Utilities Co.
Southern Laboratory Supply Co.
Thomas, Arthur H., Co.
Will Corporation

Glassware, Chemical, Quartz
Hanovia Chemical & Mfg. Co.
See also Laboratory Supplies

Glycerine
See Glycerol

Glycerol Plants
Garrigue, Wm., & Co.
Hercules Engineering Corp.

Grinders
See Crushers and Grinders

Hardness Testing Apparatus
See Laboratory Supplies

Heaters, Liquid
Kestner Evaporator Co.
Stevens Brothers

Hoods, Laboratory
Alberene Stone Co.

Hot Plates (Laboratory)
General Electric Co.
Hoskins Mfg. Co.
See also Laboratory Supplies

Hydrometers
Central Scientific Co.
Eimer & Amend
Greiner, E., Co.
Griebel Instrument Co.
Heil, Henry Chemical Co.
Hiergesell Brothers
Mojonnier Bros. Co.
New York Thermometer Co.
Rovey Instrument & Chemical Co., Inc.
Sargent, E. H., & Co.
Scientific Materials Co.
Scientific Utilities Co.
Southern Laboratory Supply Co.
Taylor Instrument Cos.
Thomas, Arthur H., Co.
Will Corporation
See also Laboratory Supplies

Hygrometers
Central Scientific Co.
Eimer & Amend
Engelhard, Chas.
Heil, Henry Chemical Co.
Hiergesell Brothers
Mojonnier Bros. Co.
Rovey Instrument & Chemical Co., Inc.
Scientific Utilities Co.
Southern Laboratory Supply Co.
Taylor Instrument Cos.
Will Corporation
See also Laboratory Supplies

Impregnating Apparatus
Buffalo Foundry & Mach. Co.
Devine, J. P., Co.
Stokes, F. J., Mach. Co.

Indicators
Brown Instrument Co.
Eimer & Amend
Taylor Instrument Cos.

Indicators, Volumetric
LaMotte Chemical Products Co.

Injectors
General Ceramics Co.
Knight, Maurice A.

Insulating Material, Electric
Diamond State Fiber Co.
General Bakelite Co.
General Electric Co.

Insulating Material, Heat
Celite Products Co.
Magnesia Association of America

Intermediates
Barrett Company
Du Pont de Nemours, E. I., & Co.
Hooker Electro Chemical Co.
National Aniline & Chemical Co.
Newport Chemical Works
Semet-Solvay Company

Intermediates, Plants for
Badger, E. B. & Sons Co.
Bethlehem Foundry & Mach. Co.
Buffalo Foundry & Mach. Co.
Devine, J. P., Co.
General Ceramics Co.
Stevens Brothers

Jars, Acid Storage
See Chemical Equipment, Stoneware

Jars, Battery Glass
See Glassware, Chemical

Jars, Battery Hard Rubber
American Hard Rubber Co.
Goodrich, B. F. Rubber Co.

Kegs, Wooden
International Cooperage Co.

Kettles, Caustic Soda
See Kettles, Chemical Casting

Kettles, Chemical Casting
Badger, E. B. & Sons Co.
Bethlehem Foundry & Mach. Co.
Buffalo Foundry & Mach. Co.
Devine, J. P., Co.
Duriron Company
Garrigue, Wm., & Co.
Jacoby, Henry E.
Nelson, Alfred Metal Works
Sowers Mfg. Co.
Sperry, D. R., & Co.
Stevens Brothers
Technical Products Co.

Kettles, Copper
See Coppersmiths

Kettles, Enameled Lined
Elyria Enameled Products Co.
Pfaudler Co.
Sperry, D. R., & Co.
Technical Products Co.

Kettles, Steam Jacketed
See Kettles, Chemical Casting and Kettles, Enameled

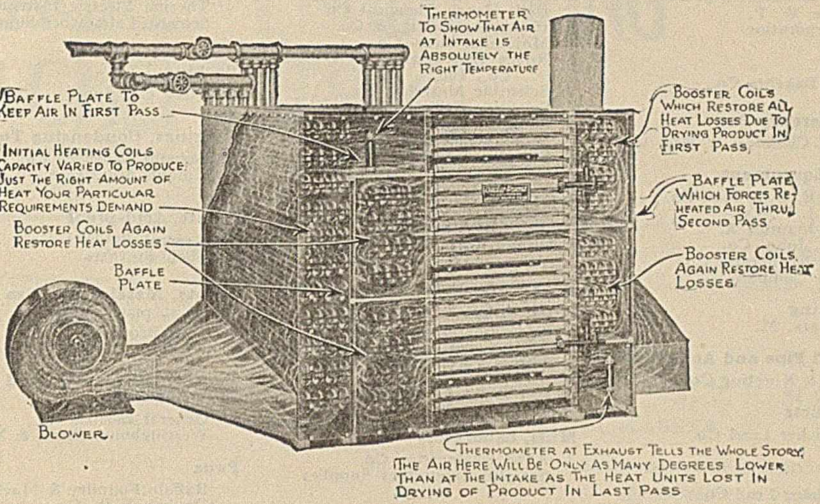
Kettles, Stoneware
See Chemical Equipment, Stoneware

Kilns, Bone Black
Colwell, Lewis

Laboratory Furniture
Alberene Stone Co.
Kewaunee Mfg. Co.
Peterson, Leonard & Co.

Laboratory Gas Machines
Central Scientific Co.
Eimer & Amend
Sargent, E. H., & Co.
Schaar & Co.
Tirrill Gas Mach. Ltg. Co.
Will Corporation

Laboratory Supplies
Ainsworth, Wm., & Son.
Berge, J. & H.
Braun Corporation
Braun-Knecht-Heimann-Co.
Central Scientific Co.
Daigger, A., & Co.
Denver Fire Clay Co.
Eimer & Amend
Engelhard, Charles
Glass Specialty Co.
Greiner, Emil, Co.
Griebel Instrument Co.
Hanovia Chemical & Mfg. Co.
Heil, Henry Chemical Co.
Hiergesell Bros.
Mojonnier Bros. Co.
Palo Company
Reynolds, Teschner & Volk Co.
Rovey Instrument & Chemical Co., Inc.
Sargent, E. H., & Co.
Schaar & Co.
Scientific Materials Co.
Scientific Utilities Co.


Thermometer To Show That Air At Intake Is Absolutely The Right Temperature
Baffle Plate To Keep Air In First Pass
Booster Coils Which Restore All Heat Losses Due To Drying Product In First Pass
Initial Heating Coils Capacity Varied To Produce Just The Right Amount Of Heat Your Particular Requirements Demand
Baffle Plate Which Forces Reheated Air Thru Second Pass
Booster Coils Again Restore Heat Losses
Baffle Plate
Booster Coils Again Restore Heat Losses
Blower
Thermometer At Exhaust Tells The Whole Story. The Air Here Will Be Only As Many Degrees Lower Than At The Intake As The Heat Units Lost In Drying Of Product In Last Pass

Purchasers' Reference (*Continued*)

Laboratory Supplies (Continued)
Southern Laboratory Supply Co.
Thomas, Arthur H., Co.
Tirrill Gas Mach. Ltg. Co.
Valentine, W. P.
Will Corporation

Lacquers
General Bakelite Co.

Lamps, Mercury Arc
Hanovia Chemical & Mfg. Co

Leaching Equipment
Badger, E. B. & Sons Co.
Devine, J. P., Co.
Knight, Maurice A.
Johnson, John, Co.
Swenson Evaporator Co.
Zaremba Company

Lead Burning
McNamara, M.

Lead Lined Pipe and Accessories
Schutte & Koerting Co.

Lead Products
Eagle Picher Lead Co.

Lead Red
Eagle Picher Lead Co.

Lead, White
Eagle Picher Lead Co.

"Lignone"
Robeson, J. S., Inc.

Lime
Mitchell Lime Co.

Linings, Cupola
Celite Products Co.

Litharge
Eagle Picher Lead Co.

Machinery, Mining and Metallurgical
Abbé Engineering Co.
Denver Fire Clay Co.
Dorr Company

Magnesium Metal and Salts
Dow Chemical Co.

Magnets
Magnetic Mfg. Co.

Metallographic Apparatus
Bausch & Lomb Optical Co.
Central Scientific Co.
Eimer & Amend
Heil, Henry Chemical Co.
Hommel, Ludwig, & Co.
Mojonnier Bros. Co.
Rovey Instrument & Chemical Co., Inc.
Scientific Materials Co.
Scientific Utilities Co.
Southern Laboratory Supply Co.
Thomas, Arthur H., Co.
Will Corporation
See also Laboratory Supplies

Meters, Flow for Air, Gas and Water
General Electric Co.

Microscopes
Bausch & Lomb Optical Co.
Central Scientific Co.
Eimer & Amend
Heil, Henry Chemical Co.
Rovey Instrument & Chemical Co., Inc.
Mojonnier Bros. Co.
Scientific Utilities Co.
Southern Laboratory Supply Co.
Thomas, Arthur H., Co.
Will Corporation
See also Laboratory Supplies

Microtomes
Bausch & Lomb Optical Co.
Central Scientific Co.
Eimer & Amend
Heil, Henry Chemical Co.
Mojonnier Bros. Co.
Rovey Instrument & Chemical Co., Inc.
Scientific Materials Co.
Scientific Utilities Co.
Southern Laboratory Supply Co.
Thomas, Arthur H., Co.
Will Corporation
See also Laboratory Supplies

Microphotographic Apparatus
Bausch & Lomb Optical Co.
Central Scientific Co.
Eimer & Amend
Heil, Henry Chemical Co.
Hommel, Ludwig, & Co.
Mojonnier Bros. Co.
Rovey Instrument & Chemical Co., Inc.
Scientific Materials Co.
Scientific Utilities Co.
Southern Laboratory Supply Co.
Will Corporation
See also Laboratory Supplies

Mills, Ball
Abbé Engineering Co.
Stokes, F. J., Mach. Co.

Mills, Color
Abbé Engineering Co.
Raymond Bros. Impact. Pulv. Co.
Williams Pat. Crusher & Pulv. Co.

Mills, Laboratory
Abbé Engineering Co.
See also Laboratory Supplies

Mixers
Abbé Engineering Co.
Caldwell, H. W., & Son Co.
Elyria Enameled Products Co.
Garrigue, Wm., & Co.
Jacoby, Henry E.
Sowers Mfg. Co.
Sperry, D. R., & Co.
Stevens Brothers
Stokes, F. J., Machine Co.
Technical Products Co.
Werner & Pfleiderer Division, Joseph Baker Sons & Perkins, Inc.

Montejus, Automatic
Buffalo Foundry & Mach. Co.
Devine, J. P., Co.
General Ceramics Co.
Knight, Maurice A.
Schutte & Koerting Co.

Mortars and Pestles
See Laboratory Supplies

Nitrating Vessels
Badger, E. B. & Sons Co
Bethlehem Foundry & Mach. Co.
Buffalo Foundry & Mach. Co.
Duriron Company
General Ceramics Co.
Knight, Maurice A.

Nitrators
Badger, E. B. & Sons Co.
Bethlehem Foundry & Mach. Co.
Buffalo Foundry & Mach. Co.
Devine, J. P., Co.
Duriron Company
Stevens Brothers
Stokes, F. J., Mach. Co.
Technical Products Co.
Werner & Pfleiderer Division, Joseph Baker Sons & Perkins, Inc.

Niter Pots
Bethlehem Foundry & Mach. Co.
Buffalo Foundry & Mach. Co.
Duriron Company

Nozzles, Spray, Acid-proof
Duriron Company
Schutte & Koerting Co.

Oil Bleaching Plants
Garrigue, Wm., & Co.

Oil Refining Machines
Garrigue, Wm., & Co.

Oil Testing Apparatus
See Laboratory Supplies

Ovens, Electric
General Electric Co.
Hoskins Mfg. Co.
Reynolds, Teschner & Volk Co.
Thermo Electric Instrument Co.
See also Laboratory Supplies

Packing
Sarco Co., Inc.

Packings, Condensing Tower
General Ceramics Co.
Knight, Maurice A.

Paints, Acid-proof
General Bakelite Co.
Toch Brothers

Paints, Metal Protective
Eagle Picher Lead Co.
Toch Brothers

Panels, Rheostats and Tungar Rectifiers
General Electric Co.
Westinghouse Elect. & Mfg. Co.

Pans
Buffalo Foundry & Mach. Co.
Devine, J. P., Co.
Duriron Company
Mantius Engineering Co.
Sowers Mfg. Co.
Sperry, D. R., & Co.
Swenson Evaporator Co.
Technical Products Co

Pans, Crystallizing, Stoneware
See Chemical Equipment, Stone ware

Pans, Enameled
Elyria Enameled Products Co.
Pfaudler Company

Papers, Filter
Angel, H. Reeve, & Co., Inc.
Eimer & Amend
Heil, Henry Chemical Co.
Southern Laboratory Supply Co.
Thomas, Arthur H., Co.
See also Laboratory Supplies

Paper, all Kinds
Angel, H. Reeve, & Co., Inc.

Patent Attorneys
See Professional Directory

Percolators
Badger, E. B. & Sons Co.
Buffalo Foundry & Mach. Co.
Devine, J. P., Co.
Elyria Enameled Products Co.
General Ceramics Co.
Knight, Maurice A.
Pfaudler Company
Stokes, F. J., Mach. Co.

Physico-Chemical Apparatus
Central Scientific Co.
Eppley, Marion

Pipe Bending
Pipe & Tube Bending Corp. of America

Pipes, Hard Rubber
American Hard Rubber Co.

Pipe and Accessories, Acid Proof
Bethlehem Foundry & Mach. Co.
Duriron Company
Elyria Enameled Products Co.
General Ceramics Co.
Knight, Maurice A.
Schutte & Koerting Co.
Thermal Syndicate, Ltd.

Pipe and Fittings, Lead or Tin Lined
Eagle Picher Lead Co.
Schutte & Koerting Co.

Platinum Ware (Laboratory)
American Platinum Works
Baker & Co., Inc.
Bishop, J., & Co. Platinum Works
Braun Corporation
Braun-Knecht-Heimann-Co.
Central Scientific Co.
Daigger, A., & Co.
Denver Fire Clay Co.
Eimer & Amend
Engelhard, Charles
Heil, Henry, Chemical Co.
Pacific Platinum Works
Palo Company
Rovey Instrument & Chemical Co., Inc.
Sargent, E. H., & Co.
Scientific Materials Co.
Scientific Utilities Co.
Southern Laboratory Supply Co
Thomas, Arthur H., Co.
Will Corporation

Porcelain Ware (Laboratory)
Berge, J. & H.
Braun Corporation
Braun-Knecht-Heimann-Co
Central Scientific Co.
Daigger, A., & Co.
Denver Fire Clay Co.
Eimer & Amend
Engelhard, Charles
Griebel Instrument Co.
Heil, Henry, Chemical Co.
Herold China & Pottery Co.
Palo Company
Rovey Instrument & Chemical Co., Inc.
Sargent, E. H., & Co.
Scientific Materials Co.
Scientific Utilities Co.
Southern Laboratory Supply Co.
Standard Scientific Co.
Thomas, Arthur H., Co.
Will Corporation

Portable Ozonators
Central Scientific Co.
General Electric Co

Pots, Caustic
See Castings, Chemical

Power Plant Machinery
Technical Products Co.

Preheaters
Buffalo Foundry & Mach. Co.
Cast Iron Pipe Publicity Bureau
Elyria Enameled Products Co.
Hercules Engineering Corp.
Pfaudler Company
Thermal Syndicate, Ltd
Zaremba Company

Presses, Blocking & Extrusion
Technical Products Co

Presses, Hydraulic
Johnson, John, Co.
Shriver, T., & Co.
Werner & Pfleiderer Division, Joseph Baker Sons & Perkins, Inc.

Pulleys, Magnetic
Magnetic Mfg. Co

Pulverizers, Industrial
See Crushers

Pulverizers, Laboratory
Abbé Engineering Co.
Central Scientific Co.
Denver Fire Clay Co.
Eimer & Amend
Scientific Materials Co.
Southern Laboratory Supply Co.
Thomas, Arthur H., Co.
See also Laboratory Supplies

Pumps, Acid
American Hard Rubber Co.
Beach-Russ Co.
Buffalo Foundry & Mach. Co.
Chemical Equipment Co.
Duriron Company
General Ceramics Co.
Johnson, John, Co.
Nash Engineering Co.

Pumps, Centrifugal
American Hard Rubber Co.
Beach-Russ Co.
Chemical Equipment Co.
Duriron Company
General Ceramics Co.
Technical Products Co.
Wheeler Condenser & Eng. Co.

Pumps, Hard Rubber
American Hard Rubber Co.

Pumps, Laboratory
See Laboratory Supplies