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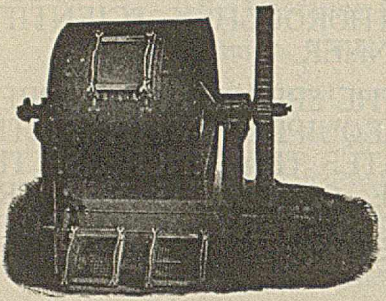

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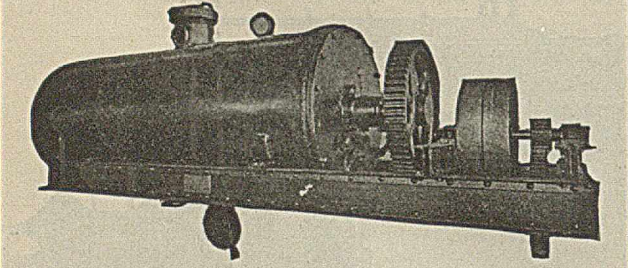

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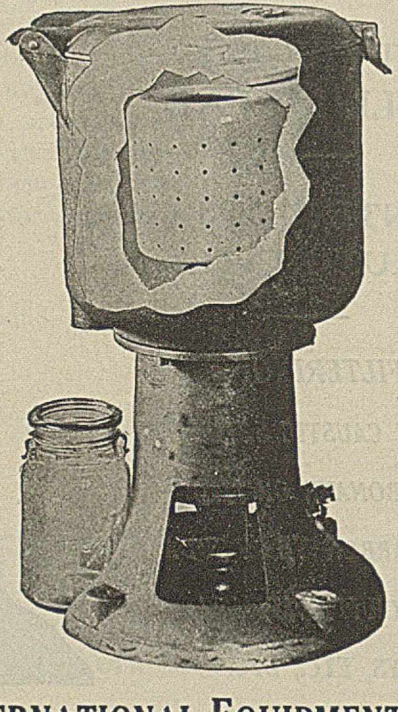

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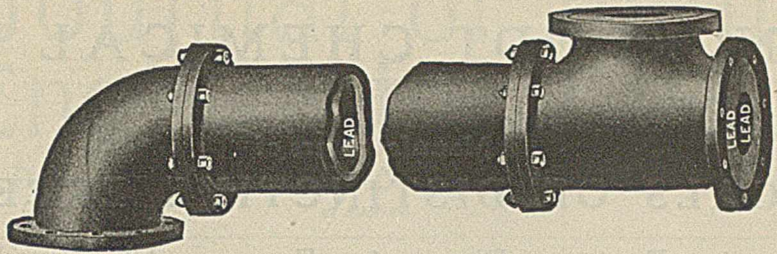

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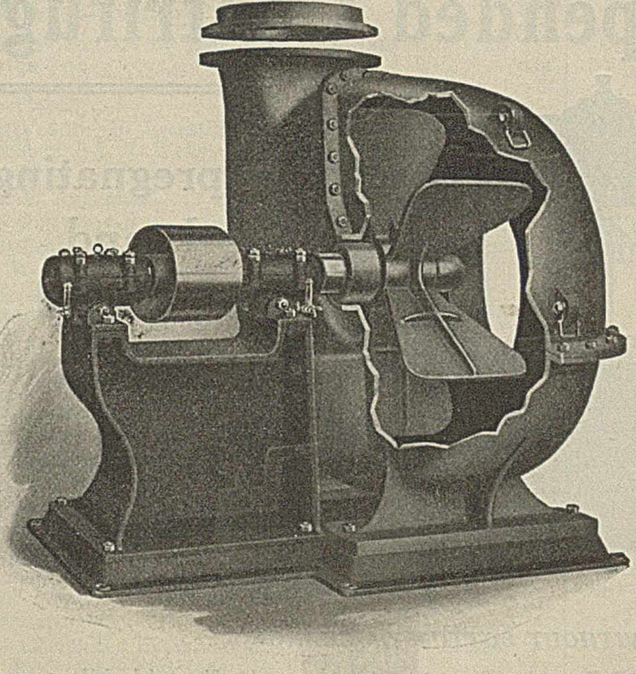

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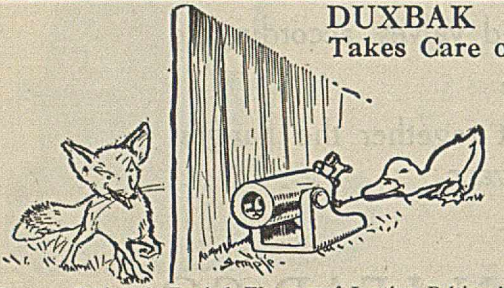

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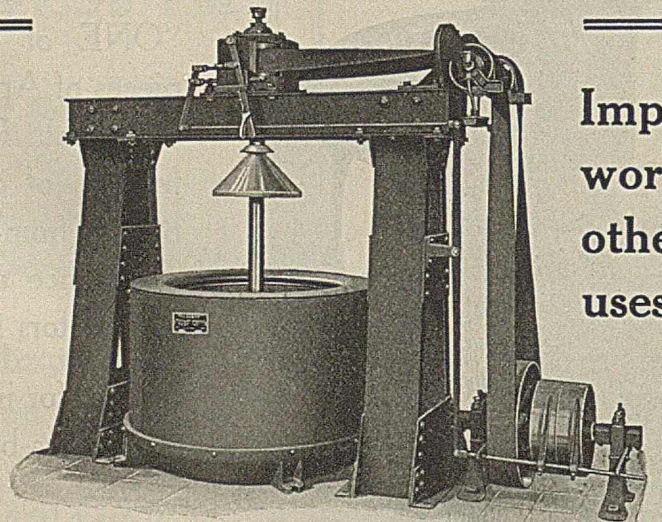

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EDITORIALS

FIRST PLACE TO GOVERNMENT NEEDS

It is the desire of THIS JOURNAL to be of any service possible to the chemists of our government who are charged with the investigation of special problems connected with the war; likewise to serve those chemists who in university and private laboratories are patriotically coöperating with the government in the solution of such problems. In this spirit we therefore gladly depart from normal editorial policy and beg to tender to all such chemists throughout the continuance of the war this first portion of the editorial section for announcing any needs which may arise in the prosecution of their important work.

Dr. W. F. Hillebrand, Acting Director of the Bureau of Standards, under date of June 14, 1917, asks that publicity be given to the following:

GAS INTERFEROMETER NEEDED

The National Bureau of Standards requires for immediate use in an important military investigation several gas interferometers and desires information as to where such apparatus can be purchased or borrowed. The apparatus needed is the Rayleigh gas interferometer with gas tubes 100 cm. long of the form built by the Zeiss Company, or an apparatus equivalent to this. Any information relating to such apparatus should be forwarded to the Director, Bureau of Standards, Washington, D. C., Attention of Gas Laboratory.

GREETINGS TO PROFESSOR GRIGNARD

Among the distinguished members of the scientific commissions from France and England now visiting this country, chemists will be especially interested in the presence of Professor V. Grignard of France. He has come to us at the request of the National Research Council to confer with the Chemistry Committee of the Council and with our War and Navy Departments, and to give us the benefit of the experience which two years of war have brought to the chemical profession in his country. Appreciation of Professor Grignard's brilliant achievements in chemical research and respect for his sound judgment, make doubly warm the hearty greetings which all American chemists extend to him.

CHEMICAL STATISTICS ASSURED

It is a great pleasure to be able to announce the completion of the two thousand-dollar fund for the coöperation of the American Chemical Society with the Bureau of Foreign and Domestic Commerce in the compilation of a census of imports of chemicals other than dyestuffs in a typical pre-war fiscal year. The hope expressed at the conclusion of the rather despondent editorial on this subject in the June issue has been justified; the full amount has been pledged, and the work can now promptly begin.

The detailed itemization of these imports, together with the amounts of each, will constitute a valuable and safe guide to those who patriotically desire for our country national self-containedness in its chemical industries.

There is a deeper significance in this movement, however, than the compilation of such a census. The fund subscribed by representatives of the chemical industries is proof of a desire not only for information from government records on the basis of which new lines of needed manufacture may be inaugurated, but also for prompt and regular issuance of statistics on current imports, which will give invaluable aid to the continued, healthy growth of all of our chemical industries. If those in charge of and responsible for such matters will but compare the character of the information on imports now furnished our chemical manufacturers with that which the German government has for years furnished its manufacturers, they will readily see to how great an extent we have been handicapped by lack of such basic facts. The many problems now to be solved concerning the character of the classifications and itemizations of this census will determine the form of the statistics on current imports. Again we express a hope, namely, that complete statistics on current chemical imports will soon become an asset of the American chemical manufacturer.

THE TARIFF COMMISSION AND SCHEDULE A

Soon after its organization the Tariff Commission announced that it would begin at an early date a thorough investigation of Schedule A (chemicals). To aid the Commission in this complex field an expert adviser was to be appointed. In this connection the following letter was received, under date of May 31, 1917, from Dr. F. W. Taussig, Chairman of the United States Tariff Commission:

My dear Dr. Herty:

It will interest you, I believe, to know that the Tariff Commission has appointed Professor Grinnell Jones to act as Special Expert in connection with its inquiries upon the chemical industries of the country and Schedule A of the existing tariff act.

As you know, the Tariff Commission conferred with Professor Stieglitz and the Advisory Council of the Chemical Society and secured from the Council lists and recommendations of chemists whose services would be helpful to the Commission. Some of the gentlemen suggested proved not to be able to give continuous service, such as is necessary for the work of the Commission, and we finally selected Professor Jones. We are glad to have been able to act in coöperation with the Chemical Society and are indebted to you for the suggestion which led to this coöperation. There is no reason now why public mention of the action taken by the Commission should not be made.

. . . .

This action of the Tariff Commission gives rise to several very pleasant reflections.

Heartiest congratulations to Professor Grinnell Jones upon the unsolicited opportunity thus afforded for public service of nation-wide import! Likewise congratulations to the Tariff Commission upon having secured for its expert adviser in matters pertaining to the chemical industries one of the brilliant young chemists of America whose attainments and character assure thoroughness, accuracy of detail, breadth of vision, uncompromising rectitude and patriotic loyalty!

The fine suggestion by Dr. B. C. Hesse for a Board of Control for the Society in national matters, as presented at the Kansas City Meeting of the Council, has already borne fruit. Pending the determination of certain constitutional questions the Council appointed a committee along the lines suggested by Dr. Hesse to advise the President of the Society on all matters of national bearing. When, therefore, President Stieglitz received from Chairman Taussig a request for immediate nominations for this office the machinery was already provided to give prompt recommendations.

We are confident that all will appreciate the action of the Tariff Commission in thus seeking the counsel of the organized body of American chemists. Too often appointment to public office is accompanied by an unseemly scramble of office seekers for recommendations and for political influence, not to mention persistent personal pleas. All such have here been avoided.

Another reflection, to which we are always glad to give expression, is the value of organization. Sometimes in the past we have heard men say, "Why should I spend my money on dues to the American Chemical Society? I get the benefit of the journals in the library of the Company (or University)." We believe that the present phenomenal growth of the membership of the Society is due to a constantly increasing appreciation of the fact that the Society is more than a mere publisher of journals; more and more its function as a great national force is being recognized, and as it expands to a more complete inclusion of all American chemists that force correspondingly increases. In such days as these no man can afford to live to himself or for himself alone.

THE SEPTEMBER MEETING

On Saturday, May 26, 1917, the Directors of the Society, at a special meeting, considered in all of its bearings the holding of an Annual Meeting this fall. As a result of their deliberations it was decided that the meeting should be held at Boston in September as previously voted by the Council.

The Council will meet on the afternoon and evening of Monday, September 10, 1917. The meetings of the Society will take place on September 11, 12 and 13. The Northeastern Section has been requested by the Directors to omit the usual annual banquet and excursions, and to arrange a program characterized by simplicity and seriousness, and bearing as fully as possible on questions concerning the activities of chemists both in the government service and in the industries during the present war.

The General Meeting will be held on Tuesday morning. This will be followed in the afternoon by a general conference to be opened by Dr. W. H. Nichols, Chairman of the Committee on Chemicals of the National Defense Council, and by Dr. M. T. Bogert, Chairman of the Chemistry Committee of the National Research Council, the conference then to be continued from the floor. It is expected that an informal, get-together meeting of a social character will be held on Tuesday evening, at which time opportunity will be given for informal discussion of problems of the day.

Wednesday morning will be devoted to divisional conferences, and the afternoon to divisional meetings, with papers, or a continuation of the conferences, as the divisions may decide. The presidential address will be delivered on Wednesday evening.

Thursday, both morning and afternoon, will be given to divisional meetings.

We feel confident that the decision of the Directors to hold the Annual Meeting, and along the lines above mentioned, will receive the hearty endorsement of all members of the Society. The gravity of the times makes fitting the elimination of the usual social functions; at the same time it is the compelling reason for a thoughtful assembly of chemists. In the conferences planned opportunity will be given for sounding the keynote of the present situation and for adjusting viewpoints to the new conditions under which we are now working. The country needs the judgment of its chemists on many phases of war conditions. This judgment can best be reached through the inspiration of the spoken word in the conferences, where opportunity will be afforded for interchange of views by men from all sections of the country. This meeting will be no holiday occasion—it should prove a well-spring of strength for our country.

CONCERNING THE EXPOSITION OF CHEMICAL INDUSTRIES

In the midst of the present general upheaval of normal conditions there has been evident from time to time somewhat hysterical agitation of certain ideas which, while of undoubted value, by no means admit of general application. For example, it has been suggested in some quarters that under present conditions the Third National Exposition of Chemical Industries should be abandoned. Against this suggestion, fortunately confined to a very limited number of proponents, we wish to enter most earnest and emphatic protest. This unhesitating protest is based upon the record of what the two previous Expositions have proved themselves to be and upon the thought and purpose which underlie the great expansion already assured this third occasion.

There can be no difference of opinion as to the impropriety of holding this year expositions of the usual popular type. While nominally based upon some historic event of our national life, and while marking through various exhibits certain definite steps forward in industrial life, nevertheless, such expositions really serve as occasions for holiday trips, for rest from daily routine or simply for amusement. As a people we are in no mood for such events.

The National Exposition of Chemical Industries, on the other hand, has an entirely different function. From the outset those charged with the responsibility of formulating its policies have never sought to make of its exhibits a "show," but have consistently held to the belief that the American people would be thoughtfully interested in attractively arranged exhibits illustrative of the rapid progress of an industry which holds within itself so much of fascinating interest and which, at the same time, has such deep significance for our national welfare. Results have proved that this conviction was fully justified.

It was further believed that through this popular insight into the work of the chemist there would be brought about a truer conception of the function of the chemist in all phases of industrial life. In this way the exposition has already stimulated the establishment of laboratories for control and for research in many industrial organizations which hitherto had never had the benefit of this means of efficiency and rational advance.

The spirit of the Exposition has never been one of self-glorification of an industry which seeks to flatter itself by boasting of past accomplishments, but rather has been that of a fearless exhibition of shortcomings, in order that the way might be clearly indicated for future effort. The Exposition has portrayed the splendid achievements of the past only for the purpose of gaining courage and confidence for the greater work of the future.

Up to the present the development of the ideals of the Exposition has been chiefly along the lines of products manufactured and the machinery utilized in their production. If, however, the full service of the Exposition is to be rendered it must act as a coördinating influence in the coöperation of all those factors which go to make up a truly great chemical industry. To the expert knowledge of the chemist and the skill of the machine builder must be added the confidence of capital and an intimate knowledge of the sources of raw materials. It is hoped that this third Exposition will result in marked progress in these two lines. Of all periods in our history this is the most urgent for such progress to be made. The real sinews of war must be furnished by the chemical industries; whatever contributes to their welfare brings the day of a righteous peace nearer.

For these reasons we feel that the Third National Exposition of Chemical Industries should be held next September as planned, confident that its continued growth and evolution will be attended by results of deepest significance to the welfare of our country.

ANOTHER POSSIBLE FORM OF COÖPERATION BETWEEN UNIVERSITIES AND THE CHEMICAL INDUSTRIES

We have recently received a letter from a member of the chemistry staff of a well-known university from which the following paragraph is quoted:

> I wish to come into closer touch with industrial plants as an actual worker during the summer months' vacation. This would give me a more intimate knowledge of present works conditions and thus enable me better to prepare and advise my students to meet the present industrial demands. It would temporarily help to relieve the apparent present stress in some industry until the younger and less experienced men were broken in, would increase my effectiveness in the preparation of chemical engineers, and I could assuredly give full value for any compensation advanced me.

It is fully realized that this is not the first time such a desire has been expressed, and that in the past the temporary character of the proposal has proved a bar to its acceptance. However, the changes in the personnel of plant forces due to enlistment and to the draft may give rise this summer to abnormal conditions which might be relieved temporarily by additions from university forces. Certainly such plant experience would be reflected in better teaching during the next collegiate year, and in this matter the industries have a very direct interest.

The correspondent above quoted, asks this question—"Can you suggest any man or men to whom such a proposition might appeal to the extent of their offering such employment?"

Unfortunately, we had at the time no information which was of any value. This very shortcoming suggests a possible service and we therefore gladly offer to act as a clearing house of information on this subject for those professors and instructors who may care to file their names with us and for those in the chemical industries who may desire to have a list of such available men.

FRIENDLY CONFIRMATION OF A POLICY

In the June issue we urged the members of the Society to exert their personal influence in maintaining, and, indeed, in increasing the list of our advertisers under the new rates recommended by the Society's representatives. It is too early as yet to ascertain the extent of the response to this appeal. It is, nevertheless, a satisfaction to have received such an endorsement of the spirit of the appeal as was contained in the "lead-off" editorial of the *Manufacturers Record* in its issue of June 16, 1917. This is reproduced here with a few eliminations:

TO USE "THEIR PERSUASIVE POWERS"

> The *Journal of Industrial and Engineering Chemistry*, published by the American Chemical Society, announces that, in view of increased cost of operation, the Publication Committee has recently decided to advance its rates 40 per cent, to take effect immediately; and in publishing this statement the *Journal* appeals to members of the Society to render valuable aid by "using their persuasive powers" in holding all former advertisers, and by urging those not now advertising to become advertisers in the *Journal*.
>
> The MANUFACTURERS RECORD has not as yet advanced its rates to meet these new conditions, notwithstanding the great increase in the cost of publication of this as of all other papers, but whenever it is compelled to do so, it trusts that it can appeal to its readers, as the *Journal of Industrial and Engineering Chemistry* has appealed to the members of the American Chemical Society, to use their "persuasive powers" to induce all advertisers to continue to advertise, and to induce those who are not now advertising to use the advertising pages of the MANUFACTURERS RECORD.
>
> If we can have the hearty coöperation of all of our readers in furtherance of efforts to increase advertising and to make advertisers know the value to the readers of the MANUFACTURERS RECORD of these advertisements, we shall be glad to have learned the lesson from the *Journal of Industrial and Engineering Chemistry*.
>
> A good example is being set to other publishers in facing the issue of higher cost of publication and the necessity for higher advertising rates, and in appealing to the readers of the publication to coöperate in holding and securing advertising in the publication. Success to this excellent campaign!

THE PRESENT STATUS OF AMERICAN CHEMISTS AND WAR SERVICE

For the information of all chemists there is given below the "Report on the War Service for Chemists" and the "Plan for the Impressment of Chemists for War Service as Chemists and for the Preservation of the Supply of Chemists", as recommended to the Council of National Defense by a committee consisting of William H. Nichols, M. T. Bogert, A. A. Noyes, Julius Stieglitz and C. L. Parsons. The documents were drafted after careful consideration of the experience of our Allies. Dr. William H. Nichols, chairman of the Coöperative Committee on Chemicals of the Advisory Commission of the Council of National Defense, has embodied this material in his report with the recommendation that it be adopted by the Council of National Defense. That body has not yet acted upon the report, nor has any action been taken in regard to the status of chemists as a class; it is possible that the cases of chemists, drafted will have to be considered individually. Whatever action is taken, it must receive the approval of the President before becoming a fixed policy. The wording of this report, and the lack of final action thereon, would seem to make clear the patriotic duty of chemists at this time — WAIT! [Editor]

REPORT ON THE WAR SERVICE FOR CHEMISTS

Chemists and chemical engineers are normally needed in almost all branches of industry (including the standardization and control of food products) for the successful operation of processes, the detection and speedy correction of difficulties and the improvement of products. England, France, and Italy found it necessary to recall all chemists from the ranks; Canada does not allow chemists to enlist; chemists have saved Germany up to the present time.

There was a decided shortage in the supply of chemists in the United States even before April 1914. The war has made the shortage acute, and it is certain that our own war needs and industries necessary to war will absorb chemists as rapidly as they can be trained.

It takes from four to seven years to *train* a chemist. The shorter time is for college graduates and chemical engineers who become wholly useful only after a further year of experience in a manufacturing plant or laboratory (corresponding to the hospital year required of medical students). The longer time is for the training of research men taking the doctorate degree in chemistry, on whose shoulders ultimately the vast need of the government and the industries fall for meeting and solving new difficulties and problems of organized research.

When chemists of mature years are called in for service in government laboratories, their places must be filled by younger men to keep the machinery working. It is, therefore, of the greatest importance that steps be taken:

1st—To keep and impress into service *in chemical* lines chemists drawn by the draft for service in the United States Army or Navy.

2nd—To provide means for keeping open sources of supply of chemists from universities, colleges, and schools of technology, and to procure volunteers in chemistry.

A tentative plan for accomplishing these results is hereby appended and recommended.

William H. Nichols, *Chairman of the Chemistry Committee, National Defense Council.* Past President Society of Chemical Industry. President 8th International Congress of Applied Chemistry.

Marston T. Bogert, *Chairman of the Chemistry Committee, National Research Council.* Past President American Chemical Society.

A. A. Noyes, *Past President American Chemical Society.*

Julius Stieglitz, *President American Chemical Society.*

Charles L. Parsons, *Secretary American Chemical Society.*

PLAN FOR THE IMPRESSMENT OF CHEMISTS FOR WAR SERVICE AS CHEMISTS AND FOR THE PRESERVATION OF THE SUPPLY OF CHEMISTS

I—There shall be organized a Committee of three to advise the President of the United States through the War Department on requests for exemption of chemists. This committee might well include besides a Government representative two chemists, one a chemical engineer or technical chemist, the second a university man. These men should be nominated to the President by the Council of National Defense.

II—Requests for exemption of individual chemists shall be made to this committee by:

(1) Government, State or Municipal Laboratories and Bureaus.

(2) Heads of manufacturing plants on the basis of the imperative need of these men for their successful operation.

(3) Presidents of Universities, Colleges, and Schools of Engineering or Mining on the basis of proficiency, promise and ability of candidates for college or university degrees, specializing in chemistry. Men recommended under this head who are candidates for the doctorate degree shall not be over 26 years of age when they receive the degree, and men who are candidates for a four-year college degree shall not be over 23 years of age when they are to receive the degree.

III—(1) Chemists under 21 and over 30 years of age and chemists between 21 and 30 who have not been drafted may enroll with the above committee as volunteers in chemistry subject to the same conditions as the enlisted and exempted men.

(2) Students in chemistry under 21 years of age may enroll with the above committee for a "chemists reserve" under the conditions specified in II (3).

IV—Men thus enrolled and accepted under the provisions of the above paragraphs for war service as chemists shall be subject to the orders of the government as to location and nature of service and shall be entitled to wear a badge or other insignia indicating their official status (practice of France and possibly of other European countries). Students enrolled in a "chemists reserve" shall be subject to the same conditions as obtain for other reserves of the government and shall also be entitled to wear some insignia or badge indicating their enrollment.

ORIGINAL PAPERS

RESULTS OF RECENT INVESTIGATIONS OF THE SMELTER SMOKE PROBLEM[1]

By A. E. Wells

Received June 1, 1917

At many of the smelting plants throughout the United States, the smoke problem continues to be one of considerable importance. In fact, due to the increased tonnages of ores being handled during the last two years at many plants, some damage has been done by smoke where formerly no serious smoke troubles were encountered, and the problem in those places has assumed serious proportions. Elsewhere the problem has become important mainly because a greater number of those people engaged in agricultural pursuits in the vicinity of smelters have heard through various sources that the smelter smoke might be injurious to crops and to live stock; thus, whenever any adverse condition arises in districts contiguous to smelters, it has become the custom to blame the smelter smoke first, before trying to determine the true causes. Careful investigations in many cases have proved that the causes were wholly foreign to the smelter smoke. Whether actual damage has been on the increase, due to increased smoke output, or whether there has been a greater tendency on the part of the farmers and stock raisers to lay their natural crop and stock troubles at the door of the smelter smoke, the result has been that at many plants it has become necessary for the companies to enter upon careful investigations to determine the facts.

Believing that an outline of these investigations as carried out by the lead and copper smelting companies would be of interest to those who are directly concerned with the metallurgy of zinc, an attempt has been made in these pages to present this outline in as brief a form as possible.

As metallurgist on the smoke problem for the United States Bureau of Mines, the writer has been associated directly or indirectly with nearly all these investigations, and in many cases has assisted in the work. Coöperation with the smelting companies is possible in nearly every instance, because it is evident that the companies wish to have the true facts determined concerning the conditions in the zones around their plants. They are ready to face squarely any facts so determined which might be considered even detrimental to their interests, and are showing a willingness to go as far as practicable toward the ultimate solution of the problem by the elimination of the substances that are found to be the causes for damage. In general it might be stated that the companies are ready to meet the situation fairly, and that wherever there is a possibility of injury resulting from their present methods of operation, they are ready to make decided improvements. These improvements often involve expenditures of money beyond those yielding any financial return.

As this can be but a brief presentation of some of the most important features of the smoke problem, it will be necessary to dismiss with a few words any consideration of the dust and metallic fume element of the smoke, as this element is of minor importance.

DUST AND METALLIC FUME ELEMENT OF MINOR IMPORTANCE

The investigations that have been conducted during the last few years, including those of the Selby Smelter Commission,[2] American Smelting and Refining Co., etc., have proven conclusively that as far as damage to vegetation is concerned, dust and fume particles or acid mist are practically negligible quantities. The effect of dust and fume particles upon animal life is another matter. No doubt some injury has been done and may now be done in certain places to animal life by the toxic salts in the smelter emanations where there have been large accumulations of these toxic salts on vegetation. Generally speaking, however, wherever the amount of dust and fume being emitted is so large as to constitute a menace to live stock in the community, it is found that the value of the solids being lost would pay a reasonable return on the investment necessary for installations to recover them, without any damage consideration being involved. In most cases it is a comparatively easy matter to recover the greater portion of the solids, and at the present time there is no excuse for a smelter turning large amounts of the solid constituents of the smoke into the atmosphere, especially if those solids are known to be causing injury to live stock.

SULFUR DIOXIDE PROBLEM MOST IMPORTANT

The most important problem, therefore, is the sulfur dioxide problem. At many plants where large quantities of sulfide ores are being handled serious efforts are being made to utilize the waste sulfur dioxide through the manufacture of sulfuric acid, liquid sulfur dioxide and even elementary sulfur. Technical methods have been worked out for accomplishing the last two schemes, and small scale commercial plants erected. Two of the largest copper smelters of the west, namely, Anaconda and Garfield, have recently made heavy investments in acid plants. However, many plants are situated at such great distances from the markets for these products that only a comparatively small amount of the available sulfur dioxide can be utilized. It is recognized that although the amount of the waste sulfur gases that will be utilized in commercial products will be steadily increasing, yet for many years to come the smelters will be obliged to waste large quantities of sulfur dioxide into the atmosphere. Thus, investigations are in progress to determine how, under different climatic and topographic conditions, these volumes of sulfur dioxide, whether large or small, can be discharged into the atmosphere without causing injury to vegetation in the surrounding country.

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[1] Presented at the *Symposium on the Chemistry and Metallurgy of Zinc*, 54th Meeting American Chemical Society, Kansas City, April 12, 1917. Published with the permission of the Director of the Bureau of Mines.

[2] See This Journal, 7 (1915), 41, for abstract of Selby Smelter Commission report.

EFFECTS OF BLEACHING ON YIELD

In this connection it is necessary to determine first of all what are the effects, both in regard to superficial bleaching and in regard to the economic results on yield, of applying various concentrations of sulfur dioxide to various forms of plant life and under different atmospheric conditions. If the time were available, it would be interesting to discuss the earlier methods that were used in this country and in Germany for determining the effect of sulfur dioxide on vegetation, and to show wherein the vast amount of data that were determined by these investigations are of no value as furnishing data upon which to base definite conclusions. It is necessary to dismiss any consideration of these investigations with the brief statement that in none, whether the tests were made in cabinets, glass jars or in smoke houses, were normal field conditions even approximated, nor was there any knowledge of the actual concentration of the sulfur dioxide in contact with the plants, nor of the atmospheric conditions. A knowledge of the attendant atmospheric conditions is of the greatest importance.

The first research work along the line of making determinations under actual field conditions was that done by the Selby Smelter Commission. In these determinations, known volumes of air containing known definite concentrations of sulfur dioxide were blown for definite periods of time under known atmospheric conditions over plants growing normally in the field. A cabinet framed with wood and with celluloid sheets for the sides was placed over the plants during the period of investigation, which varied between two minutes and eight hours. Check plots were fumigated simultaneously under the same conditions with air containing no sulfur dioxide. All the determinations of the Selby Commission were made on barley, as this was supposed to be the most sensitive of all the crops.

The department of smoke investigations for the American Smelting and Refining Company in Utah, under the direction of Mr. P. J. O'Gara and Mr. E. P. Fleming, has continued the work that was started by the Selby Commission, and, through many elaborate series of careful and detailed investigations, has obtained a vast amount of reliable and definite data on the smoke problem, especially that phase of the problem concerned with sulfur dioxide. As far as the data obtained by the Selby Commission went, they were checked quite closely by those obtained by later tests. However, the work of the A. S. & R. Co. was carried out on a much larger scale, and the experiments covered so much greater range in the number of crops treated, and in regard to variety of atmospheric conditions, that comparison cannot be carried very far.

In conducting these investigations, the smoke department of the A. S. & R. Co. has endeavored to determine if damage was being done in the vicinity of the smelters by the smoke, if so, how it was done and to what extent the damage was of economic importance. These investigations were carried further to determine what steps were necessary to prevent such damage. As soon as it was evident that such investigations were producing reliable and tangible data, and were answering in a definite manner many questions concerning the smoke problem, other companies followed their example, and at the present time companies in different parts of the country are carrying on similar studies, though on a much more modest scale. Wherever it is evident that there is no effort or desire to conceal data or twist them to suit convenient theories, it is the aim of the Bureau of Mines to coöperate and help in investigations as far as practicable.

The method used by the A. S. & R. Co. for determining the effect of sulfur dioxide on plant life was practically the same as that devised by the Selby Smelter Commission, improvement having been made in the method of introducing the air into the cabinet. In the experiments of the A. S. & R. Co., the experimental plots were 6 ft. by 6 ft. in area and cabinets were 4 ft. high. The fan delivered approximately 10 cubic meters of air per minute into the cabinet, this volume being sufficient to keep the temperature and relative humidity of the air in the cabinet similar to those of the outside air. In every experiment two plots were fumigated simultaneously, one with the sulfur dioxide mixture, the other with air free from sulfur dioxide, the latter being the check plot. The determinations were made on a great number of crops, including potatoes, tomatoes, sugar beets, cereals, alfalfa, red clover and garden truck. In 1915 and 1916 there were, in all, nearly 3000 experimental plots.

Besides the work in the field, experiments were made in which the gases were drawn from the top of the stack, these gases diluted to concentrations desired, and the mixture blown over plants that were grown in boxes under conditions similar to those in the field.

In order to determine to what extent visible bleaching affected the yield or whether an economic loss could be sustained by the crops without visible injury, it was necessary to harvest the experimental plots very carefully. Records were kept of the total yield of vegetable matter, and in the case of grains, the weight of grain, weight of kernels, number of kernels per head and percentage of germination. The A. S. & R. Co. have made complete analyses for protein, carbohydrates, fat, sulfur and crude fiber.

To summarize briefly, the fumigation tests have demonstrated these facts:

(1) Under certain atmospheric conditions, bleaching of crops, especially grain crops, can be produced by very small concentrations of sulfur dioxide, even as low as one part sulfur dioxide per million parts air, if the time of application is sufficiently long. The A. S. & R. Co. tests have demonstrated that other crops are much more resistant to sulfur dioxide than are the cereals, but that in all cases the concentrations required are low if the other factors are favorable for injury.

(2) A visible bleaching on grain and many other crops, if endured during the early stages of growth, does not necessarily affect the ultimate yield.

(3) A considerable amount of bleaching can be sustained at all stages by the plants without cutting down the yield greatly. In fact, in the Selby work, it was found that in order to decrease the yield 30 per cent

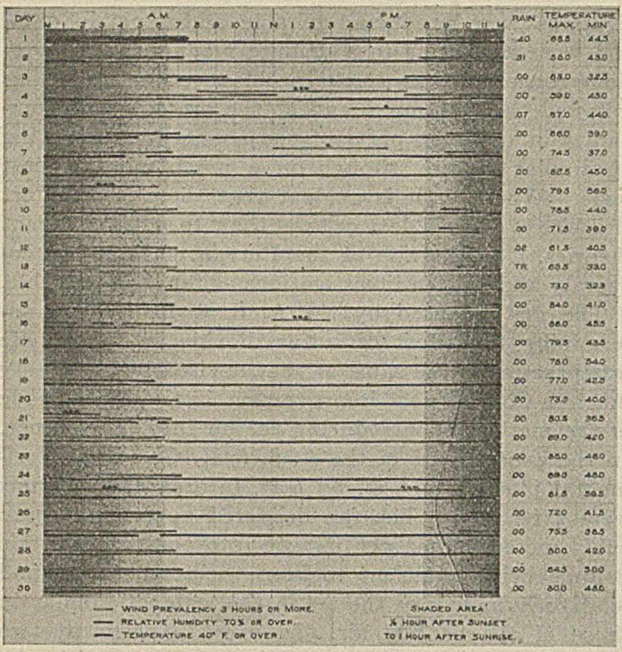

FIG. 1—COINCIDENCE OF LIGHT, RELATIVE HUMIDITY, WIND PREVALENCY AND TEMPERATURE, JUNE 1915

it was necessary to keep the plants very severely bleached during the entire growing season.

(4) There was no "invisible injury," that is to say, there was no economic loss in yield without there being a certain amount of visible bleaching. In fact it was found that in many of the fumigated plots that were treated daily with concentrations below the point of actual foliar markings, there was an actual increase in yield. Fumigated plots, even those considerably marked, as well as those treated daily without producing bleaching, showed an increase of protein above the check plots.

DETERMINATIONS OF BLEACHING CONDITIONS

The determination as to whether visible markings on crops produce economic loss has not been considered the most important phase of these investigations, although it has been necessary. The most important phase has been to determine the maximum amount of sulfur dioxide that can be present in the air without producing any bleaching under the atmospheric conditions most favorable for producing a bleach. Having determined that, it then becomes necessary so to regulate the height of discharge, concentration and temperature of the gases at the stack that the sulfur dioxide concentration in the air is less than that amount, and no injury will result.

It was established that sulfur dioxide in any such concentration as may be found in the vicinity of smelters can act on the plant only by being absorbed through the growing and functioning leaves. No action, unless it is a beneficial one, was found to take place through the soil. The beneficial effect of sulfur or sulfuric acid on soils will be discussed later in this paper. The epidermis of the plants is practically impervious to gases. It is only through the very minute breathing pores, or stomata, that all gases, including sulfur dioxide, can pass into or out of the palisade cells and sponge-like tissue of the leaf where, under the action of light, plant food is manufactured. The opening and closing of these breathing pores or stomata are controlled by guard cells. As the walls of the guard cells, like the epidermis of the plant cells, are very impervious to gases, sulfur dioxide not excepted, whenever the breathing pores are closed by the guard cells, no gases can be absorbed by the plant, excepting under extremely high concentrations, far above those encountered under any imaginable conditions. Even carbon dioxide, which is an essential plant food and which is found normally at 300 p. p. m. in the air, is not absorbed by the plants when the stomata are closed. Thus, whenever the guard cells are closed, this generally taking place at night, the plants are much more resistant to sulfur dioxide than when the cells are open.

Furthermore, carbon assimilation does not take place at night, but only during hours of daylight, all other factors being favorable. It is believed that the nascent oxygen given off when carbon is assimilated is effective in oxidizing any sulfur dioxide in the cells to sulfuric acid, and this produces the injury to the plants. Thus at night, when no nascent oxygen is present in the cells, there would be less chance for injury by sulfur dioxide even if the cells were only partially closed.

LIGHT AND HUMIDITY conditions have a very marked effect upon the opening and closing of the breathing pores. For the most part the tendency is for plants to close their stomata during the night and open them during the day. It was found that in Salt Lake Valley, in the case of alfalfa and various other plants, nearly complete closure of the stomata is the normal condition at night, opening beginning an hour or more after sunrise and closure again taking place, on a normal day, during the evening. Closure may take place as early as 11 A.M. if the humidity is especially low. Low humidity is very effective in producing a collapse of the guard cells and thus closure of the stomata.

A great deal of study has been given to the examination of the effect of different intensities of light and degrees of humidity on the susceptibility of crops to sulfur dioxide. It was found, in the investigations of the A. S. & R. Co., that plants in complete darkness were from 5 to 6 times as resistant to sulfur dioxide as were plants in the light. Plants began to show resistance whenever the light value was as low as 2 per cent, but there was no difference between 8 per cent and 60 per cent values. It was determined, both in the work of the Selby Commission and in the work of the A. S. & R. Co., that humidity is of very great importance as affecting the susceptibility of crops to sulfur dioxide. In the Salt Lake Valley it was found that 70 per cent was about the critical humidity; above that point plants were much more susceptible to sulfur dioxide than below.

It may be stated that in any locality with a definite concentration of sulfur dioxide in the air, four factors must be in coincidence before injury will take place, namely temperature, light, relative humidity and wind prevalency, the latter determining the time of application of the sulfur dioxide. For example, in order that

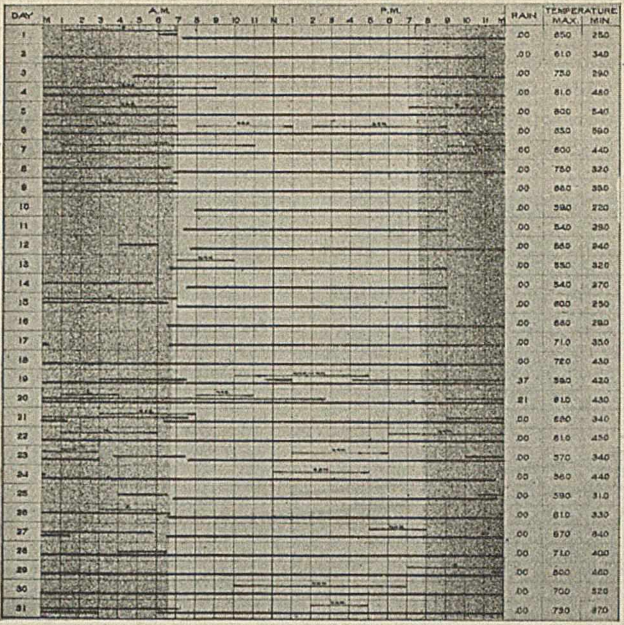

FIG. II—COINCIDENCE OF LIGHT, RELATIVE HUMIDITY, WIND PREVALENCY AND TEMPERATURE, MAY 1916

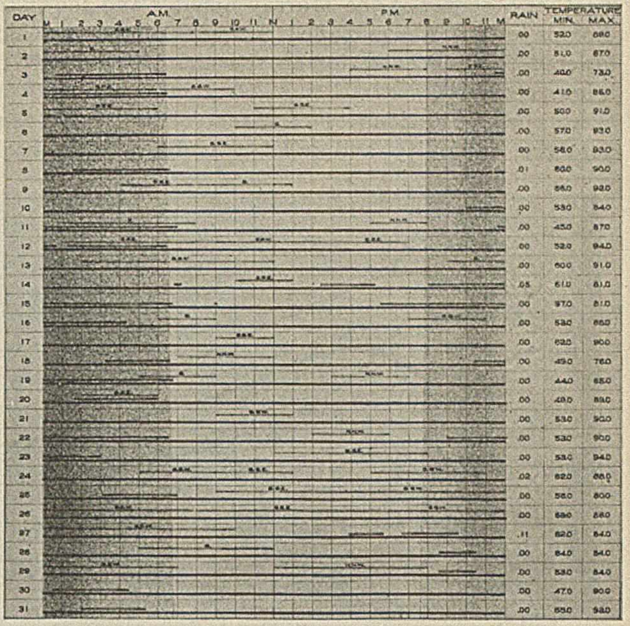

FIG. III—COINCIDENCE OF LIGHT, RELATIVE HUMIDITY, WIND PREVALENCY AND TEMPERATURE, JULY 1916

a concentration of one part sulfur dioxide in a million parts of air should produce bleaching on the most susceptible plants, *e. g.*, barley, oats, alfalfa, etc., it is necessary that this concentration exist around the plant for three hours and that the humidity shall be 70 per cent or more, the temperature above 40°, and that the fumigation should be made in the daylight. Under the same external conditions, greater concentrations would require shorter time of application. Under lower humidity conditions, higher concentrations or longer times of application were necessary to produce the same bleaching.

INFLUENCE OF WEATHER CONDITIONS

Thus, in order to know the possibilities of injury to vegetation in the region of smelters, one must determine not only the average and maximum values for the sulfur dioxide in the smoke stream, but also the weather conditions, that is, wind prevalency, relative humidity, temperature and light conditions. A knowledge is necessary of the number and duration of the critical periods, that is to say, the periods when all factors favorable for the bleaching of crops with small concentrations of sulfur dioxide are coincident. If these periods occur frequently or are of long duration, then the amount of sulfur dioxide that can be discharged into the air without doing injury must necessarily be lower than under more favorable conditions.

For the determination of the weather conditions, a complete installation of standard weather instruments is essential. This equipment must consist of wind vane, anemometer, thermograph, hygrograph, maximum and minimum thermometer, rotating psychrometer, sunshine bulb and rain gauge. The wind direction and velocity, sunshine and precipitation and relative humidity should be automatically recorded.

The American Smelting and Refining Co. during the last three years have kept a very accurate and close record of the weather conditions around their plant in Murray, Utah, and with their consent I will describe briefly their method of plotting the weather data so that the critical periods during the months can be seen readily. This method will surely be of value to those who are called upon to do similar work in other places.

It was found that in the Murray smoke zone, the sulfur dioxide concentrations in the air under the conditions existing in 1915–1916 were such that the critical weather conditions were: (1) temperature above 40° F.; (2) relative humidity above 70 per cent; (3) wind prevalency 3 hours or more; (4) daylight.

In Fig. I, the weather data for June 1915 are plotted to bring out the time of coincident factors. The shaded portion of the figure shows approximately the hours of darkness per day during which the stomata of the plants were normally closed and during which time very little gas was taken through the breathing pores of foliage. During hours included in the light portion, it may be assumed that the breathing pores were open. The lowest line shown in the space representing each day indicates the time during which the temperature was above 40° F. The line next above shows the hours during which the humidity was above 70 per cent, and the highest line, wherever it is present, shows that for at least 3 hrs. there was a prevalent wind. It is to be noted that on June 4 between 8 o'clock in the morning and 12 o'clock noon there was a period of 4 hours when there was a steady south-southwest wind and humidity was above 70° and temperature above 40° F. The average sulfur dioxide concentration in the air in a northeast direction around the Murray plant during this time was above the toxic limit for these conditions, and there was produced a well-defined zone of bleaching on vegetation over an area having the form of an elongated ellipse running in a northeasterly direction from the plant. On Fig. II are shown the same data for May 1916. On May 20, 1916, another period of coincidence was found, but on that day the adverse climatic conditions were forecast by the weather observer at the Murray Smelter and the sulfur dioxide output was curtailed during that period, which lowered the concentration in the air. As a result no injury occurred.

At night, coincidences of three factors, *i. e.*, temperature, humidity and wind prevalency, frequently occur and for long periods of time. In July 1916, many long periods of these three coincident factors were found (Fig. III). However, no bleaching has been done at night, even though the sulfur dioxide output from the smelter remained high. This fact checks the observations which were made in experimental work on the fumigated plots, showing that at night, when the breathing pores of the plants are closed and carbon assimilation is at a standstill, the plants are very resistant to sulfur dioxide.

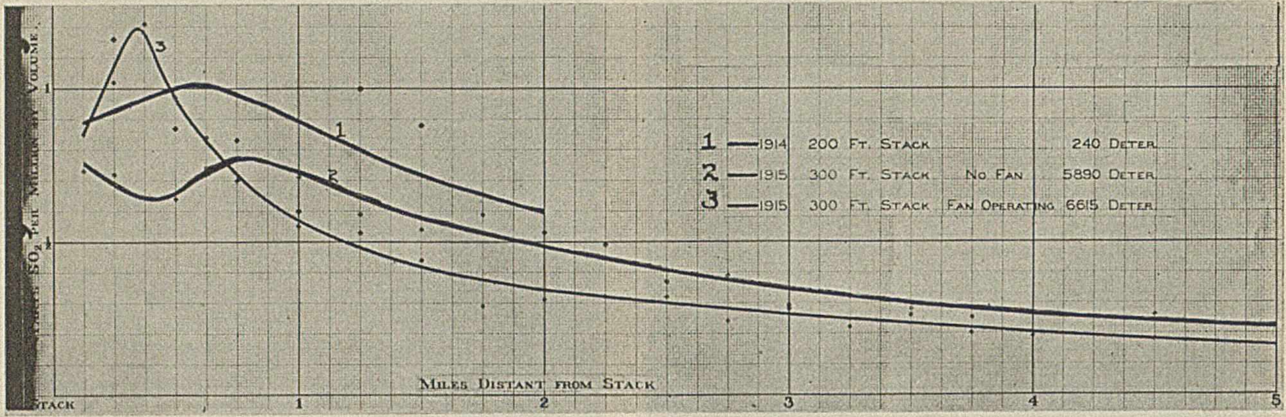

Fig. IV—Murray Gas Stream: Average Concentrations of SO$_2$ in 5-Mi. Zone

Having determined the concentration of sulfur dioxide necessary to produce markings upon vegetation under the various field atmospheric conditions, and also having obtained complete data concerning the atmospheric conditions that may exist, it is then necessary to know whether or not sulfur dioxide is present in sufficient strength in the field to do damage under the existing operating conditions of the plant. If such is found to be the case, it is then necessary to determine how the sulfur dioxide concentration in the smoke zone can be lowered without actually reducing the sulfur dioxide output from the smelter.

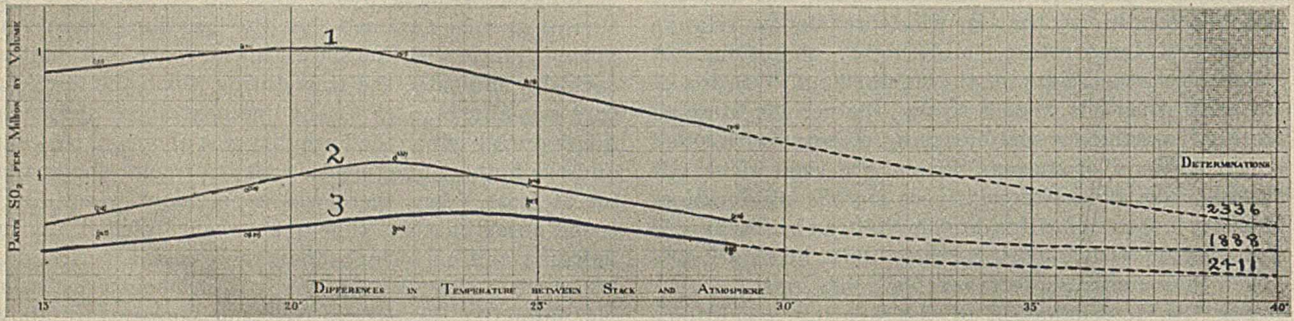

Fig. V—Murray Gas Stream: Diluter Fan Operating
Segregation of SO$_2$ Determination According to Differences in Temperature between Stack and Atmosphere
Observations Made: (1) Inside of $^3/_4$-mi. Zone, (2) Between 1- and 2-mi. Zones, (3) Outside of 2-mi. Zone and Mainly Inside of 4-mi. Zone

DETERMINATION OF SULFUR DIOXIDE IN AIR

The method that is now being used quite generally by all the smelting companies for the determination of the sulfur dioxide condition of the atmosphere, is one that was devised originally by Mr. J. R. Marston, Chief Chemist at the Selby Smelter, and which was developed to its present high degree of accuracy, speed and ease of manipulation by the chemists of the Selby Smelter Commission. By this method a sample of the atmosphere can be taken in a few seconds time and analysis made in less than 5 minutes. In fact the field men are supposed to make from 10 to 13 determinations per hour.

Concentrations as low as 0.1 part sulfur dioxide per million parts of air are determinable. Laboratories supplied with aspirators and vacuum pumps, titration bottles and reagents, are equipped on automobiles, in which the investigators can follow up the smoke stream or change from one part of the stream to the other. In most cases these "smoke cars" are also supplied with wind vanes and anemometers. By the use of several machines, it is possible to obtain many thousand determinations in a season, these being taken at all parts of the smoke stream and under all conditions of temperature, humidity, wind velocity and prevalency.

DATA FURNISHED BY AMERICAN SMELTING AND REFINING COMPANY

With the consent of the A. S. & R. Co., the air data that have been obtained in the Murray Gas stream during the last three years under three conditions of operation of the plant are shown in the curves of Fig. IV. These curves represent the average sulfur dioxide concentrations that were found in the air with different heights of discharge and temperatures of the gas at the stack. Such curves give a very clear idea of the sulfur dioxide content of the smoke stream under the three conditions, and aid toward making estimates as to the best method for improving the conditions. From these curves it is apparent that by increasing the height of discharge of the smoke, the dilution of the sulfur dioxide into the atmosphere is very greatly benefited. (Compare 1 and 2, Fig. IV.) The point at which the maximum average concentration of sulfur dioxide was found with a 200-foot stack was about one-half mile from the stack. With a stack 300 feet high, the point of maximum average concentration had moved out to the three-quarter mile zone. However, the concentration found in the three-quarter mile zone with the higher stack was much less than the concentration from the half-mile zone with the shorter stack. The high concentrations in Curve 2, at a distance of about 1/4 mile from the plant, were not due to stack gases but to low gases leaking from the furnaces, etc. The curve for the stack gases begins at the 3/8-mile zone.

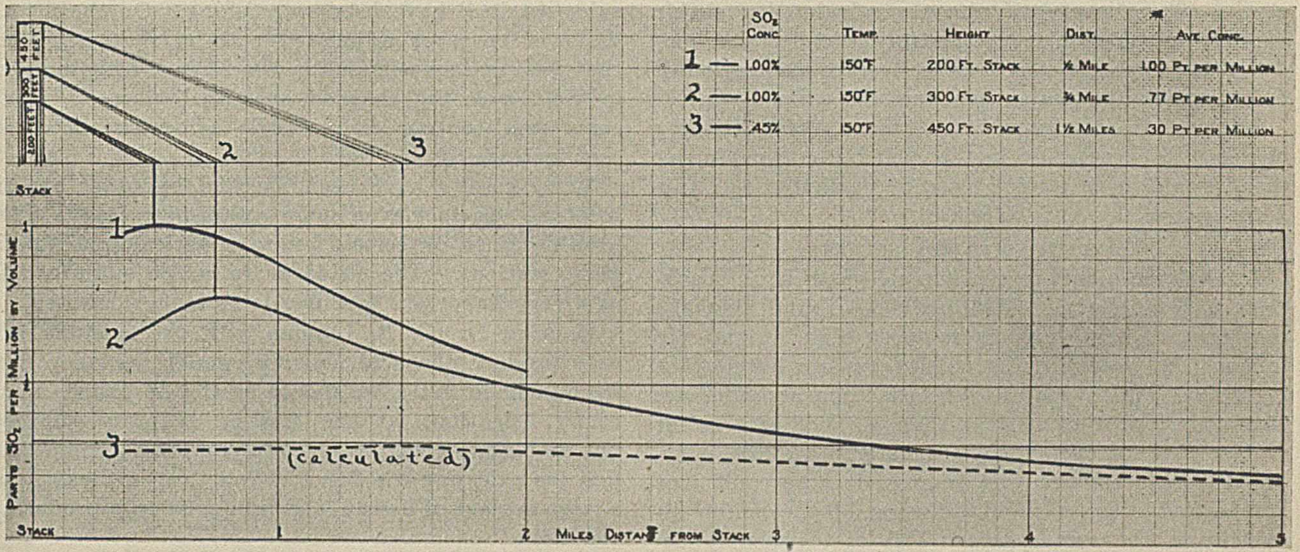

FIG. VI—MURRAY GAS STREAM: ZONES OF MAXIMUM CONCENTRATION

The dilution of the sulfur dioxide in the stack itself by the introduction of cold air may be carried to too great an extent, for the cooler gases will settle closer to the stack, and even though the concentration in the stack is lower, yet the actual concentration of the sulfur dioxide coming in contact with vegetation in the near vicinity of the stack may be higher. This fact is shown by Curve 3 in Fig. IV. It is to be noted that when the gases were diluted from 0.75 to 0.25 per cent SO_2, and at the same time cooled to nearly the atmospheric temperature by the introduction of outside cold air by a diluter fan, the point of maximum average concentration was about 3/8 of a mile from the plant, and that the concentration at that point was higher than under either of the two previous conditions. The effect of diluting gases in the stack was to increase the concentration within the three-quarter mile zone, but outside of that three-quarter mile zone the concentrations were less.

The effect of increasing the difference in temperature between the stack gases and the outside air is shown even more clearly in the curves given in Fig. V. It is to be noted that, as the difference in temperature of the stack gases and air was increased, the point at which the gas currents met the ground extended further out from the stack. However, the further out the point of maximum concentration, the less was the actual concentration found.

The maintenance of a considerable difference in temperature between stack gases and atmosphere is of the greatest importance. It has been found in one instance that putting the furnace gas through a bag house, which procedure of course necessitated reducing the temperature of the gases to that at which a bag house could be operated, resulted in the sulfur dioxide gas doing considerable bleaching to the surrounding vegetation, whereas in former years, when the gases went into the atmosphere unfiltered, but at a higher temperature, there was practically no sulfur dioxide injury. It has been concluded by those who are investigating these problems, that in cases where the smelter must discharge large quantities of sulfur dioxide into the atmosphere, especially one located immediately adjacent to agricultural districts, it is much better to remove the solids at as high a temperature as is practicable. A bag house, although it gives the most perfect clearance of solids, is not always desirable for those conditions, as the use of a bag house may necessitate reducing the temperature to too low a point. An electrical precipitation apparatus may not give perfect clearance of the solids, but in such cases is much preferable. The higher the temperature of the gases in the stack, of course, the greater the amount of arsenic and sulfuric acid mist that will escape, and in cases where large quantities of these are present, there is a maximum limit of temperature at which precipitation should be effected.

The amount of sulfuric acid mist that, at most plants, would escape under the conditions of high temperature electrical precipitation treatment, would do no harm to the surrounding vegetation; at the worst would produce only a slight spotting of the vegetation. It can be stated that at many lead, copper and zinc smelting plants where a recovery of the dust and fume is desirable, it would be much better for the smoke conditions in the immediate vicinity of the plant if only partial clearness of dust and metallic fumes were obtained, that is to say, 85 or 95 per cent, at a temperature which would still leave the gases much higher in temperature than the atmosphere, rather than to obtain perfect clearness, if, in order to obtain complete recovery of the dust and fume, it would be necessary to put the gases through a bag house and consequently allow them to escape into the atmosphere at a low temperature.

In Fig. VI are shown again the curves which represent the average concentration of sulfur dioxide in the air around the Murray plant with a 200- and 300-ft. stack. There is plotted also the calculated probable average sulfur dioxide concentration under the condition of a 450-foot stack and a gas concentration of 0.45 per cent, the temperature remaining about 150° F.

If this last condition were attained, the possibility of injury to vegetation in the vicinity of the Murray plant would be so remote as to be negligible, and this is the aim of the A. S. & R. Co.

CONDITIONS IN ZINC PLANTS

At the zinc plants in the natural gas belt, in southeastern Kansas and Oklahoma, it is found that the roaster stack temperatures are very high, around 350 to 400° C. Where the temperatures are lower, that is, around 150 to 200° C., the gas concentrations are also very low, that is, less than 0.3 per cent sulfur dioxide. Thus, even though the stacks are low, varying in height between 100 and 130 ft., the conditions are favorable for a rapid diffusion of the sulfur dioxide into the atmosphere. This fact probably accounts for the fact that very little, if any, sulfur dioxide injury has been noted in the vicinity of the plants in that district. In cases where the sulfur dioxide may be doing damage, it will be necessary to determine the critical atmospheric conditions for that district, and how often or for how long these critical conditions may occur. If they occur only occasionally it may be the most economical procedure to curtail the sulfur dioxide output during those critical times, rather than build higher stacks, especially at those plants which are of only a temporary nature.

At the zinc plants, as at the lead or copper smelters, wherever it is possible to dispose commercially of the acid or any sulfur product, it is highly desirable that such products be manufactured. If acid or other products cannot be disposed of commercially, then the best method for wasting the sulfur dioxide is to discharge the gases through a high stack and at as high temperature as is practicable.

BENEFICIAL EFFECTS OF SULFUR AND SULFURIC ACID ON SOIL

In regard to market for the sulfur or the acid, it is important to note that in the last several years there has been developed a new outlet which promises to be of great importance, especially to those smelters in the west. This outlet is made through the use of sulfur and sulfuric acid for agricultural purposes as a fertilizer and as an agent for reclaiming vast areas of now useless lands. Within recent years a number of the U. S. Department of Agriculture Experiment Stations, especially those in Wisconsin, Oregon and California, have made some very remarkable discoveries concerning the beneficial effect of sulfuric acid on soils.

Among the most important and recent of the investigations along this line were those of Dr. C. B. Lipman and L. T. Sharp at the University of California,[1] and those made by the smoke department of the American Smelter and Refining Co. in Utah. Dr. Lipman's earlier experiments were made in pots, but later were made in field plots, using sulfuric acid. The A. S. & R. Co. experiments were made in field plots, using solid elemental sulfur, gaseous sulfur dioxide and liquid sulfuric acid. The beneficial results obtained have been astonishing. On the fifteen kinds of crops experimented with in 1916, all plots that were treated with sulfur or acid gave a big increase in yield over the checked untreated plots—in many cases over 100 per cent, and in some, over 150 per cent increase.

These results have been checked by other experimenters. In fact even more astonishing results have been obtained on certain crops at agricultural experiment stations. The value of sulfur or sulfuric acid as a very important fertilizer is no longer doubted.

Quoting Dr. C. B. Lipman,[2] "If the smelters will only produce the acid cheaply enough, as they now seem inclined to do, we should be able to banish much costly litigation, let the smelter industry develop untrammeled, give the smelter companies compensation for oxidizing the SO_2 and last, but not least, put a large acreage of barren land into good crop-producing condition."

U. S. Bureau of Mines
Washington, D. C.

THE NATURE OF CEMENT MILL POTASH

By R. J. Nestell and E. Anderson

Received May 31, 1917

Of the many sources of potash which have been suggested, exploited or developed since the supply of German material was shut off by the war, one that holds many interesting features and potential possibilities is the escaping dust and fume from cement mills.

Up to a comparatively short time ago, this material, belched forth from the stacks of cement plants to the amount, in some cases, of 10 tons or more per kiln per day, constituted only a very serious problem as a nuisance to be abated in populous districts, or an unavoidable but negligible feature of plant operation in localities where a question of nuisance needed no consideration.

Where it has been necessary to provide some means of catching this escaping dust, several different meth-

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[1] *Univ. Cal. Publ. Agri. Sci.*, **1**, 275.

[2] *Ibid.*, No. 13, **1**, 557.

ods of collection have been employed, among which may be mentioned simple settling chambers of large capacity, bag houses, water sprays, and electrical precipitation. The latter is, however, the only one that has received any extended application.

Originally installed for the purpose of preventing the escape of objectionable quantities of dust, and thus to remove the cause of complaint and litigation on the part of adjacent residents or land owners, the electrical precipitators or "treaters" began the collection of large quantities of mineral dust and fume.

With the increasing value of crude potash salts, due to decreased or entirely eliminated imports of the foreign material, the possibility and practicability of utilizing this cement dust as a source of potash were soon recognized.

This dust, collected from cement kiln gases, consists of partly calcined raw material and ash from the fuel which have been mechanically carried over by the draught, and also of volatilized alkali compounds.

These latter are principally in the form of sulfates. Presumably these alkalies are volatilized as oxides which then combine with products of combustion and calcination to form salts. Since practically all fuel used for cement burning contains sulfur, there are present in the kiln gases, besides carbon dioxide and water, also sulfur compounds, the latter probably largely in the form of sulfur dioxide. Consequently there exists the possibility of the alkalies combining either as carbonates, hydroxides or sulfites, and, due to the possible oxidation or reduction of the latter, as sulfates or sulfides.

ANALYSES OF VARIOUS DUSTS

An analysis taken at random from the many which have been made of treater dust from a plant where oil is used as fuel, shows the following percentage composition:

SiO_2	8.41%	K_2O (Total)	8.91%	SO_3	14.98%
$(FeAl)_2O_3$	7.02	K_2O (Water-soluble)	7.65	CO_2	13.80
CaO	39.23	Na_2O	3.65	H_2O and undetermined	3.40
MgO	0.60				

This sample is slightly below the average in K_2O content, which usually runs about 10 or 11 per cent. Of this, approximately 86 per cent is water-soluble, and, as fertilizing material is sold by law upon its water-soluble content, it would show this dust, with a present average value of $3.50 per unit K_2O, to be worth about $27.00 per ton.

The soluble K_2O is present entirely as K_2SO_4, while the insoluble portion is largely made up of unchanged silicate from the raw mix.

This analysis represents the composition of the collected material, when no attempt is made to separate the heavy mechanically-carried-over calcined part from the true volatilized compounds. In some of the Cottrell installations, however, the construction is such that the collected dust may be segregated, thus obtaining a separation of these two mentioned fractions. An analysis of the lighter portion, which is precipitated last in such an installation, and which carries the greater part of the volatilized constituents, is as follows:

SiO_2	1.61%
$(FeAl)_2O_3$	0.63
CaO	7.78
MgO	0.74
K_2O (Total)	28.96
K_2O (Water-soluble)	28.40
Na_2O	12.54
SO_3	41.64
CO_2	2.76
H_2O and undetermined	3.34

LIME AND ALKALIES PROBABLY COMBINED AS	
K_2SO_4	52.50%
Na_2SO_4	28.71
$CaSO_4$	2.33
$CaCO_3$	6.27
CaO	3.31
K_2O as silicates	0.56

This sample is typical of the material obtained where oil is used as fuel, and all the sulfur compounds have been oxidized to sulfates.

From this analysis it is evident that the volatilized alkalies have combined with the sulfur compounds rather than with the carbon dioxide, in spite of the great preponderance of the latter in the kiln gases. With fuel carrying about 1 per cent sulfur, this ratio of sulfur dioxide to carbon dioxide, in ordinary kiln practice, is about 1 : 300.

While the analyses just cited are representative of material collected from oil-fired kilns, it has been found that *where coal is used as fuel* a product of somewhat different character is obtained.

The following is an analysis of dust collected from a plant where powdered coal carrying about 1.5 per cent sulfur is the fuel:

SiO_2	17.68%	SO_3	9.94%	K_2O (Total)	1.33%
$(FeAl)_2O_3$	11.56	Sulfur in sulfides and sulfites	1.63	K_2O (Water-sol.)	6.74
CaO	32.28			Na_2O	1.48
MgO	1.52	CO_2	10.64	H_2O	0.96

The composition of a sample of dust from which the greater part of the heavier portions have been removed by previous precipitation, is shown by the following analysis:

SiO_2	11.90%
$(FeAl)_2O_3$	10.94
CaO	21.85
MgO	1.19
Total S as SO_3	17.47
K_2O (Total)	20.60
K_2O (Water-soluble)	16.04
Na_2O	1.14
CO_2	10.90
C	1.03
H_2O and undetermined	2.98

LIME AND ALKALIES PROBABLY COMBINED AS	
K_2SO_4	29.65%
Na_2SO_4	2.61
$CaSO_4$	4.06
$CaCO_3$	24.75
CaO	6.33
K_2O as silicate	4.56

The most important differences in the potash material from coal-fired and oil-fired kilns, as shown by the analyses given, lie in the relative amounts of soluble and insoluble K_2O, and in the wide variation in potash concentration in the lighter fractions of dust obtained from kilns using these two different forms of fuel.

Thus when oil is used as fuel, the soluble potash in the heavy dust was 86 per cent of the total, and in the lighter material, 98 per cent, while the corresponding figures for dust from the coal-fired kiln were 59 and 79 per cent, respectively. Similarly, in the case of oil-fired kilns, the ratio of the total potash content of the heavier to the lighter fraction was 1 : 3.25, while the corresponding ratio in the dust where coal was used as fuel was 1 : 1.79.

Since, as has been stated, the lighter fraction contains a greater percentage of volatilized compounds, the analyses of these fractions would throw the most light upon the reasons for the differences in potash solubility and concentration above mentioned.

Thus in the dust from coal-fired kilns, where the total potash content was relatively low, and with a high percentage of insoluble, the sum of the silica, alumina and iron oxide was 22.84 per cent, while where oil was used, and the total potash content was high and practically all soluble, the sum of the silica, alumina and iron oxides was only 2.24 per cent.

An appreciable difference is also noted in the sulfur content in the two cases, since with oil fuel the amount of sulfur in the dust is higher than where coal is used. In the latter case the sulfur is also frequently present in large part as sulfide and sulfite.

Experiments on coal-fired kilns have proved that increasing the sulfur content of the fuel, and maintaining a less reducing atmosphere in the kiln, both tend to produce a potash product of a higher degree of solubility. But even with a large excess of sulfur over that required to combine with all the volatilized alkalies, the per cent of insoluble potash in the collected material was still considerable.

In the two cases cited, all the soluble K_2O has been in the form of sulfate, but the following analysis of dust collected from an oil-fired kiln using the wet process, shows that soluble potash compounds, other than the sulfate, may exist in such dust. The fuel used in this plant does not contain sufficient sulfur to combine with all the volatilized potash, so that some of the potash must appear as carbonate, due to the large excess of CO_2 in the kiln gases:

ANALYSIS OF DUST

CaO	37.70%
K_2O (Total)	19.57
K_2O (Water-soluble)	18.08
Na_2O	0.97
SO_3	13.60
CO_2	7.70

LIME AND ALKALIES PROBABLY COMBINED AS

K_2SO_4	29.70%
K_2CO_3	2.91
Na_2CO_3	1.66
CaO	29.96
$CaCO_3$	13.82
K_2O in silicates	1.49

Since an excess of sulfur does not always prevent the formation of insoluble potash compounds, and a deficiency of sulfur does not necessarily result in the formation thereof, it follows that a reason for the existence of such compounds must be sought for elsewhere.

In the dust from the oil-fired and coal-fired kilns previously referred to, where in the first case the per cent of insoluble K_2O was 0.56 per cent, and in the second case was 4.55 per cent, it seems safe to assume that the amount of mechanically carried over raw material was practically the same. Consequently the difference noted in the amount of silicious material shown cannot be due to a greater proportion of calcined raw mix in one case. The only other source of silicious material is the ash from the coal used as fuel. Ordinarily this coal carries 8 to 12 per cent ash, of which 35 to 40 per cent is SiO_2 and 40 to 50 per cent R_2O_3; and since this ash, coming as it does from finely powdered coal, must be in a state of extremely fine subdivision, approaching that of a true fume, it is reasonable to suppose that part of this ash would be collected among the lighter portions of the dust.

Since approximately 9 lbs. of coal ash are introduced into the kiln per barrel of clinker burned, if only one-half this amount is carried out with the gases, it would still be sufficient to affect appreciably the composition of the collected dust, as the amount of dust caught per barrel of clinker produced is only about 20 lbs. Consequently it is probable that the considerable amount of insoluble potash shown to be present in the dust from coal-fired kilns is in reality due to a combination of the volatilized potash with the finely divided, incandescent particles of silicious coal ash.

On account of the practical impossibility of separating the insoluble potash compound from the other constituents of the dust, its exact identification has not been effected.

The so-called "insoluble" potash is completely soluble in dilute HCl, and, as will be shown later, also in boiling water on sufficiently long continued treatment. This latter property was taken advantage of in an attempt to throw some light upon the nature of the compound in question.

A sample of the dust was first treated with boiling water according to the official method for water-soluble potash. The residue was then boiled with water under a reflux condenser for several hours, and the resulting solutions, numbered 1 and 2, in each case analyzed. These analyses, with hypothetical combination, are given below:

ANALYSES OF DUST

Solution	1	2
SiO_2	0.05%	0.08%
R_2O_3	....	0.71
CaO	8.49	0.91
MgO	0.13	....
K_2O	6.10	1.66
Na_2O	0.87	0.25
SO_3	7.46	0.61
S in sulfides and sulfites	0.70	0.00
Alkalinity as OH	3.78	1.22

(a) As silicates.

HYPOTHETICAL COMBINATION

Solution	1	2
K_2SO_4	11.28%	0.00%
K_2O	0.0(a)	1.66(a)
Na_2SO_4	1.99	0.0
Na_2O	0.0	0.25
$CaSO_4$	1.97	1.04
CaS (including $CaSO_3$)	1.57	0.0
CaO	6.46	0.48
MgO	0.13	0.0
Al_2O_3	0.0	0.71
SiO_2	0.05	0.08

The slowly soluble potash, which, in the above hypothetical combination, is given as silicate, appeared, of course, in solution as hydroxide, due to hydrolysis, which decomposition may be influenced to a certain extent by the presence of lime in the solution.

Other investigators[1] have shown that when a feldspar is boiled in presence of lime, the potash is brought into solution in the same form. Hence it is reasonable to suppose that the original potash compounds in the two cases were similar in nature, and that, therefore, this slowly soluble material is a type of recombined silicate which, as previously pointed out, was formed through the union of the silicious ash particles and the potash vapor.

If, also, as seems reasonable, such a compound is of greater specific gravity than that formed from the potash vapor and the sulfur gases, this would explain the difference in potash concentration already noted.

The possibility of such a silicious combination has long been recognized, and a method for overcoming the effects thereof on the solubility of collected potash, has been patented by Haff and Cheeseman.

WATER-SOLUBLE POTASH CONTENT OF DUSTS

The chief use of this treater dust being as a fertilizer, and as its value for such purpose is based upon its content of water-soluble potash, the question of solubility is of prime importance.

In order to determine not only the ready solubility of the potash in water, but also to gain some knowledge of the degree of solubility which it might show when subjected to conditions similar to those existing

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[1] W. H. Ross, THIS JOURNAL, 9 (1917), 467.

in its practical application as a fertilizing material, a series of tests was made to determine these facts. A description and the results thereof follow.

Wherever figures for "water-soluble" potash are given herein, they have been obtained by the Official Method of the A. O. A. C., which consists of washing 2.5 g. of the material, contained in a 12.5 cm. filter, with 200 cc. boiling water, and determining the K_2O in the resulting solution. The older method for this determination, and which is still used by some fertilizer chemists, is to boil the material with water under a reflux condenser for one-half hour.

One of the reasons for the adoption of the new method by the A. O. A. C., was that it was found, in in certain cases, that the older method gave results somewhat below the true value, and tests we have made in connection with this work show this to be so.

Analysis of the dust used for these solubility experiments showed the following K_2O content:

TOTAL K_2O	10.91 per cent	Per cent of Total
Water-soluble	5.84	53.5
Soluble in 5% HCl	10.03	91.9

In order to show the effect of continued treatment with hot water, 10 g. of dust with 100 cc. water were boiled under a reflux condenser for varying periods of time, and the amount of K_2O then in solution determined, with the results shown in Table I:

TABLE I

TIME HOURS	PER CENT K_2O DISSOLVED	PER CENT OF TOTAL K_2O DISSOLVED
1/2	5.49	50.3
2	6.65	60.9
4	7.68	70.4
6	8.51	78.0
8	9.13	83.7
10	9.95	91.2
12	10.12	92.8
14	10.35	94.9
16	10.45	95.8
20	10.55	96.7
24	10.56	96.8

This table shows very strikingly the ultimate solubility of practically all the potash under the conditions of the treatment given. It also emphasizes the importance of accurately stating conditions of treatment when reporting "soluble potash" and indicates that the criticism of the old method for obtaining soluble potash was justified. Thus, according to the new method, there was 5.84 per cent soluble K_2O, while with one-half hour boiling, only 5.49 per cent was found.

The reason for this difference is probably due to a primary combination between the potash and the silica to form a slowly soluble silicate which is, however again broken down by continued treatment with the hot alkaline solution. Further evidence bearing on this point will be found in some of the following experiments.

To illustrate the effect of continued cold water treatment, 10 grams of dust with 100 cc. water were placed in 16-oz. bottles, tightly stoppered, and subjected to continuous agitation in a revolving container. The percentage of extraction obtained is shown in Table II. A parallel run was made with similar conditions except that the extraction water was separated from the dust each day, and fresh solvent added. The results obtained in this series appear in Table III.

TABLE II

Time Hrs.	Per cent K_2O Dissolved	Per cent of Total
1	5.59	51.2
24	5.92	54.3
72	6.06	55.5
168	6.24	57.2
336	6.38	58.5
672	8.00	73.3
840	8.25	75.6

TABLE III

Time Hrs.	Per cent K_2O Dissolved	Per cent of Total
168	6.62	60.6
336	6.86	62.8
504	7.20	66.0
672	7.34	67.3
840	7.40	67.8
1008	7.46	68.3

In order to simulate, to a certain extent, conditions of leaching which obtain when fertilizing material is applied to the land, an apparatus was arranged for carrying on continuous percolation of the treater dust with measured amounts of cold water. This apparatus was designed by H. V. Welch, and is shown in Fig. I. The dust to be leached was placed in 16-oz. bottles from which the bottoms had been removed and replaced by a couple of layers of filter paper held in position with a disc of wire screen. These bottles are supported in a wooden frame over a drain pan, and the water supplied to the tops of the bottles by means of the rubber tubes which terminate in openings arranged around the periphery of a circular pan below the distributer. The latter is a large wooden pulley through which passes a tube connected with the water supply. This pulley is revolved by means of belting from a small electric motor. By this means each bottle receives the same amount of water, which may be controlled by regulating the size of the opening in the water supply tube, and measured by collecting the water delivered by any one of the tubes.

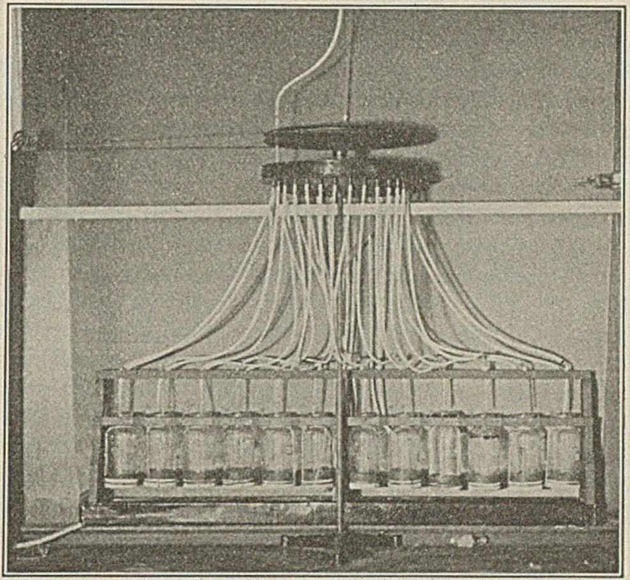

FIG. I

Fifty grams of the dust were used, and the amount of water passing through was 2400 cc. per day. At the end of the specified times, the residues were dried and analyzed for K_2O, allowance being made in the calculation for the loss in weight of the dust, due to the removal of salts other than potash. The results are shown in Table IV.

TABLE IV

Time	Per cent K_2O Dissolved	Per cent of Total
336 hours	6.72	61.5
672 hours	6.81	62.4
1008 hours	7.26	66.5

Considering Tables III and IV, which show the amounts of potash dissolved when the soluble salts are removed from the sphere of action, it is seen that the potash compounds are brought into solution by the action of cold water at a well defined, though slow rate. Comparing Tables III and IV with Table II shows that ultimately more potash is dissolved when the soluble constituents of the material are allowed to remain in the solvent. In all probability this is due to the action of the lime present, since, as previously stated, this has a marked solvent action on such silicious material. This action is shown more clearly where the solvent was used at boiling temperature, for, in this case, where the dissolved products, a large proportion of which is lime, were allowed to remain with the solvent, the rate of solution was 22 per cent greater than in a similar test where fresh solvent was used from time to time.

While the rate of solution in cold water is very much slower than in hot, it is, nevertheless, considerable, and it is safe to assume that the greater part of such slowly soluble potash material from cement kiln gases, would be rendered available in the course of a season.

As is known, ground feldspar is often used as a potash fertilizer. Compared with the recombined silicious potash of cement kiln dust, this potash material is much more slowly soluble, which is evident from the fact that a feldspar-lime mixture, containing practically the same percentage of lime as the treater dust, yielded, on boiling with water for 16 hours, only 1.7 per cent of the total K_2O, while the treater dust, from which all of the readily soluble potash had been removed, under parallel conditions gave 35 per cent of its remaining, slowly soluble K_2O.

EFFECT OF SOIL ADMIXTURE

Some tests were made to determine the effect of an admixture of soil upon these potash compounds. It is, of course, known that soluble potash salts, when mixed with some soils, tend to become, in part, soluble. Our tests show that with treater dust this action is also quite rapid, so that in a comparatively short time a large part of the originally soluble potash becomes so attached to the soil that it cannot be extracted when treated according to the Official Method for water-soluble potash. At the same time, however, the originally slowly soluble potash compounds are being rendered soluble. The ultimate result of such action of soil on a mixture of the two types of compounds existing in this treater dust, as shown by the following tests, is to yield a larger relative percentage of readily soluble potash than is the case where the original material consisted entirely of perfectly soluble salts.

In the first set of these tests, a hot water extraction of the original dust was made, and aliquot parts of the resulting solution poured upon samples of soil contained in beakers. These were then allowed to stand for varying periods of time, when the residual water-soluble potash content was determined. At the end of two weeks, this water-soluble potash had decreased 13.6 per cent, and at the end of four weeks, 38.7 per cent.

The dust remaining, after the water-soluble part was removed by washing, was also mixed with soil and allowed to stand. At the end of two weeks, 12 per cent of the slowly soluble potash had become soluble, and at the end of four weeks, this solubility had increased to 17 per cent.

From these results it is evident that the effect of the soil upon the readily soluble potash is more pronounced than that upon the slowly soluble, so that the net result would be to decrease the total amount of readily soluble potash in such a mixture.

The following test confirms the above assumption: The original dust was mixed with soil, moistened with water, and allowed to stand as in the previous cases. At the end of three weeks, the soluble potash had decreased 2.45 per cent of its original value. At the end of six weeks, the decrease was 4.9 per cent, and at the end of ten weeks, was 9.95 per cent.

As was shown above, with the soluble part of this dust similar to the soluble potash salts of the ordinary fertilizer, this decrease, in only four weeks, was 38.7 per cent. It is possible that this recombination between the soluble potash and the soil is analogous to the one pointed out in connection with the solubility of the dust in boiling water. As was stated then, a half-hour boiling showed a soluble potash content of 5.49 per cent, while the Official Method gave 5.84 or a decrease, caused by boiling, of 6 per cent of the total soluble potash present. When the silicious material in the mixture is largely increased by the addition of soil to the dust, it is to be expected that the recombination, under similar treatment, would be more marked. Tests made by boiling such mixtures confirm this view. Thus a mixture of 10 per cent dust and 90 per cent soil, which showed by the Official Method 0.66 per cent soluble potash, on boiling one-half hour, gave only 0.47 per cent, a decrease of 29 per cent.

It appears evident, from the data presented, that the Official Method for determining soluble potash in fertilizer does not necessarily give a true indication of the potash value of all such material. As to the ultimate availability for plant use of the potash in a fertilizer, it would seem that such slowly soluble potash compounds as have been shown to be present in dust from cement kilns, more nearly approach the ideal form of a plant food than do the more readily soluble potash salts, since these slowly soluble compounds undoubtedly can be assimilated by the plants in the course of a season, and are not to such a large extent apt to be leached out by rains and irrigation.

The United States Bureau of Soils has under way a series of experiments on leaching this dust with water under conditions of high pressure and temperature, a complete report of which will undoubtedly be published in the near future. The results of some of their early experiments would indicate that the rate of solution of the slowly soluble potash compounds is enormously increased by this treatment.

SUMMARY

I—Dust from cement kiln gases may be composed of mechanically carried over raw material and solid residues from fuel combustion, together with volatilized alkalies.

II—Such dust contains considerable amounts of potash present both in readily and slowly soluble form.

III—The readily soluble potash usually occurs as sulfate, due to a combination of this base with the sulfur of the fuel and where there is a deficiency of sulfur, partly as carbonate.

IV—The slowly soluble potash is probably of a silicious nature, largely formed by the union of potash vapor with incandescent ash particles.

V—This silicious potash becomes soluble on boiling with water for a few hours, and on treatment with cold water for longer periods.

VI—The presence of lime accelerates the solution.

VII—Slowly soluble potash compounds are also formed by the interaction of potash salts in solution with silicious material, this recombination being greatly accelerated by heat.

VIII—The action of moist soil promotes the availability of the slowly soluble potash.

IX—In view of the gradual and continued solution of the potash in cement kiln dust, it should be of particular value as fertilizer material.

Acknowledgments are due to Mr. R. C. Haff and associates, of the Security Cement & Lime Company, and to Mr. H. V. Welch, of this laboratory, for assistance and suggestions.

Laboratories of the Western Precipitation Company
Los Angeles, California

SOME RELATIONS OF THE EFFECT OF OVERHEATING TO CERTAIN PHYSICAL AND CHEMICAL PROPERTIES OF ASPHALTS[1]

By A. W. Hixson and Harold E. Hands

The use of carbon tetrachloride as a solvent in differentiating bitumens was first suggested by Richardson and Forrest[2] in 1906. They found that true asphaltic hydrocarbons were soluble to the same extent in it as in carbon bisulfide. In residual pitches which were carelessly refined, they found that the bitumen soluble in carbon tetrachloride was less than in carbon bisulfide. To the hydrocarbons soluble in carbon bisulfide but insoluble in carbon tetrachloride, Richardson later applied the term "Carbenes."[3] It was suggested that these were the result of weathering in true asphalts. In the case of residual pitches it was thought to be the result of overheating during the industrial processes used in production.

Kirschbraun[4] took up Richardson's suggestion and performed a series of experiments on the effect of overheating on refined Bermudez asphalt and on fluxed Bermudez asphalt. He found that carbenes were formed at high temperatures (650–700° F.) and suggested that they were the result of either cracking at high temperature or concentration—probably both.

In 1910 Mackenzie[1] took up the subject in the endeavor to determine the cause of certain discrepancies in the results of carbene determinations in the same samples made in the New York Testing Laboratory and another laboratory on the Pacific Coast. He found that in the same sample of bitumen there was an increase of carbenes when the carbon tetrachloride solution was allowed to stand in the light. He therefore called those carbenes which were precipitated completely from a tetrachloride solution on standing in the dark for 12 hrs., "true carbenes." To those which were then precipitated on allowing the filtrate from this determination to stand in the light he applied the name "pseudo-carbenes." He concluded: "That light acting upon a solution of bitumen in tetrachloride causes the bitumen to decompose, the tetrachloride giving hydrochloric acid, which in turn combines with unsaturated hydrocarbons and precipitates them. But only certain bitumens (namely, those which have been more or less overheated) can bring about this phenomenon." Similar results and conclusions were the result of practically a simultaneous work by Alexander.[2]

As far as can be ascertained, no systematic work has been published which has to do with the effect of overheating, and the presence of carbenes caused by this overheating, upon the physical and chemical properties of asphalts. This investigation was therefore undertaken with the object of determining to what extent an asphalt could be heated and still retain those properties desirable for a durable pavement. If carbenes are a result of overheating, then what is their effect upon an asphalt; is the effect due simply to the heating or do they alter markedly the properties of asphalt by their presence? It was hoped to arrive at a conclusion as to the value of the carbene specification for asphaltic materials to be used in road construction.

It was noticed that, using the same asphalt, Mackenzie was unable to check the results obtained by Kirschbraun either concerning the carbene content, or certain other properties, *e. g.*, bitumen soluble in carbon bisulfide. This is not to be wondered at since neither investigator gave details of the methods of analysis used. It is a well-known fact that in asphalt analysis two investigators have difficulty in checking each other even when the same methods are used. The errors due to technique are too well known to be recounted here. Needless to say, it is therefore impossible for any later investigators to check their results quantitatively. In this work no effort was made to check the results of either Mackenzie or Kirschbraun.

PURIFICATION OF REAGENTS

In order to be absolutely sure of the results it was thought necessary carefully to purify the carbon bisulfide and the carbon tetrachloride to be used.

The bisulfide was first shaken with lime-water until no color was imparted to it. This removed any inorganic sulfides which might be present as impuri-

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[1] Presented at the 54th Meeting of the American Chemical Society, Kansas City, April 10 to 14, 1917.

[2] Richardson and Forrest, *J. Soc. Chem. Ind.*, **24**, 311.

[3] "The Modern Asphalt Pavement," 1st Ed., pp. 118, 120.

[4] *Municipal Engineer*, **35** (1908), 349.

[1] This Journal, **2** (1910), 124.

[2] *Ibid.*, **2** (1910), 242.

ties. To insure the complete removal of any hydrogen sulfide the bisulfide was placed in a distilling flask, covered with one inch of a water solution of lead acetate and distilled over a water bath. The distillate was then fractionated using a Glinsky 4-bulb distilling head. That fraction with a boiling point of 46.3° was saved. This was water-white with a pleasant ethereal odor and gave no residue when 20 cc. of it were allowed to evaporate spontaneously on a watch glass. It was then dried over lime, placed in glass-stoppered, brown bottles, and kept in a cool, dark place.

The carbon tetrachloride was freed from carbon bisulfide by adding a quantity of alcoholic potassium hydroxide solution. It was then heated to 60° C. for one-half hour and the potassium xanthate formed was precipitated by adding water. The liquid was repeatedly washed with water until free from alcohol and potassium hydroxide. It was then fractionated, using a Glinsky 4-bulb distilling head. Fractions with a boiling point of 76.6 to 76.8° C. were kept dried over calcium chloride and stored in the same manner as the bisulfide.

In using both solvents, the wash bottles were completely covered with black paper to prevent any decomposition by light.

METHODS OF ANALYSIS

DETERMINATION OF BITUMEN SOLUBLE IN CARBON BISULFIDE (TOTAL BITUMEN)—The method proposed by the Committee on standard tests for road materials of the American Society for Testing Materials was tried. In the case of Trinidad asphalt, where the mineral matter is high, the results were very unsatisfactory. Filtration proceeded very slowly and much of the fine mineral matter went through the filter. It was also found difficult to prepare two asbestos pads for the Gooch crucible which would retain the same amount of mineral matter. For this reason great difficulty was experienced in obtaining concordant results. When very dense pads were used it was still found difficult to check the results. Moreover, when carbon tetrachloride was used as a solvent, it required several days for filtration, and in one case over a week. Obviously, this would not do, for, as Alexander and Mackenzie found, the longer the time taken to filter a tetrachloride solution of bitumen, the greater the amount of bitumen insoluble, due probably to the action of light. So the following method was used:

One gram of the asphalt (if the mineral content be low, more can be taken) was weighed into a tared 200-cc. Erlenmeyer flask and treated with 100 cc. of carbon bisulfide. The flask was then loosely stoppered and was shaken from time to time until solution was complete. This usually required about 30 minutes. The solution was then centrifuged at high speed for 30 minutes. Two C. Schleicher and Schüll No. 589 Blue Ribbon filter papers, which had been previously extracted with carbon bisulfide, were then weighed and onto these the supernatant liquid was carefully decanted. A double filter was used to insure the collection of even the finest mineral matter. The residue in the bottom of the centrifuge flasks was then washed with bisulfide and utimately all was brought upon the filters. The residue was washed with bisulfide until the washings were colorless. Suction was applied when necessary. All flasks and the filters were then dried at 100° C. and weighed. The filter papers containing the residue were then ignited to determine the amount of "organic matter insoluble" and ash. In this manner the ratio of "organic matter insoluble" to ash was found. If any insoluble matter remained in the flasks this ratio was applied to it and the ash and "organic matter insoluble" thus found were added to that found on ignition of the filter papers. The reason for this is obvious when one considers that the insoluble mineral matter in the flasks will have absorbed or adsorbed a certain amount of bituminous material. It was found that the ash determined in the fixed carbon test was slightly greater (about 1.35 per cent in the case of Trinidad asphalt) than that obtained by filtration. The reason for this is unknown. Richardson[1] is authority for the statement that the solution containing this shows, under the ultra-microscope, the characteristic Brownian movement of colloids and that it is due to colloidal clay and other mineral matter. But might not this difference be caused by a solution of slight amounts of mineral salts in the solvent? These salts might be salts of mineral acids or mineral salts of organic acids of high complexity. This might be expected, especially if the solvents were not completely water-free—a condition hard to secure.

If the mineral is colloidal then it will probably have bitumen adsorbed on its surface. In this work it was assumed to be colloidal and therefore a correction was applied to the mineral matter found on filtration. In making this correction the same ratio between ash and "organic matter insoluble" was used as that found on ignition of the filter residue. In order to determine if the long standing, as specified in the method of the American Society for Testing Materials, was of value before centrifuging, experiments were carried out in which the asphalt stood in contact with the solvent for different lengths of time. In each case one gram of refined Trinidad asphalt was shaken with 100 cc. of carbon bisulfide. The results, given in Table I, showed that long standing was not necessary when the centrifuge was used.

TABLE I

TIME OF STANDING	30 mins.	24 hrs.	48 hrs.	70 hrs.	48 hrs(*a*)
Bitumen soluble in CS_2	58.02	58.00	58.65	59.77	57.41
Mineral matter insoluble	30.00	33.31	32.66	30.04	33.48
"Organic matter insoluble"	7.98	8.69	8.69	7.19	9.11

(*a*) Stood 24 hours, was decanted and 100 cc. fresh solvent added; then stood 24 hours longer.

The following points then led to the adoption of the above method of separation:

1—The time element was cut to a minimum, it being possible to complete filtration, even from a tetrachloride solution which formerly took several days, in a few hours. This is very important in making the carbene determination.

2—Results could be made to check closely.

3—By the use of filter paper, instead of an asbestos

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[1] *J. Phys. Chem.*, **19**, 245.

padded Gooch crucible, it was possible to control more evenly the size of the openings and therefore the amount of mineral matter retained.

BITUMEN SOLUBLE IN CARBON TETRACHLORIDE—The same method was used as in determining the bitumen soluble in carbon bisulfide, using instead 100 cc. of carbon tetrachloride.

CARBENES—No attempt was made to determine the pseudo-carbenes described by Mackenzie. The bitumen soluble in carbon bisulfide but insoluble in carbon tetrachloride, when the determinations were made as described above, was taken as the carbene value.

FLOW TEST—This test was performed according to the directions given by Richardson.[1] The test was made at the melting points of the asphalts and the flow in millimeters during 5 minutes was taken. An electric oven was used.

All other tests were performed according to the directions given in The Office of Public Roads, *Bulletin* 38, on "Methods for the Examination of Bituminous Road Materials."

In making the melting-point test, the oil bath was heated at the rate of 5° per minute. All penetration tests were made under a load of 100 g. for 5 seconds at a temperature of 38° C., except in the case of the oil cement, where the load was 50 g. The New York Testing Laboratory Penetrometer was used.

TABLE II—TESTS MADE AT DIFFERENT TEMPERATURES

	CRUDE TRINIDAD ASPHALT						BRICK FILLER						OIL ASPHALTIC CEMENT						
Temperature of Heating	....	163°	200°	235°	265°	300°	....	163°	200°	235°	265°	300°	....	163°	200°	235°	265°	300°	350°
Bitumen Soluble:																			
in CS_2	54.90	...	53.77	51.62	50.39	30.70	99.26	...	98.48	98.94	98.70	97.80	98.18	...	97.27	97.36	96.88	81.32	...
in CCl_4	52.78	...	53.63	52.27	53.13	27.64	99.26	...	98.48	97.21	97.51	85.50	97.93	...	97.52	96.14	96.58	73.38	...
Carbenes	2.12	...	0.14	—0.65	—2.74	3.06	None	...	None	1.73	1.19	12.30	0.24	...	—0.25	1.22	0.30	7.94	...
Matter Insoluble:																			
Organic	9.45	...	10.58	10.87	12.00	18.29	None	...	0.78	0.17	0.17	0.78	1.55	...	2.48	2.34	2.76	16.94	...
Mineral	35.65	...	35.65	37.21	37.61	51.01	0.74	...	0.74	0.89	1.13	1.42	0.27	...	0.25	0.30	0.36	1.74	1.18
Fixed Carbon:																			
Determined	8.71	...	10.70	8.73	8.45	18.98	13.49	...	15.96	16.93	18.46	26.18	14.38	...	15.33	15.03	14.97	31.13	58.83
Corrected	8.71	...	10.70	8.30	8.02	13.26	13.49	...	15.96	14.07	12.09	13.64	14.38	...	15.33	13.52	11.23	4.83	13.46
Loss on Heating	...	...	1.0	4.95	5.21	30.11	....	0.23	1.0	16.85	34.51	47.88	....	0.40	1.0	10.00	25.00	84.48	77.12
M. P. (° C.)	113	...	129.5	133.0	130.5	Doesn't flow	78	...	121	128.3	136	159	133	...	16.4	167.5	164.5	91.3	...
Penetration	40.5	4.0	4.0	4.0	4.0	1.0	65.7	53.0	21.5	16.3	8.4	6.4	42.0	30.5	27.5	24.5	25.0	81.6	...
Flow at M. P.	10.5	...	123.5	120	90	0	32.5	...	50.5	Over 185	47.5	3.0	Over 185	...	13.5	8.0	8.0	1.0	...

MATERIALS USED

1—Crude Trinidad asphalt which had been finely powdered and air-dried before testing.

2—A brick filler which consisted of a natural asphalt fluxed with 70 per cent of asphaltic oil residuum.

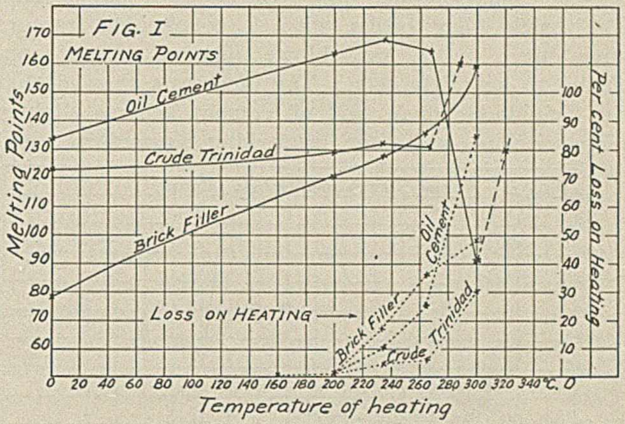
3—An oil asphaltic cement of unknown origin.

METHOD OF HEATING—About 100 g. of the asphalt were placed in a large crucible-shaped porcelain dish and heated to the desired temperature in an air oven over a period of five hours. At the end of this time it was poured out, allowed to cool, and if hard enough was ground to powder and sampled. Tests were made at the different temperatures as given in Table II.

The nature of the change on heating may perhaps be followed better by considering the change at each temperature.

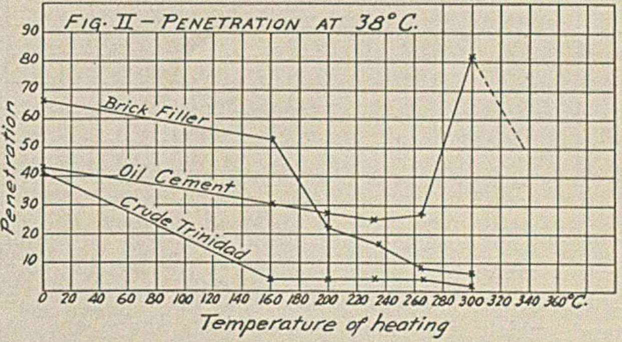
ORIGINAL PROPERTIES

The crude Trinidad asphalt when pulverized had a dry earthy appearance. The brick filler was a jet-black homogeneous substance which was quite soft and sticky. The oil asphalt was a dull black homogeneous substance which was also quite soft and sticky. However, it could easily be cut with a knife.



PROPERTIES AFTER HEATING

In the case of each asphalt there was an increase in the melting point after heating to 200° C., more marked possibly in the case of the brick filler (Fig. I). There was a decrease in the penetration (Fig. II); greatest in the case of the brick filler and crude Trinidad asphalt. The fluidity of these two asphalts also increased, that of the Trinidad being greatest at this temperature. The oil cement showed a marked decrease in fluidity. The fixed carbon (Fig. V) showed a slight increase, as was to be expected. Of special interest is the decrease of carbene content (Fig. IV) in the Trinidad asphalt. A corresponding decrease was found in the oil cement; in fact, the bitumen was even more soluble in carbon tetrachloride than in carbon bisulfide!



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[1] "The Modern Asphalt Pavement," 1st Ed., p. 537.

Changes in the nature of the asphalts were quite noticeable after heating to 235° C. The melting points continued to rise in all cases. The asphalts became harder. The Trinidad became so hard that it was easily crushed and ground in a coffee mill. The brick filler broke with a conchoidal fracture when hit a quick, hard blow. The oil cement continued to be fairly soft. The flow tests showed that the Trinidad asphalt and oil cement became slightly more viscous, while the brick filler showed its maximum fluidity at this point, it being so fluid that it flowed off the end of the plate. While the oil cement and brick filler both showed an increase in carbenes at this temperature, the decrease was still greater in the case of the Trinidad asphalt, which now became more soluble in carbon tetrachloride than in carbon bisulfide; there also appeared a decrease in the fixed carbon content! After heating to 265° a break was noticed in all the curves depicting the various properties. In the case of the Trinidad asphalt and oil cement, there was a lowering of the melting point, the fluidity, and the fixed carbon, while in all three there was a decrease in the carbenes. The Trinidad became more markedly soluble in carbon tetrachloride than in carbon bisulfide!

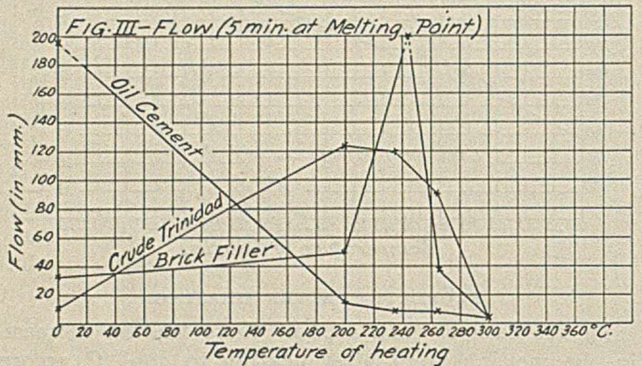
FIG. III—FLOW (5 min. at Melting Point)

Upon heating to 300° a very decided change took place. The Trinidad asphalt became so hard that it was easily ground to 100 mesh. After being ground it would not fuse together again, so it was impossible in this manner to make a cube for the melting-point determination. Fortunately, a large lump was at hand, which was then molded into shape and the test performed. However, the asphalt would not flow even after heating to 300° C. The brick filler was ground in the mill and the oil cement became very soft, mealy and lost its stickiness. While the penetration of the other samples became suddenly less, the penetration of the oil cement became decidedly greater. Its melting point became lower and it refused to flow on the flow plate. In each case a decided increase in fixed carbon and carbenes was noticed. Each asphalt seemed to lose its fluidity.

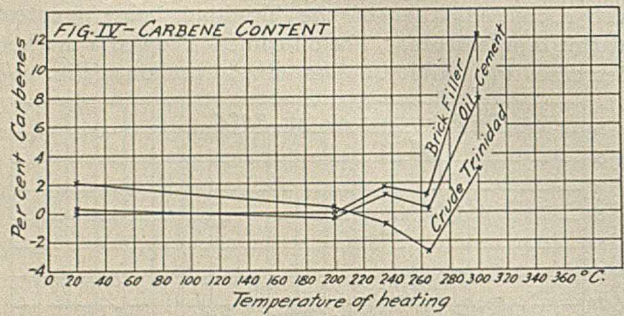
FIG. IV—CARBENE CONTENT

In centrifuging the carbon bisulfide and carbon tetrachloride solutions of these samples an interesting observation was made. In the case of the former, all the insoluble matter went to the bottom of the flasks. However, in the carbon tetrachloride solution there was a separation—there being a layer of shiny bituminous substance at the top. If this top layer consisted of the carbenes it indicates that their density lies between that of the bisulfide (1.270) and tetrachloride (1.604). This may afford an effective means for their separation.

In reviewing the changes in properties, the question naturally arose as to the cause of the Trinidad asphalt becoming more soluble in tetrachloride after heating to 235° and 265°, and why the carbene content of the other two became less at 265° than at 235°. There seemed to be a corresponding change in other properties during this range of temperature. Evidently there was a decided change in the nature of the hydrocarbons themselves. Just what this change is can at present only be surmised. The fixed carbon content may be of assistance in explaining this. If this is calculated back to the basis of the weight before heating, it may offer a suggestion. If there is no change in the nature of the hydrocarbons, and the process is simply one of distillation, we should get a straight line curve when the values are plotted. Accordingly this was done using the formula

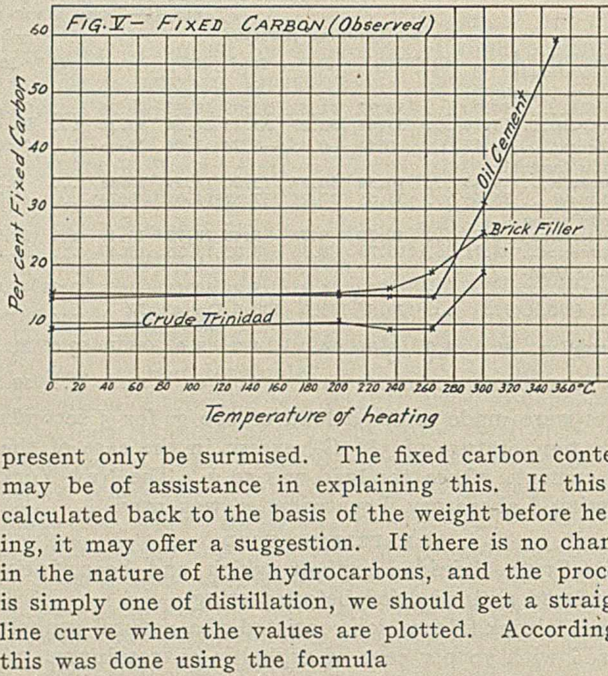
FIG. V—FIXED CARBON (Observed)

$$\text{F.C.}_{original} = \text{F.C.}_{observed} \times \frac{100 - \text{Loss on Heating}}{100}$$

and the values so obtained were plotted in Fig. VI. It is noticed that in all cases there is a drop at 235 to 265°. The brick filler and Trinidad curves then turn upward at 300°. However, the oil-cement curve continued to fall at this temperature. Evidently then, there was some change in the nature of the hydrocarbons themselves and this may give a clue as to the nature of the carbenes.

Richardson[1] has found that paraffin hydrocarbons of the series C_nH_{2n-2} yield no fixed carbon on ignition and that the amount left increased as the propor-

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[1] "The Modern Asphalt Pavement," 1st Ed., p. 118.

tions of carbon to hydrogen increased. In Grahamite, when the ratio is 8 to 1, there is as high as 50 per cent of fixed carbon. If this is true for asphaltic hydrocarbons, the general nature of the change may be followed.

By consulting Fig. VI it is seen that up to 200° the process was probably one of distillation of lighter hydrocarbons. This was confirmed by an increase in melting points and decrease in the penetration. In the case of the natural asphalts the hydrocarbons left were more mobile when melted. In the case of oil cement, when the hydrocarbons are chiefly of the paraffin series,[1] they are less mobile when heated, due to higher hydrocarbons. Upon heating to 235°–265° the curve would indicate that the proportion of carbon to hydrogen is less. This may be due simply to a distillation of low boiling point hydrocarbons rich in carbon. Those hydrocarbons left in case of natural asphalt, though very hard, show the maximum fluidity when heated to their melting point. They are also more soluble in carbon tetrachloride than in carbon bisulfide. Just what hydrocarbons are formed offers an interesting field for research.

Upon heating to 300° the natural asphalts show an upward turn in the curve, indicating that the proportion of carbon to hydrogen has again increased. This may be due to a cracking process in which either unsaturated hydrocarbons or those of the naphthene type are formed—either of which are stable at high temperatures. Carbenes now put in a marked appearance. Mackenzie suggests that the carbenes are unsaturated hydrocarbons, but might they not be both? To determine whether a large amount of unsaturated compounds appeared, the iodine numbers were run upon the brick filler and Trinidad. The method used was that of Hübl-Waller described by Holde.[2] The values are given in Table III. In neither case was there a marked increase due to the presence of carbenes.

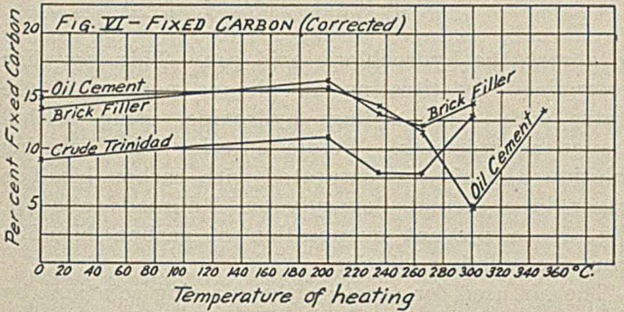
FIG. VI—FIXED CARBON (Corrected)

TABLE III—IODINE NUMBERS

	Original	Heated to 300°
Crude Trinidad	20.14	22.16
Brick Filler	15.11	19.26

In the case of the oil cement a still further decrease in the fixed carbon was observed at even 300°. Since oil residuums consist mainly of saturated paraffin hydrocarbons, it would seem that distillation of the lighter hydrocarbons proceeds even at this temperature. If such is the case, further heat should crack them into unsaturated hydrocarbons and naphthenes. Accordingly, a sample was heated to 350° C. for 5 hours. The fixed carbon was found to increase as was expected. Evidently, then, the so-called carbenes may consist of either unsaturated hydrocarbons or saturated naphthenes, or both. Much further work is necessary, however, before their nature can be definitely established.

CONCLUSIONS

I—The results of this work seem to show that carbenes are probably the result of the cracking of paraffin and asphaltic hydrocarbons into both naphthenes and unsaturated hydrocarbons.

II—Moderate heating may so change the nature of the hydrocarbons as to render them more soluble in carbon tetrachloride than in carbon bisulfide.

III—Overheating causes marked changes in both natural and oil asphalts which render them unfit for paving purposes. Whether natural asphalt which has been heated over 235° C. is still suitable for durable pavements can be determined only by actual experience, but certainly a temperature limit is important.

IV—It is believed that the fixed carbon curve when corrected to the original weight of material before heating offers a means of tracing the changes in the molecular structure of the hydrocarbons when they are subjected to the influence of heat.

V—There is a close relation between the carbene value and the physical properties of asphaltic materials. Although the physical specifications may be so made that a high carbene content will be excluded, it would seem wise to keep the carbene specification as a safeguard until further information on the subject can be obtained.

INDUSTRIAL CHEMISTRY LABORATORY
STATE UNIVERSITY OF IOWA, IOWA CITY

OBSERVATIONS ON THE ACTION OF SULFUR MONOCHLORIDE ON BITUMINOUS AND TARRY SUBSTANCES AND HYDROCARBON OILS

By JOSEPH V. MEIGS

Received March 22, 1917

It was the writer's original intention to work out an analytical method for examining bituminous substances on the basis of the amount of hydrogen sulfide evolved per unit weight of bitumen on heating the latter with sulfur. This idea was soon abandoned, however, on account of the inconvenience and undesirability, for analytical purposes, of maintaining a uniform elevated temperature (approx. 135° C.). To see whether sulfur and bitumen would react in solution, varying amounts of both were dissolved together in carbon disulfide, and allowed to stand, but no sensible reaction was observed.

On evaporating the carbon disulfide, black sulfur crystals were obtained, which, examined under the microscope in polarized light, had in some cases the appearance of a solid solution of bitumen in sulfur.

The advantages of sulfur monochloride, as a form of sulfur more active, in the cold, than the element, then presented themselves. The effect of this reagent ("Schwefelchlorür," made by Kahlbaum) on bitumen

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[1] "The Modern Asphalt Pavement," 1st Ed., p. 105.

[2] "Examination of Hydrocarbon Oils," Holde, Mueller, p. 350.

was found to be a very distinct one, not only as a reagent but also as a solvent.

A residual oil asphalt, which we will designate as "asphalt B," with a penetration of 12° (100 g., 5 sec., 25° C.), containing 99.6 per cent pure bitumen, was found, qualitatively, to be soluble in sulfur monochloride at room temperature to the extent of leaving no sticky residue on filtration of the solution. Several liquid bitumens were found to be similarly soluble.

Moreover, on treating a solution of "asphalt B" in carbon disulfide with a solution of sulfur monochloride in carbon disulfide, the writer found, by testing with filter paper moistened with ammonia, and comparison with a blank test on a solution containing no bitumen, that hydrochloric acid gas was evolved, slowly, but in considerable amount. This was the only external evidence of a chemical reaction.

More pronounced, however, were the effects, when a tar product used for paving purposes, which we will designate as "tar binder B," was so treated. In addition to a much larger evolution of hydrochloric acid gas than in the case of the asphalt, a marked change took place, in the course of 15 minutes, in the character of the solution; *i. e.*, much of the material in solution was removed, as evidenced by the precipitation of a black, friable powder, insoluble in carbon disulfide, and by a color change, from black and opaque, to deep red and transparent. It is interesting to note that when sulfur monochloride was added, full strength, to "tar binder B," in the proportion by volume of one to two, a violent reaction ensued. Vigorous ebullition and frothing took place, and a degree of heat was developed, much the same as when strong sulfuric acid and water were mixed in the same proportion (one to two). This effect is to be contrasted with the externally quiet, solvent action of strong sulfur monochloride (undiluted with carbon disulfide) on "asphalt B." Indeed, one of the most noticeable effects of the strong sulfur monochloride on "tar binder B" was to increase its viscosity to such an extent that, in the course of 10 minutes, the originally liquid material became changed to a hard, brittle mass. "Tar binder B" yielded the following fractions on distillation:

PERCENTAGES:	By Volume	By Weight
Water	1.1	0.6
First oils to 110° C.	1.3	0.9
Second oils to 170° C.	2.4	1.9
Heavy oils to 270° C.	28.8	25.4
Heavy oils to 315° C.	14.1	12.9
Pitch	52.3	58.2

In order to prove that the evolution of hydrochloric acid gas in the cases cited was not due to the presence of water in the substances themselves, or in the reagents, as well as to study the action of the sulfur monochloride, an apparatus was devised to measure accurately the ratio of the amount of hydrochloric acid gas evolved to the amount of bituminous substance acted upon by the sulfur monochloride.

The method employed in conjunction with the apparatus, which is seen in diagrammatic form in Fig. I, consisted in dissolving the bitumen in carbon disulfide, then adding the sulfur chloride reagent in a closed tube, aerating this solution with dry air, and sucking the dry air, mixed with hydrochloric acid gas and a certain quantity of sulfur monochloride vapor, *first*, through a Pennsylvania Railroad tube (*R'*), containing carbon bisulfide, in order to dissolve and remove the vapor of sulfur monochloride, *second* through water,[1] to absorb the hydrochloric acid gas. This was then determined by titrating an aliquot portion of the water with *N*/20 sodium hydroxide, using methyl orange as indicator. Before entering the reacting solution, the air was saturated with carbon bisulfide vapor in a second Pennsylvania Railroad tube (*R*, Fig. I) to prevent evaporation of carbon bisulfide from the reacting solution.

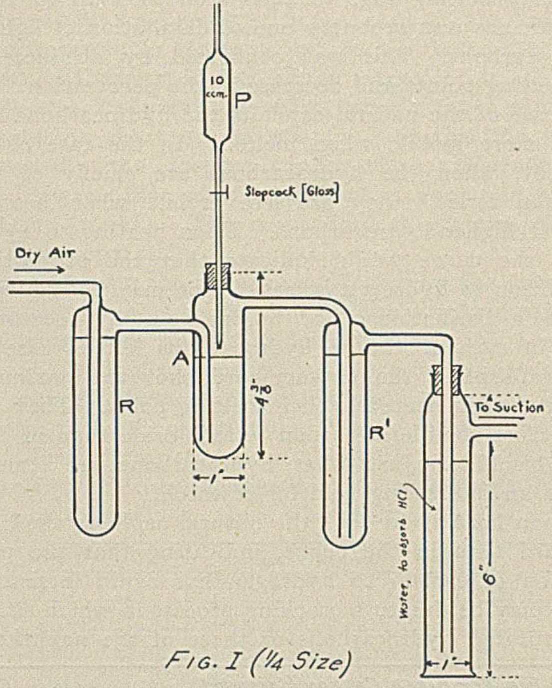

FIG. I (1/4 Size)

The air used for aerating the reacting solution (by means of aspiration) was dried and freed from carbon dioxide by passing through two drying towers, 15 inches high, filled with fused calcium chloride, then through a soda lime tube, four gas-washing bottles containing strong sulfuric acid (sp. gr. 1.84), and finally, through a drying tower 12 inches high containing alternately placed layers of glass wool and phosphoric anhydride.

The Pennsylvania Railroad tubes (*R* and *R'*, Fig. I) and the reaction tube *A* were heated to 130° C. and cooled in a vacuum desiccator over strong sulfuric acid (sp. gr. 1.84) before use. The sulfur monochloride reagent finally adopted was made by dissolving 50 g. of Kahlbaum's "Schwefelchlorür" in 470 g. of carbon disulfide, which had been previously dried by shaking with and standing over anhydrous sodium sulfate and phosphoric anhydride, respectively. This solution was kept in a glass-stoppered bottle in a desiccator over concentrated sulfuric acid in which 20 per cent by weight of phosphoric anhydride was dissolved. All the carbon disulfide used was dehydrated and pre-

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[1] It is not possible to use NaOH solution as absorbent, since carbon bisulfide is carried over into the absorbing solution, and would react with the latter, as the writer found.

served in the same manner. The asphalt, in order to remove traces of water, was kept for ten minutes with stirring, at 130° C., cooled and preserved in a desiccator containing the drying agent mentioned ($H_2SO_4 + P_2O_5$). The "tar binder B" used was dehydrated by keeping at 110° C., with stirring, for 5 minutes, then cooled and preserved as in the case of the asphalt.

It is to be emphasized that the action of the sulfur monochloride on the substances examined was found to be distinctly a time reaction. Indeed, in the case of the hydrocarbon oils to be mentioned, bubbles of hydrochloric acid gas were seen coming off and shown to be such, even after the lapse of 16 hours. The action in the case of the asphalts and tar examined was much more rapid, but nevertheless, time-consuming, especially as regards the asphalt.

Blank determinations on the apparatus, using a solution of sulfur monochloride without any bitumen, checked closely, and in the standard length of time employed for reaction and aeration (4 hours), and with the standard rate of passage of gas (one bubble per second through the Pennsylvania Railroad tubes), there was imparted to the water used as absorbent of the hydrochloric acid gas, an average acidity equivalent to only 0.043 mg. of hydrogen ≎ 0.84 cc. of 0.0504 *N* sodium hydroxide. The pipette *P* (Fig. I), used for adding the sulfur monochloride reagent, passed into the reaction tube *A* through a cork stopper, made gas-tight by soaking in paraffin. This pipette was heated to drive off adsorbed moisture, immediately before use.

The results are expressed in what the writer proposes to call a "hydrogen number," namely 100 × milligrams of hydrogen removed from organic combination and evolved as hydrochloric acid gas by the oxidizing action of sulfur monochloride, on one gram of the substance examined. Expressed in terms of sodium hydroxide solution, we have the following formula for the "hydrogen number," *viz.:*

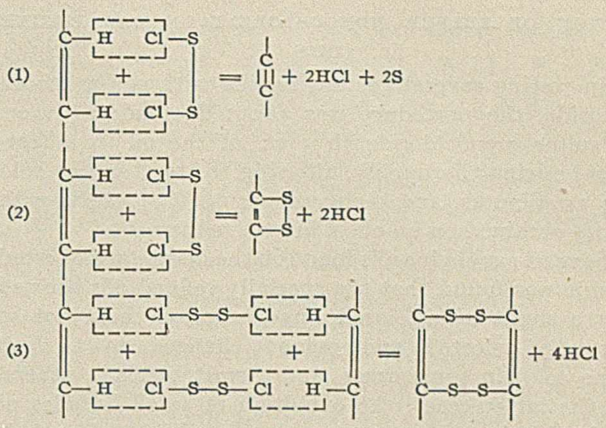
$$\frac{\text{cc. NaOH Solution} \times N}{\text{weight of sample}} \times 100,$$

where N = normality of the sodium hydroxide, preferably $N/20$ or $N/50$. The writer used from 0.2 to 0.5 g. of bituminous or tarry matter and 10 cc. of the sulfur monochloride reagent described above. The sample was first dissolved in 15 cc. of carbon bisulfide and the sulfur monochloride then added.

The method gave results concordant to 1 per cent. The following hydrogen numbers were determined.

"Oil asphalt B"	76.5, 75	(penetration = 12°)
Bermudez asphalt (refined)	126, 127	(penetration = 14°)
"Tar Binder B"	184, 185	

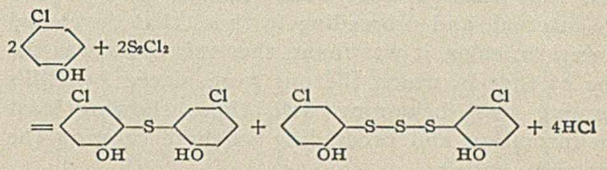
The mechanism of the reaction between sulfur monochloride and the substances examined remains to be elucidated by further work, which the writer hopes to carry on. At this time, however, it appears not unlikely that the reaction takes place between unsaturated hydrocarbons and the sulfur chloride, perhaps in one of the following ways:



Whereas the first reaction produces further unsaturation in the already unsaturated hydrocarbon, the second reaction gives rise to ring formation.

The third reaction expresses a combined ring formation and polymerization phenomenon, and is of the general type ascribed by various writers, notably Lange,[1] to express the reaction between sulfur chloride and phenols, as well as aromatic amines.

In the case of *p*-chlorophenol, Richter has shown[2] that sulfur monochloride acts as follows:



This reaction and Equation (3), above, are of the same general type, so far as condensation is concerned.

It is known[3] that the natural asphalts from the Trinidad and Bermudez deposits contain a larger percentage of unsaturated hydrocarbons than the residuals prepared from Mexican, California and Texas oils. *If* the sulfur chloride reaction, as described by the writer, be due to unsaturated hydrocarbons, then the large difference between the "hydrogen numbers" of "oil asphalt B" and refined Bermudez asphalt, noted above, is accounted for.

It should be stated that the acid gas evolved as described was shown to be hydrochloric acid by the test with ammonia, as well as by precipitating silver chloride from the solution of the gas in water. No hydrogen sulfide or other sulfur-containing gases were detected in any of the reactions.

Whether the sulfur monochloride also adds itself, as such, to unsaturated hydrocarbons, contained in bitumens, remains to be determined, possibly by means of an analytical method, which the writer has worked out, and which consists in pipetting out a portion of the reacting solution, determining the excess sulfur monochloride in this aliquot portion by shaking with water, and comparing first, with a blank, and then with the corresponding "hydrogen number" determined in the manner previously described.

[1] Lange, "Die Schwefelfarbstoffe," Leipzig, (1912), 27–28

[2] Richter, *Ber.*, **49** (1916), 1024–5; reported in *C. A.*, **11** (1917), 1100.

[3] Richardson, This Journal, **8** (1916), 319.

ACTION OF SULFUR MONOCHLORIDE ON GAS ENGINE OILS

In testing several gas engine oils with sulfur monochloride, the procedure was adopted of adding 1 cc. of sulfur monochloride to 5 cc. of the oil in a test-tube, mixing thoroughly, allowing to stand in the cold for 15 minutes, and then comparing the results with those obtained on an oil of known refinement.

Several gas engine oils found on the market were tested and it was found that the specially refined oils showed but a slight wine-colored tinge, whereas those not so carefully selected and refined changed to a deep wine color in some cases, and almost black in others. In the latter cases, the evolution of small bubbles of hydrochloric acid gas was clearly visible after half an hour, and these were shown to be such by testing with ammonia and comparing with a blank test. That is to say, the reaction in the case of the oils was found to be evidently identical, as to the evolution of hydrochloric acid gas, with the reaction in the case of the bituminous and tarry matter. It was also found that the more rapid the development of color in the case of the oils, the more vigorous the evolution of hydrochloric acid gas. Finally, if the gas engine oils were arranged in order, beginning with those that showed least color change in the same time interval, and proceeding to those that developed the darkest color, it was found that this order was the same as that in which the oils were placed by Gill's gumming test[1] beginning with those showing least gum formation and proceeding to those showing the most gum, or tar.

Since hydrogen is removed from the hydrocarbon molecule by the action of the sulfur monochloride and, since, as is well known, the removal of hydrogen (as water vapor or steam by the agencies of heat and atmospheric oxygen) constitutes a large part of the process of carbonization of lubricating oils, it would seem that sulfur monochloride might be used to measure the relative "sensitiveness" of the hydrogen in hydrocarbon oils, that is to say, as a measure of the relative stabilities of those oils.

The matter is being further studied, in order to show, if possible, whether the action of sulfur chloride on bituminous matter, tarry substances and paraffin oils, is due, as appears very likely, to the presence of unsaturated hydrocarbons.

SUMMARY

I—It has been shown that sulfur chloride acts on bituminous matter, tarry substances and hydrocarbon oils, giving hydrochloric acid gas as one product of the reaction.

II—Sulfur monochloride, undiluted, is proposed as a reagent for testing the comparative stabilities of transparent lubricating oils.

III—Sulfur monochloride in carbon disulfide is proposed as a reagent for investigating the nature of bitumens and hydrocarbon oils.

Massachusetts Institute of Technology, Boston

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[1] Gill, "Handbook of Oil Analysis," 7th Ed., p. 43.

THE PHYSICAL TESTING OF PAPER AS AFFECTED BY HUMIDITY

By Ross Campbell

Received April 23, 1917

As a result of reading the article on the "Influence of Humidity on the Physical Constants of Paper" by Kress and Silverstein, in This Journal, 9 (1917), 277, it was decided to contribute the data on the same subject which was collected in this laboratory by E. J. Goldstein during the summer of 1916.

APPARATUS

Unfortunately, we were not blessed with the excellent equipment described in the above-mentioned article. We had no method of temperature control and were forced to control the humidity by regulating a Comins Sectional Humidifier head by hand. The humidity was determined by means of a recording wet and dry bulb thermometer and a sling psychrometer. Even with this very crude control, it was found that the relative humidity did not vary more than two or three points, at most, nor the temperature more than 1°.

The tensile strengths of the specimens were determined by means of a hand-operated Schopper tensile-strength test machine. The test strips were 180 mm. long.

Resistances to folding were determined by means of a motor-driven Schopper folding machine.

Times of penetration were determined by floating the samples on an ink bath.

PROCEDURE

About 8.00 A.M. the test room was closed and the humidifier started. The sheets of paper to be tested had been hung in the test room the night previous. It was found that the humidity could be brought to the desired point by 1.00 P.M. and that, owing to the gradual increase of the humidity, the weight of the sheets to be tested was constant at about the same time. The testing was then begun. All the tests of a given kind, on a given sample were, of course, run on the same day.

OBJECT OF TESTS

The object of the tests which form the subject of this article was to determine how closely it would be necessary to control the humidity in order to have physical tests comparable from day to day. In addition it was desired to see whether the different grades, as fines, bonds, etc., varied in the same way.

PAPERS TESTED

The papers tested were the company's regular commercial output. They varied, as is shown in the table, from high-grade, loft-dried bond and ledger, to a relatively low-grade, machine-dried, fine.

Sample	Kind	Furnish (Percentages)			Thickness	Folio Wt. in Lbs. per 500 sheets
		Rag	Soda	Sulfite	In.	
A	Bond	25	Few	75	0.00384	20
B	Ledger	85	..	15	0.00385	20
C	Bond	90	..	10	0.00360	20
D	Bond	50	..	50	0.00320	20
E	Fine	Trace	25	75	0.00362	24
F	Bond	15	5	80	0.00338	20
G	Envelope	Few	25	75	0.00410	28
H	Bond	15	10	75	0.00405	20
J	Blueprint	50	..	50	0.00406	16
K	Bond	90	..	10	0.00492	19
L	Blueprint	50	..	50	0.00509	24

RESULTS OF PHYSICAL TESTING OF PAPER WITH VARYING HUMIDITY

PENETRATION (NEW STANDARD): SECS.

Av. rel. Humidity	A	B	C	D	E	F	G	H	J	K	L
54	....	....	....	....	....	....	....	....	....	....	....
61	862	686	387	722	1320	810	902	....	438	99	316
64	....	....	....	....	....	....	....	....	....	....	....
65	544	318	251	447	726	500	496	343	206	48	179
70	882	544	379	556	1326	846	996	....	403	89	367
75	733	402	269	446	1079	555	820	554	307	79	288
81	615	398	278	423	974	569	760	558	292	74	258
86	830	664	387	556	1362	826	1062	....	401	91	326
90	....	....	....	....	....	....	....	....	....	....	....
92	462	432	215	412	729	549	613	356	227	63	171
98	....	....	....	....	....	....	....	....	....	....	....

MULLEN: LBS.

Av. rel. Humidity	A	B	C	D	E	F	G	H	J	K	L
54	26.1	43.5	35.8	23.5	19.1	20.6	10.2	28.6	22.9	25.8	....
61	....	....	....	....	....	....	....	....	....	....	....
64	27.2	43.9	37.2	23.1	18.9	20.4	9.9	28.5	22.6	23.8	33.6
65	....	....	....	....	....	....	....	....	....	....	....
70	26.1	43.5	36.3	22.4	18.1	18.6	10.1	29.1	22.8	23.8	35.0
75	26.6	41.6	36.2	21.9	18.0	19.5	10.5	26.6	22.3	24.3	32.8
81	26.3	41.4	38.2	21.2	19.1	18.9	9.5	26.9	30.8	24.0	31.3
86	23.3	38.0	33.4	19.8	15.8	16.2	8.8	24.8	21.3	21.7	27.6
90	20.6	34.3	28.4	18.6	12.5	14.3	7.7	21.9	20.3	20.3	....
92	....	....	....	....	....	....	....	....	18.6	....	25.6
98	18.1	27.8	22.7	14.9	9.1	12.6	6.2	16.8	20.9	14.6	....

FOLDING, CROSS, DOUBLE FOLDS

Av. rel. Humidity	A	B	C	D	E	F	G	H	J	K	L
54	89	402	555	44	11	25	7	111	95	262	....
61	....	....	....	....	....	....	....	....	....	....	....
64	114	460	620	42	13	23	6	84	71	193	342
65	....	....	....	....	....	....	....	....	....	....	....
70	82	372	887	37	8	22	5	134	60	212	249
75	64	557	407	37	10	23	6	67	56	189	217
81	104	355	737	34	21	25	6	76	57	168	296
86	62	361	533	27	6	21	6	68	60	172	188
90	64	358	583	29	6	15	5	49	53	167	....
92	....	....	....	....	....	....	....	....	51	....	185
98	54	222	377	17	4	11	3	55	239	62	....

FOLDING MACHINE, DOUBLE FOLDS

Av. rel. Humidity	A	B	C	D	E	F	G	H	J	K	L
54	38	811	554	61	13	28	4	76	139	360	....
61	....	....	....	....	....	....	....	....	....	....	....
64	58	1260	754	77	15	24	5	75	195	388	292
65	....	....	....	....	....	....	....	....	....	....	....
70	55	2090	899	72	9	31	5	161	161	485	426
75	109	2124	1028	71	13	33	5	147	148	586	676
81	92	2457	1318	94	27	39	6	211	207	483	329
86	88	3580	1430	78	11	29	6	163	171	534	451
90	76	4140	1980	64	12	32	5	155	292	542	...
92	....	....	....	....	....	....	....	....	156	....	411
98	47	3328	2110	46	9	35	4	142	379	279	....

RESULTS OF PHYSICAL TESTING OF PAPER WITH VARYING HUMIDITY

TENSILE STRENGTH, CROSS KG.

Av. Rel. Humidity	A	B	C	D	E	F	G	H	J	K	L
54	4.21	4.62	4.46	3.28	3.25	3.06	2.89	4.21	3.42	3.53	....
61	....	....	....	....	....	....	....	....	....	....	....
64	4.02	4.23	4.66	2.96	3.14	2.99	2.69	4.00	3.26	3.57	4.73
65	....	....	....	....	....	....	....	....	....	....	....
70	3.83	4.09	4.03	2.85	2.86	2.63	2.57	3.59	2.89	3.05	4.69
75	3.80	4.03	4.32	2.90	2.76	2.55	2.35	3.62	2.96	3.20	4.34
81	3.71	3.83	3.69	2.61	2.58	2.45	2.45	3.31	2 78	2.97	4.21
86	3.22	3.67	3.83	2.43	2.33	2.39	2.25	3.29	2.61	2.93	3.89
90	2.65	2.46	2.59	1.74	1.84	1.78	1.58	2.37	1.93	2.02	....
92	....	....	....	....	....	....	....	....	2.12	....	3.34
98	1.86	2.19	2.67	1.93	1.78	1.54	1.66	1.72	2.60	1.99	....

TENSILE STRENGTH, MACHINE, KG.

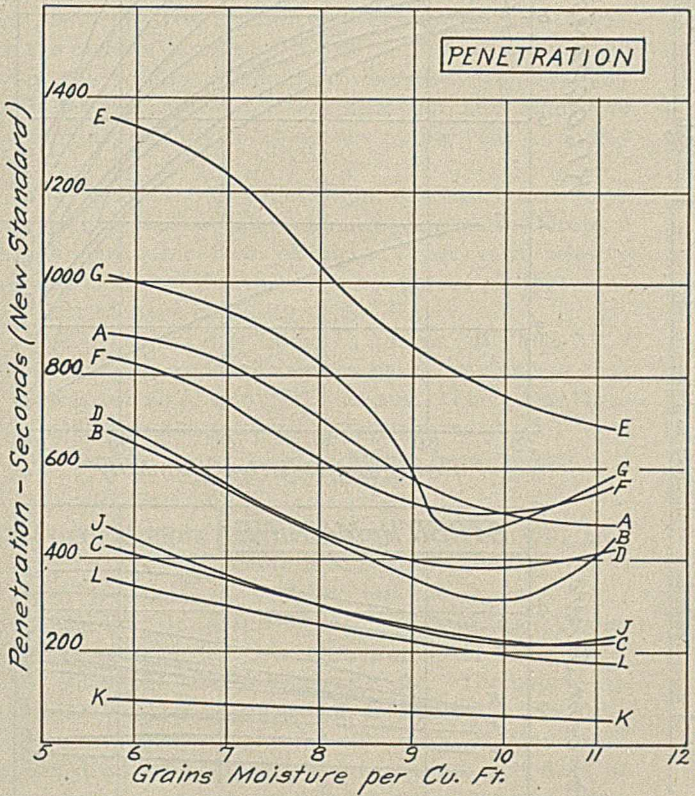
Av. Rel. Humidity	A	B	C	D	E	F	G	H	J	K	L
54	6.70	8.69	7.78	5.78	6.27	6.09	4.03	7.35	6.14	6.54	....
61	....	....	....	....	....	....	....	....	....	....	....
64	6.91	8.65	7.94	5.88	6.12	5.62	3.81	7.39	5.97	6.28	7.78
65	....	....	....	....	....	....	....	....	....	....	....
70	6.06	7.80	7.25	5.37	5.89	5.34	3.49	6.38	5.38	5.99	7.32
75	6.40	7.86	7.25	5.14	5.64	5.17	3.31	6.52	5.59	5.58	6.74
81	5.76	7.70	6.76	5.13	4.66	4.69	3.17	6.38	6.72	5.40	6.55
86	5.58	7.28	6.53	4.61	5.10	4.63	3.04	5.98	5.07	5.22	6.28
90	4.13	5.34	4.81	3.32	3.67	3.41	2.19	4.82	4.05	3.88	....
92	....	....	....	....	....	....	....	....	3.87	....	5.03
98	3.77	4.33	4.67	3.34	3.80	2.88	2.28	3.61	4.29	3.69	....

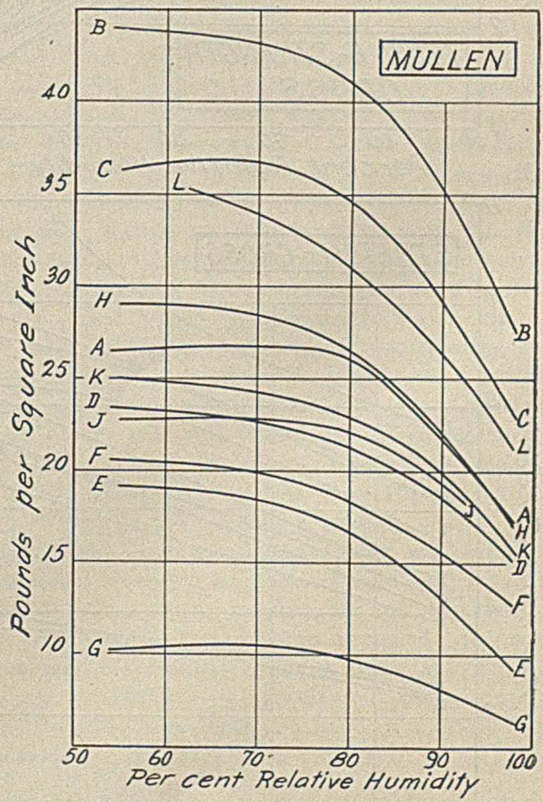
STRETCH, CROSS, PER CENT

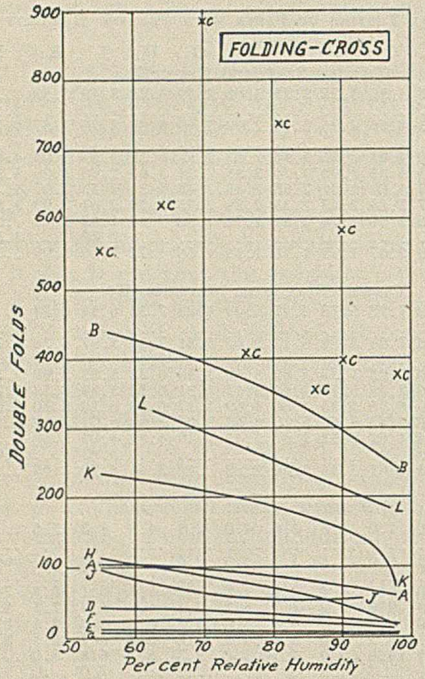
Av. Rel. Humidity	A	B	C	D	E	F	G	H	J	K	L
54	4.4	6.6	7.9	4.8	2.6	4.0	2.4	4.5	4.8	5.6	....
61	....	....	....	....	....	....	....	....	....	....	....
64	4.2	6.5	8.0	5.1	3.1	4.3	2.5	5.0	4.9	6.7	6.7
65	....	....	....	....	....	....	....	....	....	....	....
70	5.8	8.0	9.1	6.5	2.9	4.8	3.2	5.4	6.1	6.3	7.8
75	5.1	7.9	9.7	5.2	3.7	5.1	3.1	6.0	5.9	7.5	8.0
81	6.2	9.0	9.7	5.6	4.8	5.6	3.8	6.6	6.3	8.1	8.4
86	6.3	9.2	10.2	7.6	3.1	6.4	3.6	6.8	6.7	8.5	8.4
90	6.8	9.1	11.6	7.0	3.5	5.8	3.3	6.1	6.8	8.0	....
92	....	....	....	....	....	....	....	....	7.0	....	9.3
98	7.5	9.9	10.4	8.5	3.7	6.5	4.0	7.0	9.2	8.1	....

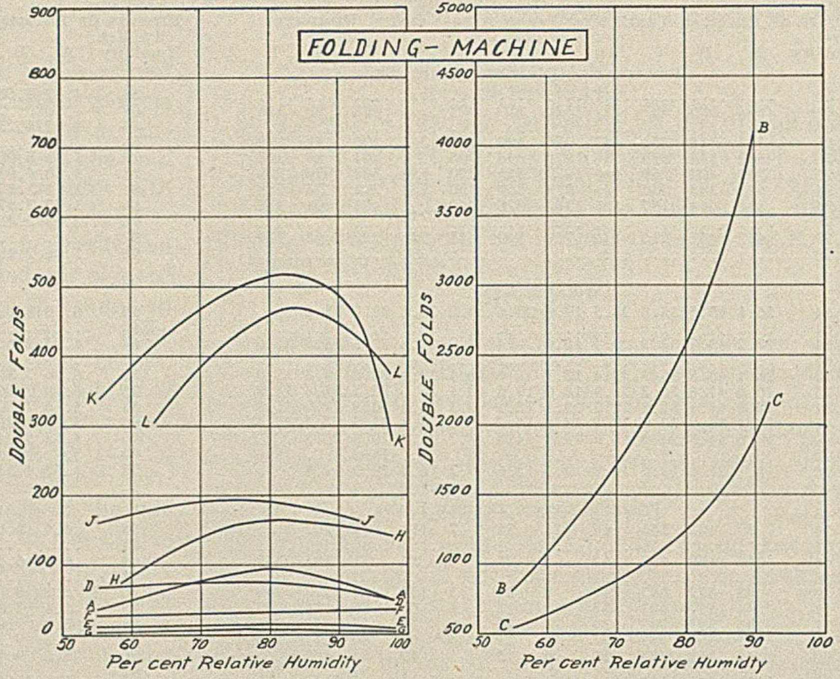
STRETCH, MACHINE, PER CENT

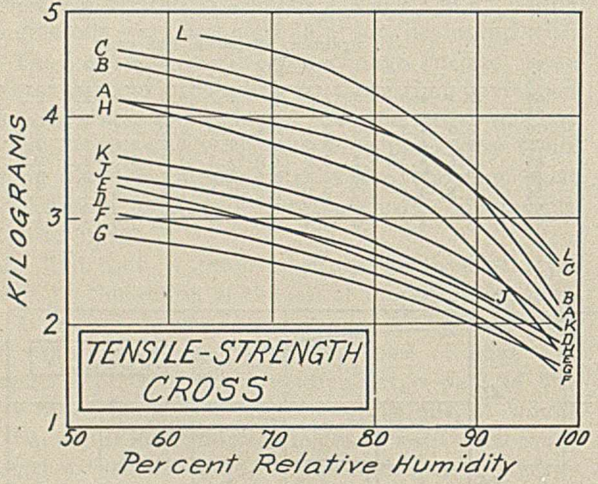
Av. Rel. Humidity	A	B	C	D	E	F	G	H	J	K	L
54	2.2	3.6	3.1	2.0	1.2	1.7	0.9	2.1	2.0	2.1	....
61	....	....	....	....	....	....	....	....	....	....	....
64	2.3	4.0	3.5	2.3	1.5	1.7	1.0	2.1	2.0	2.3	2.7
65	....	....	....	....	....	....	....	....	....	....	....
70	2.6	4.3	4.0	2.5	1.4	1.9	1.0	2.3	2.5	2.8	2.8
75	2.7	4.7	3.9	2.5	1.7	1.9	1.1	2.6	2.5	2.7	3.0
81	2.5	4.5	4.2	3.0	2.0	1.8	1.1	2.5	2.6	2.6	3.0
86	2.7	5.1	4.8	3.1	1.6	1.9	1.2	2.7	2.7	3.0	3.5
90	2.8	4.6	4.2	2.9	1.5	2.1	1.1	2.6	2.9	3.3	....
92	....	....	....	....	....	....	....	....	3.0	....	3.6
98	3.1	4.6	4.4	3.4	1.6	2.1	1.3	2.9	3.9	3.2	....

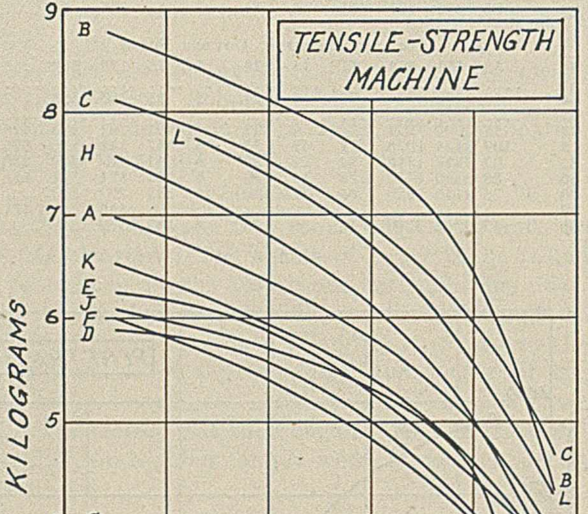


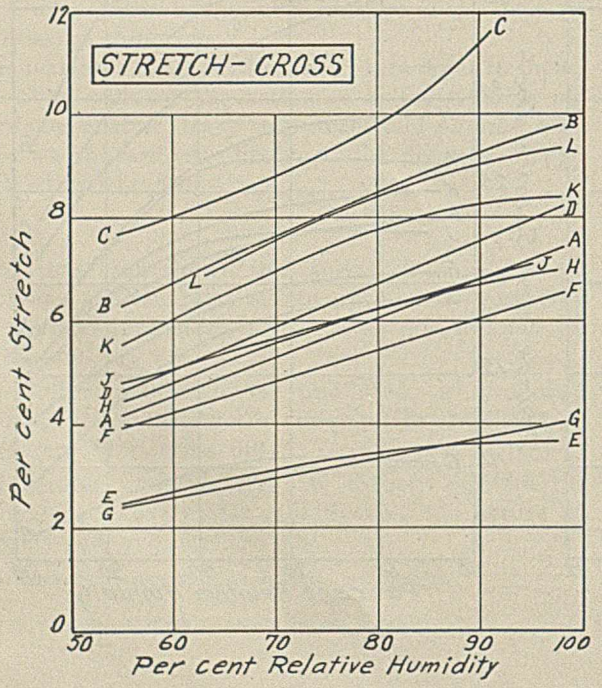



FOLDING-CROSS
Double Folds
0
100
200
300
400
500
600
700
800
900
50
60
70
80
90
100
Per cent Relative Humidity
×C
B
L
K
H
A
J
D
F
E
G


FOLDING- MACHINE
Double Folds
0
100
200
300
400
500
600
700
800
900
50
60
70
80
90
100
Per cent Relative Humidity
K
L
J
H
D
A
F
E
G
Double Folds
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
50
60
70
80
90
100
Per cent Relative Humidty
B
C


TENSILE-STRENGTH CROSS
Kilograms
1
2
3
4
5
50
60
70
80
90
100
Per cent Relative Humidity
L
C
B
A
H
K
J
E
D
F
G


TENSILE-STRENGTH MACHINE
Kilograms
2
3
4
5
6
7
8
9
50
60
70
80
90
100
Per cent Relative Humidity
B
C
L
H
A
K
E
J
F
D
G


STRETCH- CROSS
Per cent Stretch
0
2
4
6
8
10
12
50
60
70
80
90
100
Per cent Relative Humidity
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L
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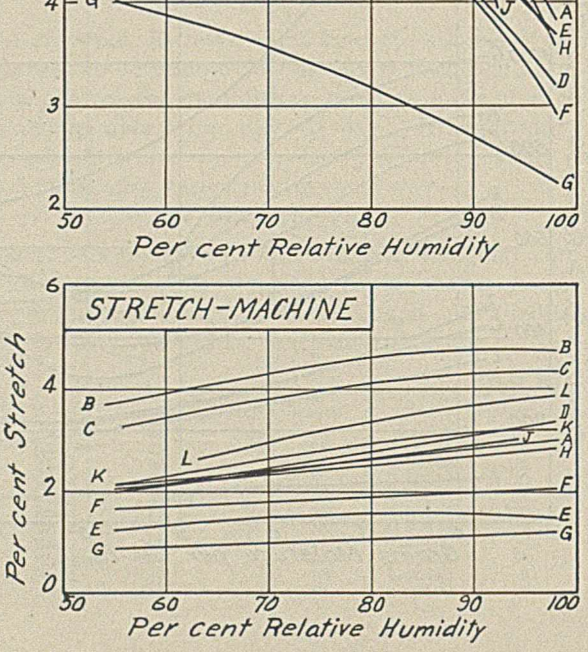
A
J
H
F
G
E


STRETCH-MACHINE
Per cent Stretch
0
2
4
6
50
60
70
80
90
100
Per cent Relative Humidity
B
C
L
D
K
J
A
H
F
E
G

RESULTS

The results obtained are given in the accompanying set of tables and plots. Before making the plots, two preliminary sets were made, one using relative and the other absolute humidities. It was found that the results could be plotted against the relative humidity only, except in the case of the penetration tests, where the results yielded a curve only when plotted against the absolute humidity.

It will be noted that the results here given agree with those obtained by Kress and Silverstein in the case of the Mullen test plot only. These variations may have been due to the higher grades of paper used in our tests, but this seems rather doubtful, as no such variations were observed over the range of qualities tested here.

It was found impossible to draw a curve for "penetration" for sample "H" owing to the wide variations noted between different tests at the same humidity. In the "folding-cross" tests no curve could be drawn for "C," the points being as shown on the drawing. The "folding-machine" tests for B and C were so far beyond the range of the other samples that their curves are presented on a different scale.

SUMMARY

The magnitude of most of the tests decreased 40 to 50 per cent as the relative humidity increased from 50 to 98 per cent. The stretch in the machine direction increased about 30 per cent and in the cross direction about 40 to 50 per cent under the same circumstances.

The results of the folding tests in the machine direction tended to reach a maximum at about 80 per cent relative humidity in all except two cases. In the cases of samples "B" and "C," the curve plotted from the results of this test increased very rapidly with the increase of relative humidity and tended to become asymptotic to about the 95 per cent humidity line.

The time of ink penetration decreased 40 to 50 per cent as the absolute humidity increased from 6 grains per cubic foot of air (55 per cent relative humidity at 80° F.) to 11 grains per cubic foot (100 per cent relative humidity at 80° F.).

Special attention is called to curves "B" and "K." These samples were the same in every way except that "B" was tub sized and "K" was not. The advantages of a good tub size are very clearly shown.

Research Laboratory, American Writing Paper Company
Holyoke, Massachusetts

THE OCCURRENCE OF GERMANIUM IN MISSOURI AND WISCONSIN BLENDES[1]

By G. H. Buchanan

Of the fifty or more elements which we usually distinguish as rare, few are more worthy of the distinction than the element germanium. Discovered in 1886 by Winkler in a new silver mineral, argyrodite, and identified by him as the eka-silicon of Mendeléef, it has dropped back into oblivion since the days of this classic work, until to-day it is one of our least known elements. With but few exceptions our entire knowledge of the properties of the element is due to Winkler. According to Urbain,[1] the material worked over by Winkler for the preparation of germanium was a mixture of argyrodite with other minerals, and did not contain more than 0.36 per cent of argyrodite. Since the germanium content of argyrodite is 6 to 7 per cent, the germanium content of his raw material could only have been between 0.02 and 0.03 per cent. From this material Winkler obtained 80 kilos of mixed metallic sulfides which yielded 156 g. pure germanium.

Argyrodite, the richest source of the element heretofore known, has proved exceedingly rare, and during the thirty years that have elapsed since the work of Winkler only a very few additional sources of the element have been brought to light.

Krüss has reported the presence of 0.1 per cent germanium in euxenite. Its occurrence in samarskite, tantalite and niobite has been reported and denied, a disagreement which is not surprising in view of the complexity of these minerals. Two other sources have been more recently discussed. Urbain[2] by spectroscopic methods detected germanium in 38 out of 64 blendes from various localities. Taking 550 kilos of one of these, a Mexican blende, he obtained from it 5 g. pure germanium. Bardet,[3] also by spectroscopic methods, detected traces of germanium in certain French mineral waters. Since the recovery of germanium from blendes by the method of Urbain was long and costly, he believed that the residues from these mineral waters might yield sufficient germanium to provide for the needs of scientific study. From 100 kilos of residues, representing 250,000 liters of mineral water, he obtained 60 mg. GeO_2.

A more recent report of the occurrence of germanium is due to W. F. Hillebrand and J. A. Scherrer:[4] in a paper on "The Recovery of Gallium from Spelter in the United States," mention is made of an examination for germanium of a number of blendes, carried on at the Bureau of Standards by Dr. K. Burns. By the use of the spectroscope germanium was identified in several of these, notably in a Missouri sulfide. A short paper by the writer was published in This Journal in July, 1916, p. 585, relating to the identification of germanium in zinc-bearing materials. At that time it was not possible to give details as to the origin of the rich germanium-bearing material. It is the purpose of the present paper to discuss the nature of this material, which now appears to be the richest source of the element known.

During the summer of 1915 there was brought to the writer's attention an oxide of zinc which had been prepared from spelter residues by the American process. A chemical examination revealed the presence of considerable quantities of an unusual constituent, which was identified as the element germanium.

The identification tests consisted in a distillation of

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[1] Presented at the *Symposium on the Chemistry and Metallurgy of Zinc*, 54th Meeting American Chemical Society, Kansas City, April 10 to 14, 1917.

[1] *Compt. rend.*, **150**, 1758.

[2] *Ibid.*, **149**, 602.

[3] *Ibid.*, **158**, 1278.

[4] This Journal, **8** (1916), 225.

the oxide of zinc with hydrochloric acid, a slow current of chlorine being bubbled through the solution during boiling to prevent distillation of arsenic. The strongly acid distillate was diluted and saturated with hydrogen sulfide. A voluminous white precipitate was formed which was readily soluble in alkalies and which dissolved in water, although more slowly. The sulfide was slowly re-precipitated from its aqueous solution upon addition of strong acids. The addition of hydrofluoric acid to the aqueous solution of the sulfide, followed by saturating the mixture with solid potassium chloride, produced a grayish, gelatinous precipitate, the double fluoride of potassium and germanium.

A roughly quantitative determination of the ratio $GeO_2 : GeS_2$ gave the value 0.747. The theoretical ratio, assuming 72.5 for the atomic weight of germanium, is 0.766. The sulfide precipitate was weighed without washing free from precipitated sulfur, since the usual alcohol-carbon bisulfide washing caused the precipitate to run through the asbestos Gooch. The presence of sulfur in the precipitate when weighed would, of course, lower the ratio. Bearing this in mind, the agreement between calculated and observed values is fairly close.

By distilling weighed samples of the oxide of zinc with chlorine and hydrochloric acid, and precipitating and weighing the sulfide, the value $GeO_2 = 0.25$ per cent was obtained.

A sample of the oxide of the element, prepared by ignition of the sulfide and treatment of the residue with nitric acid, was examined at the Bureau of Standards with the spectroscope and was reported, "Germanium, principal constituent."

As has been stated, the oxide of zinc in which this considerable amount of germanium was detected was prepared from spelter residues. The attempt was now made to locate geographically the source of the element.

The residues in question were mixed residues from Joplin and Wisconsin ores. An examination of a number of oxides of zinc prepared from ores from various localities, including those made from Missouri and Wisconsin ores, was now undertaken. For this work a delicate test for the presence of germanium was required. The following procedure was applied with success to a large number of samples; the details are those which were found necessary with this class of material. The essential details of the method are due to A. A. Noyes:

Weigh a 100-g. sample of the oxide of zinc into a liter distilling flask connected with a water-cooled condenser, and add 200 cc. concentrated hydrochloric acid. Pass chlorine into the mixture until the gas appears in the receiver of the condenser, and then heat the mixture to boiling and distil to about half volume, continuing the passage of a slow current of chlorine. Dilute the distillate with an equal volume of water and pass hydrogen sulfide into it for at least 30 minutes. If no precipitate is formed (other than the usual opalescence due to sulfur), germanium is absent. If a precipitate is formed, filter it off on a small paper and wash it with a very little cold water.

Place the paper containing the precipitate in a flask with about 150 cc. water, boil for 15 minutes, and filter. To the filtrate add 50 cc. concentrated hydrochloric acid, cool and treat with hydrogen sulfide as before. A white flocculent precipitate indicates the possible presence of germanium.

Filter on a small paper and wash once with a little cold water. Pour ammonia through the filter, receiving the solution and washings in a platinum dish. Evaporate to dryness. Moisten the residue with concentrated nitric acid and evaporate to dryness again. When dry, ignite for a few minutes.

To the residue add a very little water and a few drops of hydrofluoric acid, saturate with solid potassium chloride and allow to stand in the cold for 15 minutes. If germanium is present a grayish, gelatinous precipitate is formed, soluble on heating or diluting the solution.

The presence of germanium is not reported unless this last confirmation test is obtained.

With this procedure positive results were obtained with both Joplin and Wisconsin Separator ores. Positive results were also obtained from Mineral Point "Special Leaded Oxide of Zinc," from an oxide made from a Mexican ore (La Bufa), and from one or two others. Negative results were had from two other Mexican ores, from ore from Austinville, Va., from Mineral Point "Prime Oxide of Zinc," and from New Jersey ores ("XX Oxides"). In all cases where positive results were obtained the amounts detected were very much less than were met with in the oxide made from spelter residues, probably not one-tenth as much. It is probable that the procedure described would detect as little as 0.01 per cent germanium in an oxide of zinc.

It is evident from these results that the germanium content of the residuum may have been derived from either the Wisconsin or the Missouri ore, or from both of them, and that it has been greatly concentrated during the metallurgical treatments which it has undergone. The treatment in the spelter retorts and in the oxide fires has carried on this concentration on an enormous scale and we have, as a result, an abundance of a material much richer in germanium than the original ores.

The properties of the substance as given in the literature explain the nature of this concentration. The metal is said to be readily obtained by reduction of the oxide with carbon at a red heat, so that under the conditions prevailing in the spelter retort the germanium must be present in the elementary state. It is not markedly volatile at 1350° C. Accordingly, while the zinc was distilling off into the condenser, the germanium *for the most part* remained behind, and was discharged with the residues. The qualification seems necessary, since Uhler has detected traces of germanium in the leady residues from the redistillation of low-grade metal.[1] In the zinc oxide furnaces the ger-

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[1] Browning, "Introduction to the Rarer Elements," 4th edition, p. 84.

manium burned to oxide and passed off with the zinc smoke into the bags.

It is possible to obtain a rough approximation of the amount of germanium in the original ore by assuming a zinc oxide content of 10 per cent for the residues, and of 50 per cent for the original ore. Assuming in all cases complete recoveries, the GeO_2 content of the residues would have been one-tenth that of the oxide of zinc, or 0.025 per cent, and that of the original ore would have been approximately 0.01 per cent.

The work reported in the preceding paragraphs was carried on by the writer in the Research Laboratory of The New Jersey Zinc Company, at Palmerton, Pennsylvania, to the officials of which company the writer is under obligations for permission to publish these results. Through the kind offices of Mr. George C. Stone, of the New Jersey Zinc Company, a supply of the germaniferous oxide of zinc has been furnished the Massachusetts Institute of Technology for study. This work has already been begun.

Massachusetts Institute of Technology
Cambridge, Massachusetts

PHOSPHOR-TIN AND A VOLUMETRIC METHOD FOR ITS ANALYSIS

By Richard Edwin Lee, W. H. Fegely and Frank H. Reichel

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The paper presented here traces its origin to a request forwarded to this laboratory for a method for the rapid and accurate analysis of an alloy of phosphorus and tin, known commercially as "phosphor-tin." This material is purchased according to specifications. Analysis of each shipment, therefore, is desirable. Furthermore, since the correct proportions of the material to be used in the various processes can be determined only from a knowledge of its composition such an analysis is practically necessary. It is obvious, therefore, that a method corresponding to the description in the request should be available. No such method, however, was found in the literature.

In this connection it may be contended that inasmuch as the tin in the alloy can be readily determined by some standard method, such as the sulfide method, and the percentage of phosphorus estimated by the "method of difference," that the problem presented was not one difficult of solution. It should be noted, however, that the presence of any impurities in the alloy would cause a corresponding error in the calculation of the phosphorus content. This of course would render the procedure valueless. Obviously the problem requires for its solution the formulation of methods for the determination of both phosphorus and tin.

PROPERTIES AND USE OF PHOSPHOR-TIN

The phosphorus in phosphor-tin alloys varies as a rule from 0.1 to 5 or 6 per cent. According to Desch,[1] phosphor-tin is grouped with the so-called "brittle alloys," which are described by him as "alloys produced commercially for the purpose of facilitating the addition of small amounts of elements to molten metals. Thus silicon and phosphorus as such are now seldom added to metals, rich alloys of these substances with iron, copper, or tin being usually employed. These rich alloys are composed principally of intermetallic compounds, as silicides and phosphides."

Phosphor-tin is manufactured on the large scale by melting tin and phosphorus in large furnaces which are frequently provided with apparatus for the partial exclusion of air. The alloy has a crystalline structure and is very hard and brittle. In color it resembles tin.

This alloy is used instead of tin in the manufacture of various tin alloys for the purpose of either preventing the formation of oxide or enhancing certain mechanical qualities of the alloy into which it enters. For example, in the manufacture of certain bronzes, if phosphorus is added in small amounts, it apparently does not produce, as was originally suspected, a new alloy known as phosphor-bronze. It serves simply as a deoxidizing agent in the molten metal, the resulting phosphoric oxide passing into the slag or scum on the surface.[1] When the metals entering into the composition of the alloy are melted in the absence of phosphorus the alloy is more or less seriously contaminated with oxides. It is obvious, therefore, that if the quantity of added phosphorus be carefully adjusted, the resulting product is merely a purified alloy. However, if a larger quantity of phosphorus is introduced than is required when it is to function simply as a reducing agent the product is an alloy with properties distinctly different from those of the merely purified alloy.

In the manufacture of bronze, according to Desch, "if the quantity of phosphorus introduced through the medium of phosphor-tin exceeds that required for complete deoxidation by more than about 0.1 per cent, it will cause brittleness owing to the separation of hard particles of the phosphide, Cu_3P. Such a mixture is sometimes very incorrectly called phosphor-bronze. If the alloys are to be employed in the manufacture of gear wheels, bearings, etc., the quantities of tin and phosphorus present vary from 6 to 15 per cent and 0.7 to 1.5 per cent, respectively. These alloys are very hard and better able to resist friction. The hardness is due in part to the presence of the hard particles of copper phosphide. The presence of these hard masses in the comparatively soft matrix of lead produces the combination of great hardness with a limited but distinct plasticity which is required for such purposes."

It is not desirable, however, to enter into a detailed account in this paper of investigations in this field of ternary alloys; nor is this necessary to make it perfectly obvious that methods for the rapid and accurate chemical analysis of alloys similar to phosphor-tin are of immediate need in control work.

PRELIMINARY EXPERIMENTS SHOWING THE BEHAVIOR OF THE ALLOY IN CERTAIN SOLVENTS

At the very beginning of this investigation it was concluded that it would be necessary at some stage of the work to determine whether the phosphorus in the alloy is wholly in the chemically combined or uncombined form, although it seemed rather improbable

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[1] C. H. Desch, "Metallography," **1910**.

[1] Rosenhain, "Introduction to Physical Metallurgy," **1914**, 152.

that it should exist in the latter form. Subsequent work indicated that the metalloid is present in the alloy in the form of a definite compound.

The early part of the experimental work was devoted, therefore, to a study of the effect of various solvents on suitably prepared samples of the alloy with the following results:

Sulfuric acid (5 N) failed to dissolve the sample, but sulfuric acid (sp. gr. 1.84) effected its immediate solution. *Hydrochloric acid (sp. gr. 1.20)* readily dissolved the alloy, but 5 *N* acid apparently had little effect on it. *Nitric acid (sp. gr. 1.42)* decomposed the sample, leaving a white residue. When *aqua regia* was added to the alloy the authors were very much perplexed to find at first that the sample apparently ignited and burned with a blue flame. It may be noted here that it was this rather unexpected behavior which later suggested the proposed method for the solution of our problem.

Having ascertained how to effect the solution of the alloy it was decided to attempt quantitative determinations of tin and phosphorus, using sulfuric acid (sp. gr. 1.84) as a solvent, with a view to determining whether all of the phosphorus was liberated as phosphine, or whether it was partially oxidized to phosphoric acid.

One-half gram of the sample was dissolved in 10 cc. of sulfuric acid (sp. gr. 1.84) and evaporated to 7 cc. The solution was then diluted with 150 cc. of water and saturated with hydrogen sulfide. The precipitate of tin sulfide was filtered on a weighed Gooch crucible, dried, and finally ignited to the oxide and weighed. The phosphoric acid in the filtrate was then determined. As the sulfuric acid would eventually act as an interfering substance, it was precipitated as barium sulfate, using barium nitrate as the precipitant. The barium sulfate was filtered off, washed, and rejected. To the filtrate, heated to 85°, 50 cc. of ammonium molybdate solution were added. The precipitate of ammonium-phosphomolybdate was filtered on a weighed Gooch crucible, dried at 110° and weighed. From the weight of this precipitate the percentage of phosphorus was calculated. The determinations of the tin by the method outlined checked within satisfactory limits, but the results obtained from the phosphorus determinations were not concordant, the conclusion being that varying portions of the phosphorus were oxidized during the process of solution. Concentrated sulfuric acid was, therefore, abandoned as a solvent for the alloy.

Solution of the sample in hydrochloric acid proved to be the real starting point of the method presented in this paper. A 0.5-gram sample of the alloy was treated with hydrochloric acid (sp. gr. 1.20). It dissolved rapidly with the evolution of phosphine. The solution was evaporated to 10 cc., diluted with 100 cc. of water and saturated with hydrogen sulfide. The precipitate of tin sulfide was filtered out on a weighed Gooch crucible, washed, ignited, weighed as the oxide and the tin calculated as before. The series of results obtained checked very closely with those obtained when sulfuric acid was used as a solvent. This standard procedure for determining tin was used in the early stages of the work to check the determinations of tin by the proposed method. Further confirmation of these results was secured later by the electrolytic method.

The filtrate from the tin sulfide was heated to remove hydrogen sulfide, then neutralized with ammonium hydroxide and magnesia mixture added. Six separate tests failed to show evidence of the presence of phosphoric acid, even after 24 hrs.

With the evidence at hand indicating that the phosphorus is evolved quantitatively in the form of phosphine when the alloy is dissolved in hydrochloric acid, the solution of one phase of the problem, namely, the determination of the phosphorus content, was anticipated if a method could be formulated by which the gas might be absorbed and oxidized to phosphoric acid.

DEVELOPMENT OF METHOD FOR DETERMINING PHOSPHORUS

A variety of solutions have been employed in gasometric methods for absorbing phosphine quantitatively. Only two of those suggested, however, were found suitable, owing to the nature of the procedure involved. These two were bromine water and a solution of potassium permanganate.

The *apparatus* used consisted of a Florence flask of 500 cc. capacity fitted with a 3-holed rubber stopper through which a 100-cc. tap-funnel and two pieces of glass tubing bent at right angles were inserted. For the absorption train, three Erlenmeyer flasks of 150 cc. capacity were connected in series with the Florence flask.

AQUEOUS SOLUTION OF BROMINE—To each of the Erlenmeyer flasks 100 cc. of bromine water were added. The train was connected to the evolution flask in which a 0.5-g. sample of the alloy was placed. Hydrochloric acid (sp. gr. 1.20) was added to decompose the alloy. The greater part of the bromine in the first absorption flask disappeared before that in the second flask was attacked, owing to the rapid absorption and oxidation of the phosphine. The evolution flask was finally freed from phosphine by sweeping out the system with natural gas or carbon dioxide. By this latter procedure most of the remaining bromine was displaced from the water solution and escaped into the laboratory. Owing to the well-known irritating action of bromine vapors on the respiratory passages it was thought that the use of bromine water as an absorbent might not be regarded as entirely satisfactory for routine analytical work. Nevertheless, four analyses were made. The phosphoric acid in each flask was determined separately to be sure that no phosphine escaped the last flask in the train, it having been shown that none remained in the hydrochloric acid solution in the evolution flask.

The contents of the three flasks in which the respective delivery tubes had been rinsed were transferred to beakers marked Nos. 1, 2 and 3, corresponding to the positions in which the flasks were located in the train. The phosphoric acid present in each flask was determined by a standard procedure with the results given in Table I.

Table I—Retention of Phosphine by Aqueous Solutions of Bromine

Flask No.	Per cent Phosphorus Found			
	1	2	3	Total
Experiment 1	2.69	0.32	0.00	3.01
Experiment 2	2.91	0.07	0.00	2.98
Experiment 3	2.87	0.16	0.00	3.03
Experiment 4	2.51	0.50	0.00	3.01

The absence of phosphorus in the third absorbing-flask indicates that no phosphine escaped.

Although it appears that bromine water may be used for routine work with satisfactory results if operations are conducted in a hood, or if a trap is provided to prevent the escape of bromine vapor, it was abandoned as an absorbent for one which proved more suitable. This was a solution of potassium permanganate.

AQUEOUS SOLUTION OF POTASSIUM PERMANGANATE—The use of a solution of potassium permanganate as an absorbent of phosphine with its ultimate oxidation to phosphoric acid, H_3PO_4, immediately suggested the attractive procedure of determining the phosphorus by titration of the excess of a known quantity of a standard solution of the substance. Unforeseen difficulties were encountered, however, when an effort was made to conduct the analysis according to the foregoing scheme.

The hydrochloric acid which is used as the solvent for the alloy tended to pass over into the absorbing flasks where it decomposed the permanganate. This fact made it necessary to search for another absorbent which would trap the hydrochloric acid, but not the phosphine. Water and aqueous solutions of sodium hydroxide, sodium carbonate, and ammonium hydroxide were tested separately with respect to the property of absorbing the two gases. All of these substances were found to absorb hydrochloric acid gas as fast as it was evolved; but unfortunately, they absorbed phosphine also. This was shown by adding bromine to the solutions to oxidize the phosphine to phosphoric acid, and then precipitating the latter. Sodium hydroxide dissolved the most phosphine and water the least. In all cases, however, enough was dissolved to make the results valueless. Other solutions were tested in similar respects but the results obtained were no more encouraging. Finally the search for an absorbent which would prevent the passage of the hydrochloric acid into the permanganate solution and at the same time be inert as regards its action toward phosphine was abandoned. This meant, of course, the relinquishing of the scheme whereby the excess or unused portion of permanganate was to be titrated and the substituting of a procedure providing for the precipitation of the phosphoric acid from the absorbing solution of potassium permanganate.

With the adoption of the method of the ultimate precipitation of the phosphorus as phosphoric acid the next problem that presented itself was the determination of that concentration of the absorbing solution which would prove most efficient. It was thought advisable, however, to employ a solution of such concentration that all of the phosphine would be absorbed in the solutions in the first two of the three absorbing flasks as this would provide for a relatively large margin of safety when analyzing new alloys.

The best concentration of permanganate to be used in the analysis of alloys containing a given percentage of phosphorus was determined by a series of experiments in which a moderately concentrated solution was used at first, followed by the gradual reduction of the concentration of the solution in each succeeding experiment until phosphoric acid was found in the absorbent in the third flask. In each of the determinations in the series reported in Table II, using sample No. 1 of the alloy, 90 cc. of potassium permanganate solution of known concentration were introduced into each of the three Erlenmeyer absorption flasks, after which the experiment was conducted in the same manner as when an aqueous solution of bromine was employed as the absorbing agent.

Table II—Retention of Phosphine by an Aqueous Solution of $KMnO_4$

No.	Grams $KMnO_4$ in 270 cc. of absorbing solution	Per cent Phosphorus Found			
		Flask No. 1	2	3	Total
1	3.0000	3.01	0.02	....	3.03
2	2.5000	2.90	0.09	....	2.99
3	2.0000	2.76	0.25	....	3.01
4	1.5000	2.73	0.28	....	3.01
5	1.0000	2.74	0.29	....	3.03
6	0.5000	2.61	0.39	....	3.00
7	0.2500	1.87	1.01	0.16	3.04

From the data in Table II, it was concluded that a concentration of 0.5 g. of potassium permanganate in 270 cc. was necessary for the complete absorption of the phosphine in the first two flasks. But since the percentage of phosphorus in different samples varies ordinarily from 2 to 6 per cent it was thought advisable to employ a solution containing 1 g. in 270 cc.

EFFECT OF THE PRESENCE OF NITRIC ACID IN THE PERMANGANATE SOLUTION—Following the absorption of the phosphine by the potassium permanganate solution and its ultimate oxidation to phosphoric acid, about 30 cc. of nitric acid (sp. gr. 1.42) were added to the 270 cc. of solution preparatory to the precipitation of the phosphoric acid. It occurred to the authors that if the nitric acid were added to the absorbing solution before the phosphine was introduced, it might be possible to use an absorbing solution with a smaller concentration of potassium permanganate. The series of experiments reported in Table III show how well the suspicion was founded.

Table III—Retention of Phosphine by a Solution of $KMnO_4$ and HNO_3

No.	Gms. $KMnO_4$ in 270 cc. of absorbing solution containing 30 cc. HNO_3	Percentages Phosphorus Found			
		Flask No. 1	2	3	Total
1	0.5000	3.00	0.03	....	3.03
2	0.4500	2.96	0.03	....	2.99
3	0.4000	2.97	0.04	....	3.01
4	0.3500	2.89	0.11	....	3.00
5	0.3000	2.92	0.10	....	3.02
6	0.2500	2.64	0.35	....	2.99
7	0.2000	2.02	0.87	0.12	3.01

The increase in the absorbing and oxidizing power of this solution over the potassium permanganate solution is probably not due merely to the oxidizing action of the nitric acid but to reactions into which it enters or effects. For example, nascent chlorine is introduced into the system by the action of the nitric acid on the hydrochloric acid which distils over from the acid in the evolution flask. Other reactions probably occur also. At least three strong oxidizing agents, potassium permanganate, nitric acid and nascent chlorine are acting together under the conditions of the procedure.

PROCEDURE USED IN CHECKING PROPOSED METHOD FOR DETERMINING PHOSPHORUS

The authors have attempted so far to show experimentally that the phosphorus present in phosphor-tin is probably in the form of a phosphide, that on solution of the alloy in hydrochloric acid it is liberated quantitatively as phosphine, and that this latter substance may be entirely absorbed and oxidized in certain solutions and later determined as phosphoric acid. At this stage of the work, with a view to determining the accuracy of the proposed method for determining phosphorus, a portion of Sample 1 was analyzed by the long and rather tedious but well-known procedure, commonly known as the cyanide method. This method is sometimes employed in the determination of phosphorus in the phosphor-bronzes when accuracy is the chief consideration. The liberation of hydrocyanic gas at one stage of the method also contributes to its lack of popularity. The results obtained by use of the cyanide method were slightly but uniformly lower than those obtained by the rapid method proposed in this paper. This has been attributed to the large number of filtrations required by the older method.

CYANIDE METHOD—The procedure used by the authors in making the analyses of the alloy by the cyanide method was as follows: To 0.5 g. alloy in a 200 cc. beaker, 25 cc. nitric acid of sp. gr. 1.42, were added. The beaker was covered with a watch glass, and after the first violent action had ceased, it was placed on a water bath and heated until the alloy was completely decomposed and the residue was entirely white. All the phosphoric acid remains with the tin as stannic phosphate.

The nitric acid solution of the alloy was diluted and the stannic oxide containing the phosphoric acid was filtered off, washed several times and dried. The precipitate was transferred to a crucible, and mixed with three times its weight of potassium cyanide. The crucible was covered and the mass fused a few minutes at red heat. On cooling, the fused mass was extracted with hot water, filtered and the paper washed with hot water.

The hydrocyanic and cyanic acids were expelled from the filtrate by boiling with concentrated hydrochloric acid. The solution was evaporated to dryness to dehydrate the silicic acid which had been dissolved from the porcelain crucible. The dry residue was dissolved in a little hydrochloric acid, and hydrogen sulfide passed through the solution to precipitate small amounts of tin likely to be present. The precipitate was filtered off and washed and the hydrogen sulfide destroyed in the filtrate by adding bromine water and boiling. The phosphoric acid was then precipitated, ignited, and weighed as the pyrophosphate.

Twelve phosphorus determinations were made by this method. The results of these determinations are given in Table V.

DEVELOPMENT OF THE METHOD FOR DETERMINING TIN

A survey of the methods proposed for the determination of tin in alloys will reveal the fact that the majority of those possessing accuracy require considerable time for their execution. Even the sulfide method is regarded as being comparatively long and tedious when considered from the standpoint of the analyst doing routine work. It was recognized, therefore, at the very beginning of the work that the attractiveness of any proposed method would be greatly enhanced if it provided for a rapid and accurate determination of tin in the alloy.

In considering the problem at this stage of the work the authors were led naturally to an investigation of the solution of the alloy from which the phosphorus had been liberated as phosphine with a view to ascertaining if it could be used in determining the tin either gravimetrically or volumetrically.

It is well known that tin dissolves in hydrochloric acid in the absence of oxidizing agents with the formation of stannous chloride. It was this reaction which suggested the point of attack, namely, the problem of dissolving the sample of alloy used in the phosphorus determination in such a manner that the tin should be left in the hydrochloric acid solution (in the generating flask) in the "-ous" condition. If this could be accomplished the solution of the problem was indicated, for all that would then be required to complete the determination would be the titration of this stannous chloride solution with a suitable standard oxidizing solution.

As the result of the experimental work following the lines of inquiry suggested in the previous paragraph, it was found that if the system of apparatus used in the phosphorus determination was swept free from air before and after the liberation of phosphine by the use of illuminating gas, carbon dioxide, or any other gas inert as regards the stannous chloride, (1) the phosphor-tin dissolved in hydrochloric acid with the quantitative formation of phosphine and stannous chloride; and (2) it was possible to determine the amount of tin present by adding to the solution a slight excess of pure ferric chloride and determining the amount of reduction by titrating with a solution of potassium dichromate.

Using this procedure a number of series of determinations of tin in Sample 1 were made. The results were in close agreement with those obtained in the preliminary experiments when the sulfide method was used to determine the tin content of the different samples of the alloy. The results given in Table IV indicate the relative accuracy of the method.

TABLE IV—DETERMINATION OF TIN IN PHOSPHOR-TIN

EXPERIMENT NO.	1	2	3	4	5	Average
Sulfide Method	96.30	96.38	96.34	96.39	96.37	96.36
Proposed Method	96.35	96.42	96.37	96.41	96.43	96.40

Although the foregoing data indicated that the proposed method possessed an accuracy comparable to that of the sulfide method it was deemed advisable to secure further confirmation of the probable tin content of the alloy. With this in view an electrolytic method was used in the final series of test experiments.

to check results obtained by the method proposed in this paper for the determination of tin.

PROCEDURE USED IN CHECKING PROPOSED METHOD FOR DETERMINING TIN

According to Smith,[1] tin may be deposited electrolytically from a stannous or stannic ammonium chloride solution containing an excess of a hot saturated solution of ammonium oxalate. Therefore, instead of titrating the hydrochloric acid solution of stannous chloride in the evolution flask it was cooled at this point and then neutralized with ammonium hydroxide. The precipitate which formed was dissolved with hydrochloric acid, and 100 cc. of a hot saturated solution of ammonium oxalate were added. This solution was then electrolyzed, using a rotating anode and a tared platinum dish (previously coated with silver or copper) as the cathode. A current of $N.D._{100}$ = 5 amperes and 9 volts was applied for one and one-half hours.

The results obtained by the procedure just described confirmed those given by both the sulfide method and the proposed method. These results are tabulated in Table V.

SOLUTIONS USED FOR DETERMINING TIN STANDARD POTASSIUM DICHROMATE SOLUTION—4.1248 g. of C. P. crystals dried at 105° were dissolved in water and the solution made up to one liter. The solution was standardized by means of pure ferrous ammonium sulfate: 1 cc. of this solution was found to be equivalent to 0.005 g. of tin.

INDICATOR—The potassium ferricyanide solution used for determining the end-point in the titration with the dichromate solution was prepared just prior to use. A crystal of potassium ferricyanide about the size of a pea was dissolved in about 75 cc. of distilled water. When a drop of this solution was mixed with a drop of ferric chloride only a light brown color was produced.

SOLUTIONS USED FOR DETERMINING PHOSPHORUS

Absorbing Solution of Potassium Permanganate: Two g. of the pure salt in one liter.

Ammonium Molybdate: This solution was prepared by one of the well-known standard procedures.[2]

Wash Solution of Acid Ammonium Sulfate: To one liter of water, 16 cc. of ammonium hydroxide (sp. gr. 0.90) and 25 cc. of sulfuric acid (sp. gr. 1.84) were added.

Standard N/10 Solution of Potassium Permanganate: 3.163 g. of C. P. potassium permanganate were dissolved in water and the solution made up to one liter. It was standardized by means of pure ferrous ammonium sulfate; 1 cc. of this solution was equivalent to 0.00008829 g. of phosphorus.

PROCEDURE FOR ANALYSIS OF ALLOY

Sawings were taken from the material to be analyzed. Any iron introduced by abrasion of the saw-blade was removed by drawing a magnet over the sawings spread in a thin layer. Sawings are to be preferred to drillings as the latter are quite coarse owing to the brittleness of the alloy.

A 0.5-g. sample of the alloy was put into the Florence flask. Any fine particles of the phosphor-tin adhering to the walls of the flask were rinsed down with a jet of water. The rubber stopper, through which the two tubes bent at right angles and the tap-funnel are inserted, were fitted tightly into the mouth of the Florence flask.

To each of the three absorption flasks assembled as a train, 90 cc. of the potassium permanganate solution and 10 cc. of nitric acid (sp. gr. 1.42) were added. The train was connected with the Florence flask with a short piece of rubber tubing. Carbon dioxide or illuminating gas was then directed through the system for 3 minutes to sweep out the air, and the inlet then closed with a pinchcock: 30 cc. of hydrochloric acid (sp. gr. 1.20) were transferred to the tap-funnel, the stopcock was opened and the hydrochloric acid allowed to run into the flask. The stopcock was immediately closed and heat applied to the flask. The boiling point should be reached in about 5 minutes and maintained until the alloy is completely decomposed. When the alloy was dissolved the Bunsen burner was removed and carbon dioxide or illuminating gas was again forced through the system for 3 minutes so that any traces of phosphine in the Florence flask would be swept into the permanganate solution. Without stopping the flow of gas the absorption train was disconnected from the Florence flask. The tin remains as stannous chloride in the Florence flask and the phosphorus is found as phosphoric acid in the absorption flasks.

One or two grams of ferric chloride which gave no test for ferrous iron were added immediately to the contents of the generating flask, and the solution was titrated at once with potassium dichromate, using potassium ferricyanide as an external indicator. By determining the amount of ferric iron reduced by the stannous chloride the amount of tin present was easily ascertained (1 cc. of the potassium dichromate solution as prepared was equivalent to 1 per cent of tin when a half-gram sample was used).

The contents of the three absorption flasks were then transferred to a 500 cc. Florence flask. The permanganate solution was boiled one minute. It was then removed from the hot plate and potassium nitrite was added in small portions until the excess permanganate was reduced and the solution was colorless. It was then boiled one minute to expel any nitrous acid that might be present since it acts as an interfering substance later on in the procedure.

The solution was removed from the hot plate and cooled to about 50° by placing in a cooling bath, after which it was made slightly alkaline with ammonium hydroxide. When the neutral point was reached, a heavy precipitate of manganese phosphate formed which served as an indicator at this point. This precipitate was just dissolved with nitric acid (sp. gr. 1.42) and 10 cc. added in excess. The solution was heated to a temperature of 85° and 50 cc. of filtered ammonium molybdate were added. The

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[1] Edgar F. Smith, "Electro-Analysis," **1911**, 171.

[2] Blair, "Chemical Analysis of Iron," **1912**, 997.

temperature must not exceed 85°, because of the possibility of molybdic acid being precipitated. The contents of the flask were vigorously stirred for 5 minutes. The yellow precipitate of ammonium phosphomolybdate was filtered off and washed with acid ammonium sulfate solution until 2 or 3 cc. of the wash water did not give a brown coloration on the addition of a drop of ammonium sulfide: 7 cc. of ammonium hydroxide of sp. gr. 0.90 and 15 cc. of water were poured into the flask in which the precipitate was formed, to dissolve any adhering precipitate: the solution was then poured on the precipitate in the filter. The filtrate containing the ammonium molybdate and ammonium phosphate was next prepared for the Jones reductor. The filter was washed with water until the filtrate had a volume of about 60 cc.: 10 cc. of sulfuric acid (sp. gr. 1.84) were added. (If a precipitate forms on the addition of the sulfuric acid, it should be redissolved with ammonium hydroxide and the same amount of sulfuric acid added a second time.)

The solution was then passed through a Jones reductor charged with amalgamated zinc. It was passed through a second time after the addition of 2 cc. more of sulfuric acid. This was followed with 200 cc. of water. The solution collected from the reductor was titrated at once with *N*/10 potassium permanganate.

TEST EXPERIMENTS

In order to show the relative accuracy of the proposed method, two different samples of phosphor-tin were used in making the following series of determinations of tin and phosphorus: Twelve different portions of Sample I were analyzed for phosphorus and tin, six by the recommended procedure and six by standard procedures described in the body of this paper. This series was then followed by a similar series of analyses in which Sample II was used.

Table V—Results of Analyses of Phosphor-Tin

		Percentages Tin Found		Percentages Phosphorus Found	
Sample No.	No.	Electrolytic Method	Proposed Volumetric Method	Cyanide Method	Proposed Evolution Method
I	1	96.32	96.38	2.97	3.03
	2	96.34	96.40	2.98	3.02
	3	96.38	96.35	2.98	2.99
	4	96.38	96.36	2.96	3.04
	5	96.36	96.40	2.99	3.01
	6	96.40	96.35	2.95	3.02
II	1	96.50	96.45	3.10	3.12
	2	96.46	96.52	3.07	3.11
	3	96.52	96.50	3.09	3.11
	4	96.44	96.48	3.06	3.10
	5	96.50	96.45	3.08	3.13
	6	96.48	96.50	3.07	3.12

SUMMARY

The need of a method formulated specifically for the analysis of the alloy, phosphor-tin, has been shown, and attention has been called to the fact that the related literature apparently does not contain such a method.

A volumetric method has been developed and is proposed in the foregoing discussion. The tests to which this method has been subjected indicate that it is not only easy of execution but that it is also rapid and accurate.

The method provides for the carrying out of the determinations in a train of flasks. The alloy is dissolved in hydrochloric acid in the first flask, from which all air is excluded by means of a current of illuminating gas or carbon dioxide. The tin dissolves as stannous chloride and the phosphorus is liberated as phosphine which is absorbed by solutions in the train of three flasks. The tin is titrated at once with an oxidizing solution. The phosphine is converted into phosphoric acid by the absorbing solutions from which the acid is precipitated as phosphomolybdate which is then reduced in a reductor and finally titrated.

The time required for making the two determinations, after the sample is weighed, need not exceed 45 minutes. Other methods, adapted to phosphor-tin analysis and giving the same order of accuracy, required hours for their execution.

The proposed method provides for the detection of impurities in the alloy. It is, therefore, as well adapted for careful assay work as for "control" analyses.

As a result of the study of various absorbing agents it has been shown that potassium permanganate solutions are satisfactory absorbents for phosphine. And furthermore, it appears that the oxidizing and absorbing power of the reagent is increased in a marked degree by the addition of nitric acid.

Carnegie Hall of Chemistry
Allegheny College
Meadville, Pennsylvania

THE ELECTROMETRIC TITRATION OF ZINC[1]

By F. Russell v. Bichowsky

Of all the troubles to which the zinc chemist is heir, none perhaps is more vexatious than the trickiness and general unreliability of even the better methods of zinc analysis. Mr. Keith's[2] report discloses, for instance, that analyses of the same sample made by some of the best known zinc chemists of the country, all using the same method of analysis (the "Beale"), varied among themselves by as much as 4 per cent of the total zinc content. Of course such variations are far beyond the errors of the personal equation and can be accounted for only as being due either to loss of zinc in the processes leading to the final titration (such as for example might be due to absorption on the Fe-Mn precipitate), or to the interference of the various substances with the end-point of the ferrocyanide titration. Of these two sources of error the last is undoubtedly the most serious, as, at least in the author's experience, the loss of zinc in any of the better known commercial methods is very slight.

Assume, therefore, that we have carried through the preliminary more or less complete separation of SiO_2, Fe, Mn, Cd, etc., according to any of the regular methods. We will then have left a solution containing besides all our zinc (hoffentlich) more or less free chlorine, bromine, nitric acid, hydrochloric acid, manganese, copper, lead, iron and cadmium, and no one knows what else, all in amounts depending enormously on even the slightest variation in our procedure. Our problem is now to find the best way of determining

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[1] Presented at the *Symposium on the Chemistry and Metallurgy of Zinc*, 54th Meeting American Chemical Society, Kansas City, April 10 to 14, 1917.

[2] Keith, "Zinc Ore Analysis," Leadville Publishing and Printing Co., Leadville, Colo.

the zinc in this mixture. Unfortunately, there is, with the possible exception of Hg_2SCN, no specific reagent which will precipitate zinc without at the same time precipitating traces at least of most of the other elements. The best substitute for a specific reagent is undoubtedly potassium ferrocyanide, but unfortunately this reagent, besides precipitating almost any of the heavy metals, has the added disadvantage that it is a reducing agent, and thus will react with whatever bromine, chlorine, or nitric acid is present, and so will give too high results unless extreme care is taken in the preliminary elimination of all oxidizing agents, heavy metals and, especially, manganese. Besides this the end-point of the ordinary ferrocyanide titration obtained either by the use of uranium, molybdenum or iron, is always uncertain, especially in the poor light of the ordinary laboratory, and, moreover, the whole titration is tedious and uncertain, due to the large blank correction necessary. It is thus, perhaps, no wonder that zinc analyses vary so conspicuously among themselves.[1]

The most rational way to correct this state of affairs is not so much to improve the methods of preparation of the zinc solution (though undoubtedly precautions, such as the addition of SO_2, should be taken to remove any free oxidizing agents) as to change the conditions of the ferrocyanide precipitation by carrying it out in solutions containing from 10 to 20 per cent hydrochloric acid. In these solutions zinc-ferrocyanide is only slightly soluble, but lead, manganese, iron and copper are very soluble and even cadmium is fairly soluble. At this concentration of acid, however, the ordinary indicators are comparatively useless, as would be indeed almost any chemical indicator. For this reason electrometric methods similar to those used with so much success in the analysis of iron, vanadium, chromium, etc., immediately suggest themselves:

First, because outside of their being almost the only ones possible under these conditions, they are, under any conditions, the most convenient and accurate methods available. One does not have to depend on the time-consuming and always inaccurate outside indicator, nor on the inaccurate and, in my experience, unreliable internal indicator, such as ferrous iron. One simply notes the point of sudden deflection of a galvanometer needle, a point which can be determined, but with little care, to a fraction of a drop.

Second, this method is also the quickest and most certain. There is no danger of overrunning and the titration can be finished in less than one-third the time of the older methods.

Third, the electrometric end-point is not affected by the color of the solution, by the lighting of the room, by the amount of acid or neutral salts present, and, in fact, at least in 10 per cent acid, is not affected by iron, lead, manganese (up to 50 mg.), or small amounts of copper and cadmium, all of which (except lead) have marked effects, especially on the uranium end-point.

The method as finally worked out requires no complicated apparatus: a cheap galvanometer, a slide wire resistant, some sort of standard electrode such as a calomel electrode (made from a bottle, a cork and a piece of bent tubing, a sodium chloride solution, and a few g. of mercury and calomel), a piece of platinum wire (for the platinum electrode), some copper wire for connections, and a couple of dry cells complete the needed extra equipment, though a voltmeter is a great convenience. If this apparatus seems too complicated to make, it can be purchased already made up for the determination of chromium, iron, vanadium, etc. A detailed description of the apparatus, the theory of it and the general methods of using it will be found in the *Journal of the American Chemical Society* in several places.[1]

Having the apparatus set up, the operation is simplicity itself. The two electrodes are dipped in the beaker containing the solution to be analyzed (which solution should be hot, should contain at least 10 per cent strong hydrochloric acid, but no free oxidizing agents nor more than a trace of cadmium); by adjusting the slider of the resistance the pointer of the galvanometer should be brought to zero and the titration begun. As the ferrocyanide is slowly added with constant stirring the pointer will swing slowly until the end-point is almost reached; at the end-point the direction of the swing will be reversed. From this point on the ferrocyanide is added drop by drop until one drop causes a sudden very large but permanent deflection. This is the end-point. Or, if one has a voltmeter in the set-up, one can simply set the slider so that the voltmeter reads 0.24 volt and titrate until the galvanometer indicates zero current. This end-point is accurate, even with 20 per cent (strong) hydrochloric acid, to 0.1 cc. of the usual ferrocyanide solution.

Using this method, the preliminary operations for the purification of the ore lose their customary importance. Almost any of the best known methods can be used. My own method is to dissolve the ore in the minimum strong hydrochloric acid, add a pinch of $KClO_3$, add quickly 100 cc. dilute NH_4OH, make up to 250 cc., filter an aliquot, and acidify. Add 10 per cent excess hydrochloric acid, add SO_2 until saturated, boil out the SO_2 with heat and a stream of air (or add test lead) and titrate. In ordinarily pure ores simple solution in strong hydrochloric acid and the addition of the test lead and aluminum works very nicely. Of course, if extreme accuracy is desired or if the ore contains large amounts of cadmium, some standard method such as Breyer's[2] is to be preferred for the preliminary separations. The electrometric end-point should, however, replace Breyer's or the uranium end-points under all conditions as much more accurate and convenient, especially for small traces of zinc (where one has zinc solutions free from cadmium, manganese, etc., to analyze smaller acid concentrations should be employed).

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[1] My attention was called to the need of an electrometric method for the titration of zinc by Mr. Hyman Storth at the Bureau of Standards.

[1] Hildebrand, *J. Am. Chem. Soc.*, **35** (1913), 847; Forbes and Bartlett, *Ibid.*, **35** (1913), 1527; Kelley and Conant, *Ibid.*, **38** (1916), 341.

[2] Breyer, *Orig. Commun. 8th Int. Cong. of Applied Chem.*, **25**, 7.

While no attempt to give a complete table of experimental results is made here, certain more significant results have been collected in Tables I and II:

TABLE I

Accuracy of titrations with ferrocyanide of total zinc in solutions containing various known quantities of Zn^{++}, Fe^{++}, Mn^{++}, Pb^{++}, Cu^{++} and HCl using the electrometric end-point (E. M. F.), the ferrous ferrocyanide end-point of Breyer (iron), the usual end-point with uranium nitrate as an outside indicator (uranium).

	CONTENT OF SOLUTION IN MG.					MG. OF ZINC FOUND		
HCl (a)	Zn	Mn	Fe	Cu	Pb	E. M. F. N	Iron	Uranium
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
15	0.0	0.0	0.0	0.0	0.0	0.05	...	1.0
2	0.5	0.0	0.0	0.0	0.0	0.50	0.34	0.95
3	5.0	0.0	0.0	0.0	0.0	5.01	4.98	5.45
5	50.0	0.0	0.0	0.0	0.0	50.01	50.08	50.57
2	0.5	0.5	0.0	0.0	0.0	0.59	0.71	1.55
10	0.5	0.5	0.0	0.0	0.0	0.49	0.6*	0.7*
10	5.0	0.5	0.0	0.0	0.0	4.98	5.1*	5.3*
10	5.0	5.0	0.0	0.0	0.0	5.01	...	...
10	5.0	50.0	0.0	0.0	0.0	5.05	0.0	5.7*
10	5.0	0.0	5.0	0.0	0.0	5.09	5.11	*
15	5.0	5.0	5.0	5.0	0.0	5.08	*	*
15	5.0	5.0	5.0	5.0	5.0	5.10	*	*

* End-point very uncertain.
(*a*) HCl content in cc. 35 per cent HCl per 100 cc. of solution.

TABLE II

Content of the same Cd-free ore by different methods showing results in per cent zinc and approximate time taken (ore contained 7 per cent Mn).

METHOD	Reference	Per cent Zinc	Time
Breyer standard	*Loc. cit.* E. M. F. end-point	31.04	12 hrs.
"Beale"	*Loc. cit.*	31.74	8 hrs.
New Jersey Zinc Co.	*See below*	31.12	6 hrs.
American Zinc, Lead Smelting Co.	*See below*	31.32	5 hrs.
Author's long method	*See text*	31.10	4 hrs.
Author's short method	*See text*	31.6	2 hrs.

NEW JERSEY ZINC CO. METHOD (*Courtesy of Mr. G. C. Stone*)—Weigh out 0.5 g. of ore within 0.5 milligram. Transfer to a 250-cc. beaker. Add 15 cc. of hydrochloric acid (sp. gr. 1.20), cover and boil until all is in solution that can be dissolved by hydrochloric acid alone. If there are insoluble particles remaining, other than silica, and always with green sulfide ores, add 5 cc. of nitric acid (sp. gr. 1.42).

In case the hydrochloric acid treatment alone is necessary, boil down to about 5 cc. and remove from the hot plate.

If nitric acid is used, evaporate to dryness, leaving on the hot plate until there is no odor of acid or until a little ammonia in a beaker produces no cloud of ammonium salts when held near the assay. Remove from the plate, cool, add 5 cc. of hydrochloric acid (sp. gr. 1.20) and boil until all is in solution. If brown or green fumes are evolved it indicates that the evaporation to dryness was incomplete. In this case evaporate to dryness again with the hydrochloric acid, cool, add 5 cc. of strong hydrochloric acid as before and boil.

From this point on, the treatment is the same whether nitric acid was used in solution or not.

Wash off both sides of the cover glass and the sides of the beaker with a fine jet of cold water, using as little as possible. Be particularly careful to keep the volume down in the cases of ores carrying manganese. Add 5 g. of ammonium chloride crystals. Add saturated bromine water according to the manganese contents of the ores.

If there is no manganese, add 2 or 3 cc. to insure complete oxidation of the iron. If this is neglected the iron is incompletely precipitated by the subsequent treatment with ammonia. With small amounts of manganese, 15 to 25 cc. of bromine water are needed.

When the manganese is high, the volume of the ore solution must be less than 10 cc. Shake the bottle of bromine water violently with an excess of bromine and quickly pour 25 cc. into the ore solution before the suspended free bromine can settle.

Allow time for the ammonium chloride to dissolve completely, then add 15 cc. of ammonia water.

In the case of the high manganese ores great care is necessary on account of the excess of bromine. If the ammonia water is poured in carelessly the reaction with the free bromine which has settled to the bottom of the beaker is very violent, and may cause loss of solution or injury to the hands of the operator. The best method of manipulation is to incline the beaker at an angle, keeping the cover glass in place and to pour the ammonia water in slowly through the lip of the beaker, allowing it to run down the side of the beaker and float as a separate layer on the ore solution. Now place the beaker on a warm (not hot) part of the plate, on two or three layers of asbestos paper if there is no gradation of heat on the plate. The ammonia will then gradually diffuse into the solution, precipitating the iron and manganese completely without any violent reaction.

Bring the contents of the beaker to a boil. Allow to boil for one minute to insure the coagulation of the precipitate. Do not allow to boil longer than one minute, or there is danger of re-solution of a part of the manganese. Wash the cover glass off with a hot jet of the wash solution when removing it from the beaker.

Filter while hot, allowing all the solution to run through the filter before commencing washing. Transfer as much of the precipitate as possible to the filter, using the jet to loosen it from the beaker, and carefully wash the entire inner surface of the beaker. Then wash the filter and precipitate thoroughly three times more with a jet of the hot wash solution, containing 50 g. of ammonium chloride and 50 cc. of ammonia water per liter.

Wash the precipitate from the filter into the beaker in which the original precipitation was carried out with a small quantity of the wash solution: add a few drops of hydrochloric acid to redissolve the iron and manganese. With high manganese ores it will be found necessary to heat to boiling before the manganese will dissolve. With these same ores, if the volume is over 10 cc. concentrate by evaporation to less than 10 cc. Precipitate the iron and manganese again as with the first precipitation except that it is unnecessary to use ammonium chloride crystals. The chloride contained in the solution used for washing the precipitate from the paper is sufficient for the small amount of zinc remaining. The bromine may also be omitted on the second precipitation, with ores free from manganese, as the iron is all in the ferric condition. Where manganese is present, bromine must be used in the second precipitation, observing all the precautions necessary with the first. Ten cc. of ammonia water are sufficient on account of the smaller quantity of free acid. Filter and wash beaker, filter and precipitate as before, combining the filtrates from the two precipitations. With ores very high in iron, manganese or alumina, at least one additional separation of these constituents must be made by the same method. Experience must be relied on to determine exactly how many separations are necessary with any given ore.

Heat the solution to boiling and test, if from a manganiferous ore, by adding a few cc. of bromine water. If more manganese comes down, throw the solution away and start a new assay, as the manganese cannot be separated quantitatively from so large a volume of solution without the expenditure of more time than would be required for a new assay. If no manganese comes down, boil gently for a few minutes to eliminate bromine.

Add hot water until the volume is a little less than 250 cc. Add 4 drops of an ammonium sulfide solution made by saturating with hydrogen sulfide a mixture of 2 parts ammonium water (sp. gr. 0.90) and 1 part water by volume. If there is much copper, more sulfide may be necessary.

Add hydrochloric acid cautiously until the precipitated zinc sulfide just dissolves, then add 10 cc. excess of the 1.20 sp. gr. acid and titrate with standard potassium ferrocyanide solution (containing 44 grams per liter), using 10 per cent uranium nitrate solution as an external indicator, on a paraffin-coated spot plate. The solution must be violently stirred while titrating.

AMERICAN ZINC, LEAD SMELTING CO. METHOD (*Courtesy of Dr. John Johnston*)—Weigh 0.5 gram into a flask of 200 cc. capacity. Add 10 cc. hydrochloric acid and boil nearly to dryness. Add 5 cc. nitric acid and take to dryness. Overheating or baking should be avoided. The best time to remove the flask from the hot plate is when it is stained red all over. Care should be taken to avoid spurting. Cool, and add 10 cc. hydrochloric acid and boil to half its volume. Add 50 cc. hot water and 10 cc. ammonia. If manganese is present add 20 cc. saturated solution of bromine water. Boil and filter through 11 cm. filter, which should leave about one-third of the funnel exposed, into a beaker 375 cc. capacity. Wash three times with hot water. Redissolve precipitate into original flask with hot dilute hydrochloric acid, 1 part acid to 3 parts water. Wash well with hot water. Add 10 cc. ammonia as before, and the same amount of bromine water, if manganese is present. Boil and filter through the same paper into the same beaker. Wash three times with hot water. Make the filtrate neutral with hydrochloric acid, using litmus paper as indicator, and add 6 cc. hydrochloric acid in excess. If copper is present add 20 g. test lead and boil until all copper is thrown down. Heat to 70° C. and titrate with a standard solution of potassium ferrocyanide. Run the solution in rather slowly and stir constantly. A slight color change will be noted in the beaker when the precipitation is almost complete. This should not be ignored, since if it does not occur there is a possibility of error. Use a 1 per cent solution of ammonium molybdate for outside indicator.

GEOPHYSICAL LABORATORY, WASHINGTON, D. C.

A NEW METHOD OF SEPARATING ZINC FROM CADMIUM AND THE LATTER'S DETERMINATION IODOMETRICALLY[1]

By ERIC JOHN ERICSON

Further research in the development of the writer's method for complete spelter analysis has demonstrated the possibility of separating the bulk of the remaining zinc from cadmium by crystallization as zinc sulfate. The exact composition of the latter has not yet been ascertained. In one analysis of the crystals only 15.50 per cent was found, while the formula $ZnSO_4.7H_2O$ calls for 22.73 per cent.

Although a small trace of cadmium is entrained in the zinc sulfate or zinc-ammonium sulfate, for technical purposes only one crystallization is deemed necessary, in view of the large sample (19.2 grams) of spelter taken originally.

The procedure in spelter analysis is as follows:

Referring to earlier publications[2] for details for removing and determining lead, the filtrate from the latter is boiled until nearly neutral and a white precipitate appears. Then add 50 cc. dilute sulfuric acid (1:3), boil down to about 80 to 100 cc. volume and allow to stand over night. In the morning the bulk of the zinc will be found crystallized out as sulfate. Decant the clear solution and wash three times with cold water, allowing each washing to drain. Dilute the filtrate to 200 cc. and pass in hydrogen sulfide until all cadmium is precipitated: usually 15 to 20 minutes is sufficient with a fairly rapid evolution of gas. Allow the precipitated cadmium sulfide several hours time to settle before filtering off. Determine cadmium by any of the methods mentioned in the above-mentioned papers.

Cadmium may also be determined iodometrically according to von Berg's[1] method (modified), by transferring to an Erlenmeyer flask, adding about 125 cc. of distilled water, a measured excess of $N/10$ iodine solution and then 30 to 50 cc. dilute hydrochloric acid. Shake and titrate with sodium hyposulfite until slight iodine excess is indicated; then add a few cc. starch solution and finish titration until disappearance of the blue color. The difference is due to cadmium: 1 cc. $N/10$ iodine solution = 0.00562 gram cadmium.

The new zinc-cadmium separation has been applied successfully to zinc ores also. Before its introduction it was a difficult matter to detect and determine accurately the small amounts of cadmium usually occurring in these ores.

PROCEDURE—Dissolve 5 grams ore in nitric or hydrochloric acid, according to the nature of the ore, fume off with 20 cc. sulfuric acid, add water, boil and filter. To the filtrate add an excess of ammonia, boil and precipitate iron and alumina. Dilute to 500 cc., filter and pipette off an aliquot portion representing 3 or 4 grams; evaporate to low bulk and until small white precipitate appears; then add sulfuric acid and boil down to 80–100 cc. Remove from hot plate and allow zinc to crystallize out. Decant solution and precipitate cadmium as previously directed. Redissolve on filter with hot hydrochloric acid, neutralize filtrate with ammonia and add about 10 grams trichloracetic acid: dilute to 200 cc. and precipitate once more with hydrogen sulfide. A pure cadmium sulfide is now obtained, which may be determined by any of the methods previously described, but the most accurate is undoubtedly the gravimetric determination as sulfate.

I think that the above separation can be applied in brass analysis in detecting small amounts of cadmium. Recently, attention was called to the difficulty of detecting and determining small amounts of cadmium,[2] and the need of more accurate methods. This applies particularly to methods of separation, since the actual determination does not offer any unusual difficulties.

C. H. LORD CORPORATION
1910 CALUMET AVE., CHICAGO

THE CHEMICAL EXAMINATION OF NATURAL BRINES[3]

By O. R. SWEENEY AND JAMES R. WITHROW

The proper analysis of natural brines has always been important. They are used by chemical manufacturers to make comparisons with a view to reaching decisions as to prospective yields of salt, bromine and other products. The war-time elevation of the price of bromine from 30 cents to as high as $6.50 per lb., as well as a similar elevation of other products derived from natural brine, has given rise to search for additional sources of these products and a careful scrutiny of many of the brines encountered in oil, gas and coal

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[1] Presented at the *Symposium on the Chemistry and Metallurgy of Zinc*, 54th Meeting American Chemical Society, Kansas City, April 10 to 14, 1917.

[2] *Eighth Intern. Congr. Appl. Chem.*, 1, 183, and THIS JOURNAL, 5 (1913), 401.

[1] Sutton's "Volumetric Analysis," 10th Ed., p. 172.

[2] *Eng. Mining J.*, Mar. 3, 1917, p. 392.

[3] Read before the Industrial Division, Kansas City Meeting of the American Chemical Society, April 12, 1917.

development, and hitherto wasted. As a result many analyses have been made in the last three years as a basis for manufacturing consideration. Some of these were made in the laboratories of manufacturers themselves and some by consulting chemists. Analyses from both sources have come into the hands of the authors as the basis for report upon prospective manufacturing values. We, also, have had occasion to make check or confirmatory analyses.

It early became evident that there was no standard or uniform procedure being followed by the different workers. To this fact may be due a large part of the non-agrèement encountered from time to time, though inexperience with this type of analysis is also a factor. Few chemists, even water analysts, are experienced in such a type of work as bromine determination in brine. This may be shown best by citing a report to its president by the laboratory of the chemical company. The letter from the president of one chemical company to another stated:

"The analysis of the two samples of brine which you sent us has been completed and it was some job. The results are as follows:

	WELL A	WELL B
Depth	1200 ft.	1200 ft.
Diameter	8 in.	4 in.
Specific Gravity of Brine	1.071	1.070
CaO	0.69 per cent	0.68 per cent
Br	0.42	0.22
Halides (as sodium halide)	9.21	9.26
Iodine	None	None"

These samples were from a brine whose composition was well known to us. Furthermore, they were on the same property. It will be noticed that they are of the same depth and also the same specific gravity, CaO content, and halide content. Nevertheless, they are reported of different bromine content—a divergence of nearly 100 per cent. Such a divergence would be a very important matter industrially, for one of these wells would give nearly twice the yield of bromine for the same turnover of salt and calcium chloride and at the same fuel cost as the other well. Considering the difficulty of bromine determination, by the usual methods, the infrequency of demand for it and the concordance of all other determinations on these two brines one is tempted to suspect the accuracy of the bromine determinations. As a matter of fact even the lower value is over twice the bromine content of the field in question as shown by both analyses by various chemists and experience of *all* the plants operating on this particular brine.

Such situations give rise to controversy and discredit analytical chemistry. An examination of the literature for a basis for standard or uniform procedure disclosed no exact one which could be recommended. The procedures described for the examination of "mineral water" are not applicable directly. Certain modifications which our experience has introduced are recorded here. Not all of the procedures described have been exhaustively studied as yet. The purpose of this paper is to make a beginning with the hope that others, who have had experience in this work, will contribute their experiences, or will criticize these procedures. In this way a procedure may be developed which may be accepted as standard. The object is to develop a method which will meet the needs of the manufacturing chemist rather than a method of exhaustive analysis. Brevity and speed of manipulation, with reasonable accuracy, are, therefore, the requirements.

ANALYTICAL PROCEDURES

SAMPLE—The sample when pumped from the earth will generally be clear, but on standing it becomes turbid due to the separation of a brown precipitate. This precipitate is mainly iron, but may contain silica and alumina. It is probably caused by oxidation and hydrolysis of ferrous bicarbonate. Generally by the time the sample will have reached the chemist the iron will have separated. The scheme of agitation to suspend the deposit uniformly through the liquid before taking a part for analysis is inaccurate, as experiments have shown. Furthermore, the specific gravity is changed and this will affect the entire percentage composition. Consideration of this point has led us to conclude that the best procedure would be to collect a sample of about one liter, allow it to oxidize and settle completely, determine the amount of deposit, and then make analyses on the filtered sample. The analysis would not be exactly that of the original brine, but the difference will be very slight, and, since this procedure gives more nearly the thing that the manufacturer wants, it is best to proceed in this manner.

DEPOSIT ON STANDING (AERATION)—The sample of about one liter, which will usually contain some deposit, is allowed to stand, with occasional shaking, and removing of the stopper, for two or three days, or until deposition is complete and the precipitate settles well. The height of the liquid is carefully marked on the outside of the bottle, and the entire sample is then filtered, rejecting the first 100 cc. The precipitate is well washed, ashed and ignited to constant weight. The bottle is dried and the amount of water which it contained to the mark is determined. With these data the grams per liter are calculated, using the specific gravity of the filtered sample, and the result recorded as "*Deposit on Aeration.*" The errors will not be large if percentages be calculated, using this figure. Since in the industries all natural brines are exposed to air and allowed to settle before they are further treated, this value is just what is wanted by the manufacturer. Further examination of the precipitate is not necessary. It is a question whether or not it would be fair to assume the precipitate to be iron oxide (Fe_2O_3) and calculate it to, and report it as, ferrous bicarbonate.

SPECIFIC GRAVITY—The specific gravity is obtained by the Westphal balance, and is taken at 15° C., although perhaps it would be better to use 20° C., since this is more nearly the average temperature. The specific gravity of the fresh brine will be different from that of the sample through which the precipitate is suspended, and this in turn will be different from the filtered sample. On one brine, for example, the specific gravity of the filtered sample was 1.2307, while that of the sample in which the precipitate was suspended was 1.2342. If the chemist could take the specific gravity of the clear brine as soon as pumped from the well it would no doubt be best, from the point of view of the original brine but this will generally be impractical. Even if the specific gravity could be obtained on the fresh brine there would be some volume change after the precipitate settled and a small error would be introduced when taking a filtered sample for later analyses. For these reasons, and also because the manufacturer is interested in the *settled* brine, it is believed that the best procedure is to use the filtered, aerated brine, and to determine the specific gravity with a Westphal balance at 15° C(?). This value is used in calculating percentages.

TOTAL SOLIDS—Many chemists omit this determination because of its questionable accuracy, but its value in calculating total water content for "evaporation fuel" comparisons makes it important. Brines rich in $CaCl_2$ require a rather high temperature, above 160° C., to expel the water completely. At this temperature the magnesium and calcium salts lose a part of their acid constituents, and a wide range of values will be obtained, depending on the temperature and duration of heating. The total solids can be calculated from the complete analysis, but this value should be checked by the total solids as obtained by evaporation. This point is being studied in this laboratory at the present time, and it is hoped that by a suitable arrangement the volatilized acids may be collected, titrated and then be added to the residual weight of the total solids. It may be that a weighed excess of some base may be added to retain the acid which is otherwise volatilized. The constituents likely to volatilize are chlorine, bromine, iodine (slight), sulfur trioxide and carbon dioxide (slight). The total solids are determined in the filtered sample, using 25-cc. portions and should be reported as *Total Solids by Evaporation.* This gives the manufacturer a basis for a reasonable estimation of the water to be evaporated in working the brine.

SILICA—A 25-cc. portion of the filtered brine is acidulated with 5 cc. of concentrated hydrochloric acid and is evaporated to dryness. It is then dried at 120° C., or higher if necessary, for an hour. Five cc. of hydrochloric acid are then added, the vessel is warmed, 20 cc. of water are added, and, after warming, the whole is filtered and washed free from chlorides. The filtrate is evaporated and treated as just described, and the operation is repeated on the second filtrate. The combined precipitates are ignited in a platinum crucible, and weighed. The residue is treated with sulfuric and hydrofluoric acids. The loss in weight is reported as *silica*, and the residue is added to the iron and alumina.

IRON AND ALUMINUM—The filtrate and washing, which should contain 5 cc. of concentrated hydrochloric acid, are treated with a few drops of nitric acid, boiled a few minutes, and then made alkaline with ammonia. It is then boiled until all the ammonia is expelled, and after standing, is filtered, washed and ignited in the crucible from which the silica was expelled. The residue is reported as *Iron and Aluminum Oxides.* A separation of the iron and aluminum is not necessary. The results should be reported separately from the iron which separated on aeration. It should be remembered that the iron, aluminum and silica are not in solution as oxides, but as salts. For this reason there will be a slight difference between the total solids on evaporation and the calculated total solids.

Much time is saved if the iron, alumina and silica are all precipitated together, with ammonia. The amount of silica remaining in solution is very small. These constituents have no commercial value, and need not be reported separately. It should be remembered in this latter case that ammonium chloride must be added.

CALCIUM—The filtrate from the iron and aluminum is diluted to 250 cc. and 25 cc. are taken; this is diluted to 150 cc., heated to boiling and a hot 10 per cent solution of ammonium oxalate is added in excess. After standing for some time (15 minutes), it is filtered and washed with hot water. The precipitate is dissolved in warm dilute hydrochloric acid, a little ammonium oxalate solution added, and ammonia then slowly added to complete the precipitation. The precipitate is filtered out, after standing one-half hour, and is ignited to the oxide and weighed, or is dissolved in dilute sulfuric acid and titrated with permanganate. Our experience seemed to show that it was not necessary to allow the precipitate to stand 12 hours as is recommended in some of the books on water analysis. The calcium should be reported as sulfate and chloride.

MAGNESIUM—The combined filtrates and washings from the calcium are acidified with hydrochloric acid, a large excess of sodium hydrogen phosphate is added, and then ammonium hydroxide with constant stirring until the liquid smells of ammonia. Ten cc. of strong ammonia are added in excess and the whole is allowed to stand 12 hours. The precipitate is filtered out, washed with dilute ammonia and redissolved in hydrochloric acid (1 : 5). The volume is made up to 75 cc., a little sodium hydrogen phosphate added, and then ammonia, drop by drop, with constant stirring until the solution smells strongly. After 4 hours the magnesium is filtered out on an alundum or Gooch crucible, washed with 2 per cent ammonia water, dried and ignited to $Mg_2P_2O_7$. If an alundum crucible is used it should be heated within a glazed crucible. The magnesium should be calculated to the bromide and chloride.

The above procedure gave very good results. In the usual procedure the filtrate from calcium is evaporated to dryness, and the ammonium salts are volatilized. This requires great care, and much time, and did not give any better results than the procedure described. The reprecipitation must be carried out, even on very small amounts. There seems to be good authority, however, for the evaporation and ignition which we have omitted, and the point should be investigated further.[1]

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[1] In the discussion of this paper in the Industrial Division it was suggested that the speedier method for magnesium, used in Low's "Technical Methods of Ore Analysis," p. 159, might be of service here but we have not yet investigated this method, or the method of precipitation with sodium hydroxide sometimes used on traces of magnesium.

BARIUM AND STRONTIUM—If no sulfates are present, barium and strontium must be looked for. Indeed a case is on record where barium, lead and sulfuric acid were present simultaneously in a natural mineral water.[1] From work in progress in this laboratory it seems, however, that in the case of brines, where very little CO_2 is present, that sulfates preclude the presence of barium or strontium. Barium oxalate is sparingly soluble, and a strontium oxalate is insoluble in water. When these metals are present they will be partially precipitated along with the calcium. This point seems to have been overlooked hitherto. In cases where the barium and strontium amount to 0.2 per cent the error introduced cannot be neglected. The magnesium results may also be affected. It may be possible to precipitate the barium and strontium with ammonium sulfate before precipitating the calcium, but no work has been done on this phase. The fact that the barium is not completely precipitated by ammonium oxalate makes it impossible to apply a correction to the calcium precipitate. The determination of the barium and strontium in the calcium precipitate is too time-consuming to be practical for the ordinary technical analysis. When the barium and strontium content is small the error can be ignored. The procedure used was identical with the one described in the *Department of Agriculture Bull.*, 91, "Mineral Waters of the United States," by J. K. Haywood and B. H. Smith; a simpler method has not yet been found.

AMMONIA—Traces of ammonia have been reported in some brines, but the amount is generally so small as to be of no commercial importance. It may be, however, that its significance is greater than we now know, especially in brines for electrolysis. The suggestion has been made by cell operators that nitrogen chloride may be connected with the explosions which occur from time to time in electrolytic chlorine apparatus. If this should prove true the determination of ammonia will be important.

SULFURIC ACID, SODIUM AND POTASSIUM—Fifty cc. of the filtrate from the iron and alumina are diluted to 100 cc. and treated, while boiling hot, with 10 per cent $BaCl_2$ solution, adding it slowly and with constant stirring. The $BaSO_4$ is filtered off, the paper burned off in a porcelain crucible, and the precipitate dissolved in a few cc. of warm, concentrated sulfuric acid. The solution is now carefully poured into 250 cc. of water, and, after standing some time, is filtered, washed and ignited. It should be reported as calcium sulfate. This method of freeing the $BaSO_4$ from iron and other absorbed matter is very effective. It is essentially that taught for decades at the John Harrison Laboratory, University of Pennsylvania, Philadelphia.

The filtrate from the sulfuric acid is used for sodium and potassium. From this point, the procedure we have been using is the *same* as described in "Mineral Waters in the United States," *Department of Agriculture Bull.*, 91, *Loc. cit.* It is difficult, however, to determine small amounts of potassium in the presence of large amounts of sodium chloride, and it is believed that some procedure[1] should be used which will precipitate most of the sodium first.

CHLORINE—The brine should be tested with phenolphthalein. It will usually be neutral, but if it is not, it should be made so with $NaHSO_4$ solution. 10 cc. of the filtered sample are diluted to a liter and 10 cc. used for titration. This is diluted to 200 cc., 2 cc. of K_2CrO_4 solution are added and the mixture is titrated to the end-point. Na_2CrO_4 would probably be a satisfactory indicator here but we have not yet proved this to be true. Take an amount of standard sodium chloride solution equivalent to the amount of silver nitrate used, dilute to 200 cc. and titrate as before. The difference represents the amount necessary to affect the indicator and should be subtracted. This procedure is accurate enough since *the chlorine is used only as a check on the analytical work.* The bromine value must be deducted.

BROMINE—The colorimetric procedure, as given for ordinary waters, is not usable with brines. Experiments showed that after repeated extraction with 90 per cent alcohol the residue still contained bromine. The distillation methods are time-consuming and not very easily manipulated. For these reasons a colorimetric method was developed.

Procedure—100 cc. of the brine are made alkaline with Na_2CO_3 and are evaporated to dryness. It is then taken up in water and filtered into a 250-cc. flask. It is made distinctly acid with H_2SO_4 and is diluted to the mark: 25 cc. are pipetted into a 50-cc. Nessler tube and chlorine is added until the maximum color has developed: 10 cc. of carbon tetrachloride are then added, and the mixture is shaken and compared with a set of standards made up from NaBr solution in the same way. By this rough check the approximate amount of bromine will be discovered, and a set of standard solutions are then prepared which are very close above and below the unknown solution. Again 25 cc. are taken, chlorine water is added to a maximum color and the same amount is added to the standards; the sample is then shaken with 10 cc. of CCl_4 and poured into a wet filter; when the water has drained off the filter should be punctured and the liquid caught in a 25-cc. Nessler tube (this is best done in a darkened room but darkness is not essential). If a sample does not exactly match the standard the colors can be compared by diluting with CCl_4; or since the operation is so simple, a new set of standards can be made up, and then a new determination made. If a test shows that all bromine was not extracted by 10 cc. of CCl_4 a second extraction should be made. This is generally not necessary.

Traces of iodine which are present in most brines will not interfere. The iodine need not be reported.

It is difficult to appreciate the unreliability of published statements regarding the occurrence of bromine. For instance, although the State of Michigan reports, and the most reliable information states, that Midland, Mich., brine contains 0.1 per cent of bromine, yet the

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[1] Carles, *Ann. chim. anal.*, **1902**, 91.

[1] Professor C. W. Foulk, of the Division of Analytical Chemistry of the Ohio State University laboratory, is now investigating this matter.

most exhaustive German work on bromine[1] states on page 3 that the brine from Midland, Ohio, *sic.*, contains 4.18 per cent magnesium bromide which is equivalent to 3.63 per cent bromine, or 36 times stronger than those who operate on it claim it to be.

REPORTING RESULTS

The results should be reported in such a manner as to give the manufacturer the thing which he wants. The reporting of the constituents as ions, while strictly scientific, is of no value to the manufacturer. All of the sodium and potassium should be calculated to chloride. Since the $CaSO_4$ separates on the copper tubes in the evaporators the H_2SO_4 should be reported as calcium sulfate. The bromine should be calculated as magnesium bromide, since it has long been so considered in the trade; but bromine as free bromine should also be reported. The residual calcium and all the magnesium are calculated to chlorides since they go on the market as such. Strontium and barium should be given as chlorides. The silicon should be reported as the oxide since the form in which it is combined is not known. Iron and aluminum are reported together as oxides since their separation is too time-consuming. The residue which separates on standing should also be given. Results are preferably reported in percentages though some manufacturers are accustomed to *grams per liter*. The specific gravity and temperature should always be reported; for this reason also, a standard temperature should be used so that results would be really comparable.

When the positive and negative ions are calculated to compounds they should nearly satisfy each other. It should be borne in mind, however, that the iron, aluminum and silicon are given as oxides, and not as salts, in which form they usually occur in the brine. There may also be small amounts of CO_2 and iodine which are not included. If, however, the check is not reasonably close, it indicates an error, or else some undetermined constituent is present.

As an illustration of the extremes in composition which the analyst must expect to meet, two examples from Ohio brines will serve.

BRINE SOURCE:	Eastern Ohio Coal Mine	Southern Ohio Driven Well
Specific gravity	1.034	1.180
Baumé equivalent	4.8°	22.2°
Sodium chloride	3.26 per cent	12.08 per cent
Magnesium bromide	0.007	0.124
Bromine	0.006	0.107
Calcium chloride	1.63	10.81
Magnesium chloride	0.05	2.61
Calcium sulfate	0.001	0.03
Iron and aluminum oxides	0.21	0.04
Silica	0.12	0.002
Residue on evaporation	5.23	29.00

While this work considers primarily the commercial natural brines, the same procedure will doubtless apply to the analysis of artificial brines, such as used in soda ash manufacture and in electrolytic cells, although the amounts of calcium and magnesium will be much less in these solutions.

LABORATORY OF INDUSTRIAL CHEMISTRY
OHIO STATE UNIVERSITY, COLUMBUS

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[1] "Monographien ü. angewandte Electrochemie. Über d. elektrolytische Gewinnung von Brom," by Max Schlötter.

SEASONAL DISTRIBUTION OF SOIL AND FECAL STRAINS OF THE COLON-AEROGENES GROUP IN SURFACE WATERS

By MYRTLE GREENFIELD AND W. N. SKOURUP

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When this work was started, it was with the object of determining the variation of the organisms of the colon-aerogenes group in the surface water supplies of Kansas, during wet and dry weather, and their response to treatment.

Three supplies on the Verdigris River were chosen—Cherryvale, Independence and Coffeyville, and two on the Neosho River—Humboldt and Chanute. All the towns have rapid sand filters and coagulate with alum. Independence uses lime in addition, a part of the time. Cherryvale pumps the water from the Verdigris River into a storage basin, holding 1,288,000 gallons, which is about five days' supply. From this it flows by gravity to the city four miles distant. Table I shows the pollution at the raw water intakes of the cities in question.

TABLE I—STATISTICS OF SEWAGE POLLUTION AT RAW WATER INTAKES

	Raw Water Polluted by Sewage from				
CITY	Town	Distant Miles	Population	Connections	Sewage Purification
Cherryvale	Neodesha	20	3,011	876	None
Independence	Neodesha	24	3,011	876	None
Coffeyville	Independence[1]	24	12,144	2600	Septic tank & Contact bed
	& Cherryvale[2]	30	4,235	800	
Humboldt	Iola	8	7,866	2350	Septic tank
Chanute	Iola &	16	7,866	2350	Septic tank
	Humboldt	8	2,131	150	Septic tank

[1] Contact bed for one-third of the sewage.
[2] Contact bed in poor condition.

METHOD OF ISOLATION

A portable laboratory was set up at Independence and the collection of all samples was personally supervised. Samples were iced and delivered to the laboratory a few hours after collection. Upon receipt at the laboratory, they were plated in standard agar and incubated 24 hrs. at 37°. Various dilutions were planted at the same time in lactose peptone bile. Streaks from the positive fermentation tubes were made on Endo plates. Three coli-like colonies were picked from each Endo plate and grown on an agar slant. These slants were sent to the main laboratory and purified again by streaking on Endo plates and picking a characteristic colony. From these, transfers were made to lactose, dextrose, saccharose, and dulcite broth tubes and to the di-potassium acid-phosphate media of Clark & Lubs.[1] The broth tubes were incubated 48 hrs. at 37° and the di-potassium-acid-phosphate tubes 72 hrs. at 37°. One-half the latter was treated with methyl red to indicate the H^+ ion concentration and the other half with 10 per cent KOH to obtain the Voges-Proskauer reaction. All cultures that did not ferment lactose and dextrose were discarded.

It was demonstrated by Rogers, Clark and Evans[2] that organisms of the colon-aerogenes group occurring on grains may be differentiated from those of fecal origin by the gas ratio. Clark & Lubs[2] showed that there is a complete correlation between the gas ratio and the H^+ ion concentration, the fecal strains in their media being characterized by a high H^+ion

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[1] *J. Infec. Dis.*, **17** (1915), 137.

[2] *Ibid.*, p. 160.

TABLE II—DISTRIBUTION OF THE ORGANISMS ISOLATED (RESULTS IN PERCENTAGES OF TOTAL BACILLI)

City	Water	No. of Cultures	Period	*B. Communior*		*B. Communis*		*B. Acidi-Lactici*		*B. Aerogenes*		Total Percentages	
				Fecal	Soil	Fecal	Soil	Fecal	Soil	Fecal	Soil	Fecal	Soil
INDEPENDENCE.............	Raw	24	Rain	8.34	54.7	4.17	...	...	12.5	...	20.8	12.4	87.6
		8	Drouth	75	...	...	...	12.5	...	...	12.5	87.5	12.5
	Treated	30	Rain	11.1	25.9	...	11.1	5.42	11.14	14.19	19.5	33.17	66.8
		25	Drouth	32	20	4	...	16	4	8	16	60	40
	Tap	54	Rain	4.26	49.23	4.26	2.13	8.52	10.53	8.52	12.55	25.45	74.6
		47	Drouth	44.8	4.26	8.51	...	14.8	...	...	25.5	70.1	29.9
CHANUTE..................	Raw	27	Rain	31.8	8.8	17.2	...	...	12.05	...	50.05	50	50
		23	Drouth	39.1	8.7	8.7	...	4.35	...	4.35	34.8	56.5	43.5
	Treated	15	Rain	60	26.5	...	...	...	...	...	13.4	59.9	40.1
		24	Drouth	29.1	16.65	...	...	16.65	...	...	37.5	45.7	54.3
	Tap	30	Rain	14.8	36.5	12.75	4.25	14.8	4.25	...	12.75	39.2	60.8
		58	Drouth	34.5	1.73	3.46	...	18.9	...	6.9	34.5	63.8	36.2
CHERRYVALE...............	Raw	30	Rain	29	16.3	6.68	...	9.6	9.6	16.3	12.8	63.4	36.6
		21	Drouth	47.7	14.3	9.52	...	4.76	...	...	23.8	61.8	38.2
	Treated	32	Rain	13.3	30	3.36	...	5.66	13.33	3.36	30	26.6	73.4
		23	Drouth	13.1	26.1	4.35	...	13.1	...	4.35	39.1	37.8	65.2
	Tap	33	Rain	21.2	45.4	...	3.3	...	3.3	...	27.3	21.2	78.8
		28	Drouth	46.4	3.57	10.7	...	7.14	...	10.7	21.4	78.6	21.4
HUMBOLDT.................	Raw	30	Rain	3.8	19.5	...	3.8	23	11.55	11.55	26.8	23.8	76.2
		20	Drouth	35	5	15	...	10	...	...	35	60	40
	Treated	30	Rain	10.7	55.2	6.9	...	...	6.9	...	20.7	17.2	82.8
		23	Drouth	17.4	26.1	8.7	...	8.7	...	8.7	30.4	43.5	56.5
	Tap	53	Rain	16.63	20.82	12.5	4.47	14.5	18.53	...	12.53	38.1	61.9
		23	Drouth	61.7	...	...	...	...	...	...	38.3	66.7	33.3
COFFEYVILLE..............	Raw	15	Rain	...?	33.3	...	...	13.3	20	...	33.3	13.3	86.7
		21	Drouth	14.6	14.6	19.1	...	19.1	...	...	33.3	52.4	47.6
	Treated	15	Rain	13.3	13.3	...	20	26.6	...	...	26.6	40.1	59.9
		21	Drouth	50	...	8.32	...	4.16	...	4.16	33.3	66.7	33.3
	Tap	9	Rain	11.1	55.5	...	...	...	...	5.55	27.8	16.68	83.3
		30	Drouth	33.3	13.3	16.7	...	16.7	...	33.3	13.3	73.3	26.7
PARSONS..................	Raw	15	Drouth	73.4	...	...	...	...	...	...	26.6	73.2	26.8
	Treated	15	Drouth	53.4	...	13.3	...	13.3	...	6.66	13.3	86.7	13.3
	Tap	28	Drouth	28.6	14.3	7.14	...	10.2	...	...	39.3	46.4	53.6
SUMMARY Supplies Averaged	Raw	117	Rain	16.25	25.68	5.98	0.85	9.4	12.82	6.83	25.64	37.61	62.4
		108	Drouth	42.6	8.32	10.2	...	8.32	...	0.92	29.6	62	38
	Treated	116	Rain	18.1	32.68	2.58	5.17	5.17	7.75	4.32	22.8	31.8	68.2
		134	Drouth	31.9	15.67	5.98	...	11.95	0.735	5.22	29.2	54.5	45.5
	Tap	193	Rain	13.49	38.82	7.26	3.14	9.32	8.82	2.59	18.12	33.62	67.4
		194	Drouth	38.7	6.18	8.25	...	14.82	...	4.15	2.78	65.8	34.2

TABLE III—CORRELATION BETWEEN THE NUMBER OF ORGANISMS OF THE COLON-AEROGENES GROUP PER CC. AND NUMBER OF ORGANISMS GROWN ON AGAR AT 37° C. IN 24 HOURS

City	Water	No. of Samples	Period	% Positive for Organisms of the Colon-Aerogenes Group	Organisms of the Colon-Aerogenes Group per Cc.			Per cent of the Organisms as		Bacteria per Cc. on Agar at 37° C. in 24 Hours		
				Aerogenes Group	Max.	Min.	Av.	Fecal	Soil	Max.	Min.	Av.
CHERRYVALE....	Raw	10	Rain	100	66.0	10.0	30.1	63.4	36.6	80,000	6,000	34,700
		8	Drouth	100	66.0	1.0	26.3	61.8	38.2	3,400	1,200	2,200
	Treated	11	Rain	100	10.0	0.4	6.8	26.6	73.4	2,900	230	930
		8	Drouth	100	6.6	0.1	2.4	34.8	65.2	340	160	280
	Tap	12	Rain	100	0.6	0.1	0.4	21.2	78.8	160	40	85
		17	Drouth	58.8	0.4	0.1	0.2	78.6	21.4	140	9	65
INDEPENDENCE..	Raw	8	Rain	100	66.0	10	35.0	12.4	87.6	240,000	9,000	91,000
		3	Drouth	100	100.0	1	30.0	87.5	12.5	6,000	3,700	4,800
	Treated	10	Rain	100	6.6	0.6	2.4	33.17	66.83	1,800	260	700
		8	Drouth	100	33.0	0.2	3.1	60.0	40.0	3,900	260	1,280
	Tap	21	Rain	90.5	0.8	0.1	0.4	25.45	84.6	210	6	55
		20	Drouth	75	1.0	0.1	0.2	70.0	29.9	250	11	95.4
COFFEYVILLE....	Raw	5	Rain	100	66.0	6.6	29.7	13.3	86.7	170,000	60,000	88,000
		8	Drouth	100	100.0	1	28.4	52.4	47.6	4,100	1,900	2,170
	Treated	5	Rain	100	33.0	0.4	8.1	40.1	59.9	830	370	550
		8	Drouth	100	33.0	0.2	5.2	66.7	33.3	1,100	140	480
	Tap	8	Rain	87.5	4.0	0.1	0.3	16.68	83.3	140	25	75
		16	Drouth	75	0.8	0.1	0.4	73.3	26.7	310	9	67
HUMBOLDT......	Raw	10	Rain	100	100.0	6.6	37.5	23.8	76.2	52,000	8,000	24,600
		9	Drouth	100	66.0	1	25.4	60.0	40.0	8,600	700	2,400
	Treated	10	Rain	100	10.0	0.2	5.4	17.2	82.8	2,700	330	1,040
		9	Drouth	100	10.0	0.1	1.8	43.5	56.5	300	85	220
	Tap	20	Rain	95	1.0	0.1	0.64	38.1	61.9	140	35	70
		16	Drouth	6.4	0.4	0.1	0.19	66.7	33.3	65	5	35.3
CHANUTE.......	Raw	9	Rain	100	66.0	6.6	26.4	50.0	50.0	30,000	7,000	17,000
		8	Drouth	100	100.0	1	24.8	56.5	43.5	3,700	1,200	2,300
	Treated	9	Rain	77.8	0.6	0.6	0.6	59.9	40.1	410	110	240
		8	Drouth	100	6.6	0.2	0.7	45.7	54.3	700	180	540
	Tap	32	Rain	56.2	0.6	0.1	0.25	39.2	60.8	95	3	22
		32	Drouth	46.8	0.6	0.1	0.18	63.8	36.2	230	7	36.2
SUMMARY Supplies Averaged	Raw	42	Rain	100	100	6.6	31.74	37.61	62.39	240,000	6,000	50,800
		34	Drouth	100	100	0.1	27.48	62.0	38	15,200	700	2,460
	Treated	45	Rain	95.1	33	0.2	4.86	31.8	68.2	2,900	110	260
		37	Drouth	97.2	33	0.1	3.27	54.5	45.5	4,200	110	470
	Tap	93	Rain	80.7	1	0.1	0.39	33.6	67.38	210	3	61.4
		92	Drouth	59.5	1	0.1	0.21	65.8	34.2	250	5	43.4

concentration, the cultures from grains by a low H^+ ion concentration. The difference in H^+ concentration is easily recognized with methyl red as an indicator—being bright red with a H^+ ion concentration of 1×10^{-5} and changing to clear yellow with a H^+ ion concentration of 1×10^{-6}. The work of Max Levine,[1] Florence Hulton,[2] and one of us,[3] indicates that there is a complete correlation between the Voges-Proskauer reaction and the alkaline methyl-red reaction. The work on the 862 cultures consid-

[1] *J. Infec. Dis.*, **18** (1916), 358.

[2] *Ibid.*, **19** (1916), 606.

[3] *Ibid.*, **19** (1916), 647.

ered in this paper confirms the correlation. It is the opinion of the writers that for a rapid determination, the Voges-Proskauer is more delicate than the methyl-red determination. From this point, cultures that have a high H^+ ion concentration, in the media of Clark and Lubs,[1] and are Voges-Proskauer negative will be spoken of as fecal strains and those that have a low H^+ ion concentration and are Voges-Proskauer positive, as soil strains.

The first set of samples was taken daily from June 16 to June 27, 1916. From June 5 to 27, the rainfall was 9.47 inches. In the tables this period is called "Rain." The second set of samples was taken daily from August 14 to 22, 1916. During that time the rainfall was 0.64 inch. In the table this period is called "Drouth."

CHARACTERISTICS AND DISTRIBUTION OF CULTURES

The distribution of the cultures among MacConkey's[2] four principal groups and their division into soil and fecal strains during wet and dry weather is shown in Table II. The summary indicates that, during rainy weather, a slightly higher percentage of the cultures from raw water were fecal strains than of the cultures from treated or tap water; this checks with previous work done by one of us.[3] During dry weather there was a slightly higher percentage of fecal strains in the tap water than in the raw water. These differences are so slight that no cognizance should be taken of either. There seems to be no difference between soil and fecal strains of organisms of the colon-aerogenes group from surface water supplies in their resistance to treatment, nor is there a difference between cultures of the four principal groups of MacConkey isolated from surface water supplies, and their resistance to treatment, coagulating with alum and filtering through a rapid sand filter being the treatment.

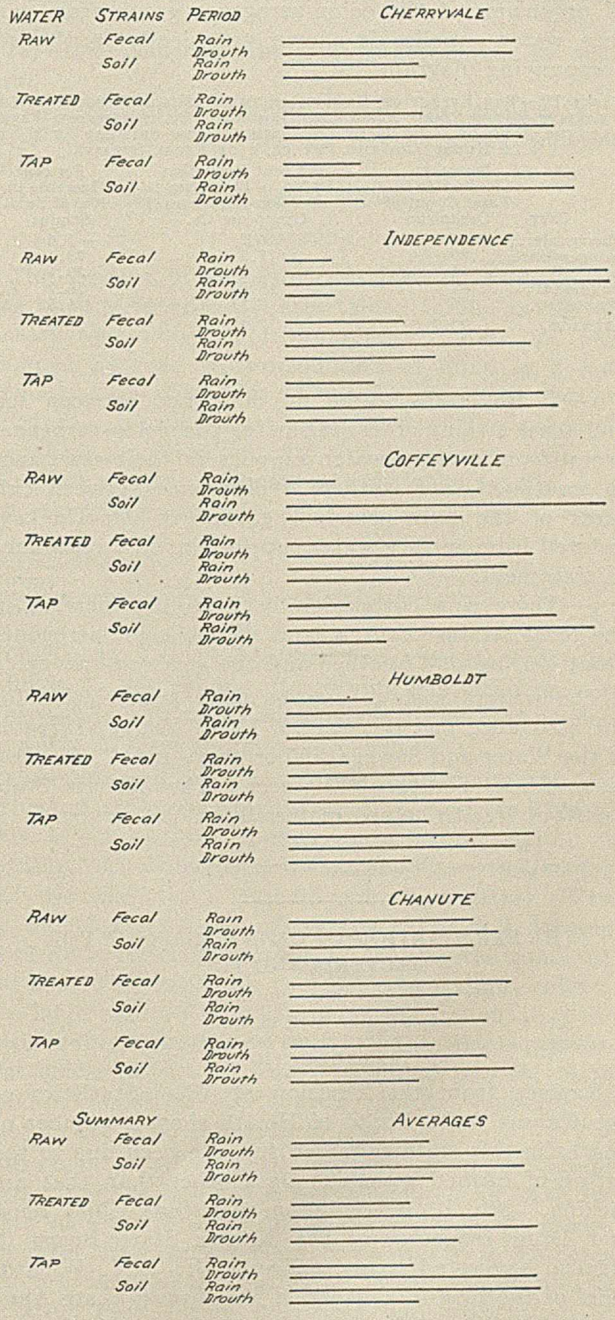
CORRELATION

Table III correlates the number of organisms of the colon-aerogenes group per cc. per cent of soil and of fecal strains, and the number of organisms grown on agar at 37° in 24 hrs. As was to be expected, dry weather conditions decreased the average count on agar and the average number of organisms of the colon-aerogenes group per cc. in the raw water. This is further shown in Table IV.

During rain or high-water periods, the greater per cent of the organisms of the colon-aerogenes group from raw water belongs to the soil strain. During dry weather, the greater per cent of the organisms of the colon-aerogenes group from raw water belongs to the fecal strain: this was noticeably true if the raw water was subject to sewage pollution.

The sanitary survey showed that the raw water at Humboldt had by far the more sewage pollution. The higher increase in the per cent of fecal strains of organisms of the colon-aerogenes group during dry weather correlates with this.

The raw water at Cherryvale shows 1.6 per cent decrease in fecal strains during dry weather. The raw water from which this data was taken was collected at the Cherryvale plant, that is, after the 5 days' storage. This would undoubtedly account for the slight decrease in the number of fecal strains during dry weather.



THE EFFECT OF DROUTH ON THE PERCENTAGES OF SOIL + FECAL STRAINS

The raw water at Independence shows 75.1 per cent increase in fecal strains during dry weather. The sanitary survey offers no explanation for this decided increase. This per cent is not of much value, due to the small number of samples collected during dry weather at Independence.

The Cherryvale per cent increase of fecal strains during dry weather is that expected from the sanitary survey.

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[1] *Loc. cit.*

[2] Prescott and Winslow, "Elements of Water Bact.," **1913**, 149.

[3] *Loc. cit.*

L. A. Rogers[1] collected samples above and below a source of pollution on a stream. Above the pollution, the greater percentage of the organisms of the colon-aerogenes group were soil strains, while below the pollution, the greater percentage were fecal strains.

The variation in per cent of soil and fecal strains of organisms of the colon-aerogenes group from surface water supplies is shown graphically in the accompanying diagram.

TABLE IV—THE EFFECT OF DROUTH ON THE AVERAGE NUMBER OF ORGANISMS OF THE COLON-AEROGENES GROUP PER CC. IN SURFACE WATER ON THE AVERAGE NUMBER OF ORGANISMS GROWN ON AGAR AT 37° IN 24 HOURS AND THE PER CENT OF FECAL STRAINS

CITY	Per cent Reduction in Total Count of Organisms	Per cent Reduction in No. of Organism of Colon-Aerogenes Group per Cc.	Per cent Increase in No. of Fecal Strains
Cherryvale......	88	6.7	—1.6
Independence....	89	7.7	75.1
Coffeyville.......	95	2.2	39.1
Humboldt.......	82	19.0	36.2
Chanute........	76	0.31	6.5
AVERAGE........	90.7	7.2	24.39

CONCLUSIONS

1—There seems to be no difference between soil and fecal strains of organisms of the colon-aerogenes group from surface water supplies in their resistance to treatment, nor is there a difference between cultures of the four principal groups of MacConkey, isolated from surface water supplies in their resistance to treatment.

2—There is a correlation between the increase in the fecal strains of organisms of the colon-aerogenes group during dry weather and the sanitary survey.

The writers wish to express their appreciation for the assistance and criticism of C. C. Young, Director of the Water and Sewage Laboratory, and C. A. Haskins, State Sanitary Engineer. The Kansas State Board of Health helped materially in the survey.

WATER AND SEWAGE LABORATORY
STATE BOARD OF HEALTH, LAWRENCE, KANSAS

THE EXAMINATION OF CANNED SALMON FOR BACTERIA AND TIN[2]

By L. D. BUSHNELL AND C. A. A. UTT

Received April 18, 1917

INTRODUCTION

Reports from the Division of Vital Statistics of the Kansas State Board of Health show a number of deaths in this state supposed to have been due to the eating of canned salmon. Data other than that are lacking. Mr. L. A. Congdon, Assistant Chief Food and Drug Inspector of the Kansas State Board of Health, suggested to us, through Dr. J. T. Willard, chief of the food laboratory of the Kansas State Agricultural College, the bacteriological examination of samples of canned salmon, with the view particularly of noting the presence of paratyphoid-like organisms. The state inspectors had sent in fifty-two samples of the various brands to the food laboratory for examination for tin. These were also used for bacteriological examination.

The samples ranged from the most expensive to the cheapest grades on the market and included forty-four different brands from twenty-six concerns.

The samples were obtained on the open market and we have no knowledge of the method of preparation.

All cans were in good condition and all held a vacuum, no swelled ends being found. All samples were offered for sale and were in a merchantable condition.

The fish was firm and of good flavor and odor in all cases. In some of the cheaper brands the meat was somewhat dry, light-colored and contained rather small amounts of oil, but these were not sold as a high-grade product.

The following commercial grades were examined:

GRADE:	Sockeye	Red and Red Alaska	Chinook	Cohoe	Pink	Chum
Samples......	8	24	2	2	10	6

BACTERIOLOGICAL EXAMINATION

The tops of the cans were carefully cleaned and covered with a 5 per cent solution of carbolic acid for about 10 minutes. This was then poured off and denatured alcohol added for about 5 minutes. The excess of alcohol was removed and the remainder burned. The top was then thoroughly flamed with a Bunsen burner flame. The can was tilted several times, flamed again and opened with a previously boiled and flamed can opener, with as little agitation as possible. The floors, table top and hands of the operator were carefully washed with carbolic acid solution before the operation began.

Standard meat juice agar plates, dextrose fermentation tubes, bile lactose fermentation tubes, deep agar shakes, milk with and without calcium carbonate added, Endo agar plates and the condensation water on agar slants were inoculated. The material for these inoculations was taken from as near the bottom of the can as possible.

To the Petri dishes were added 2 cc., 1 cc. and 0.1 cc. of salmon liquor, about 0.5 cc. was added to the milk and fermentation tubes, a large loopful was added to the deep agar and to the condensation water of the agar slants. A part of the milk was heated to 85° C. for 10 minutes and cooled quickly in cold water. The agar shakes were also cooled quickly by plunging them into cold water as soon as inoculated. A large loopful of material was smeared upon a clean slide, fixed in absolute alcohol for 15 minutes and stained in dilute methylene blue for 30 min. All cultures were incubated at 37° C. for 48 hours and careful examination made. They were placed at room temperature for 5 days and again examined.

As a check upon the methods, the increase in temperature of the contents of the can due to the flaming was noted but it was not influenced. The media was checked against *B. typhosus; B. enteritides; B. coli communis; B. paratyphosus*, A and B; *B. tetani; B. botulinus; B. anthracis symptomatici;* and three cultures of *B. Welchii*, all of which grew readily.

As a check on the ability of organisms to grow in the salmon, thirteen samples taken at random were placed in test-tubes and inoculated with the first five

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[1] "The Viability of Different Types of the Colon-Group in Water," L. A. Rogers. *J. of Bact.* (Abstract), 1, 83.

[2] Published by permission of W. M. Jardine, Dean of the Exp. Station, and J. T. Willard, Chief of the Food Laboratory, Kansas State Agricultural College, and S. J. Crumbine, Sec. Kansas State Board of Health.

organisms mentioned above. These were incubated at 37° C. for 48 hrs. and examined microscopically for increase in number of organisms. In every case all grew very readily.

The results obtained from the bacteriological investigations were entirely negative. In a very few cases a mold developed on the plates and in one case a spore-forming organism developed. In no case did we find growth in fermentation tubes or deep agar or milk cultures. Stained slides were made from fermentation tubes in many cases, but no organisms were seen. No organisms were ever noted upon slides made directly from the cans.

About 50 g. of this material from 10 different brands were fed to white rats. They ate most of this in two days; after that they were kept for three weeks on ordinary feed, but failed to develop symptoms of any sort.

EXAMINATION FOR TIN

Twenty of the above samples were analyzed for their tin content. These included the best and cheapest brands on the market and were picked at random without any reference to their quality.

Tin determinations were made according to *Journal of Official Association of Agricultural Chemists*, Vol. II, No. 2, page 173.

All tin determinations ran below 50 mg. per kilogram, showing they were well below the tolerance of 300 mg. per kilogram.

CONCLUSIONS

Canned salmon as found on the market in this state is sterile. It does not contain organisms of *B. paratyphoid* type, and does not contain aërobic or anaerobic spore formers. This is to be expected if the packers process their goods according to advertising material which they publish.

In one case they claim to heat the cans to 220° F. for 50 mins., followed by a heating to 240° F. for 60 mins. on a second day. This is necessary to protect the packers against loss of goods after it has been put on the market.

From the fact that this material will readily support the growth of pathogenic and other microörganisms, great care should be exercised in handling it after removal from the can.

Kansas State Agricultural College
Manhattan, Kansas

THE INDUSTRIAL CHEMISTRY OF CHICLE AND CHEWING GUM[1]

By Frederic Dannerth

The official estimate of chicle imported and converted in the United States in 1916 approximated 7,347,000 lbs., equivalent to at least 30,000,000 lbs. of chewing gum. An industry which has assumed these proportions may well be said to exert an influence on our national life. The retail selling price of the finished article is at the rate of $1.30 per lb., from which some idea of the financial strength of the industry may be obtained.

In view of this it has become necessary to establish standard methods for the purchase of the Crude Block Chicle. As it arrives at the port of New York or New Orleans it contains a considerable amount of moisture—usually about 40 per cent. The factors which influence the purchaser may be summarized as follows:

(1)—The moisture the gum is estimated to contain.

(2)—The shrinkage when cleaned (dirt and bark).

(3)—The chewing quality of the clean purified chicle.

(4)—The color of the crude chicle.

MOISTURE

The amount of moisture contained in crude chicle was until very recently ascertained in the course of factory operations. For example, a 100-lb. lot was chopped up into $^{1}/_{2}$-in. crumbs and dried in a hot air chamber. The loss of weight was recorded as moisture. A somewhat better idea of the value of the chicle can be obtained by proximate analysis. Thus one sample of Yucatan chicle when examined in the laboratory showed:

	Per cent		Per cent
Acetone-soluble matter (resins)	40.0	Sand and foreign matter	2.3
Gutta (and carbohydrates)	17.4	Water	35.0
Proteins	0.6	Mineral matter (ash)	4.7

Obviously, if this chicle costs $0.55 per lb., crude, its value is $0.877 per lb. after drying and cleaning. In other words, 100 lbs. of crude chicle in this case yielded 62.7 lbs. of dried and cleaned chicle.

SAMPLING—In sampling crude chicle after it has arrived at the factory a 1-lb. sample is cut from a block. This is cut up into $^{1}/_{2}$-in. crumbs just as rapidly as possible. The crumbs are transferred to a "Lightning Jar" provided with a glass lid and rubber gasket. The jar should be not more than two-thirds full, leaving room for a thorough mixing by shaking the contents, and should be kept in a cool place to prevent caking. The large amount of moisture usually present in crude chicle makes it imperative to handle the sample rapidly. Wet chicle cannot be stored in sealed jars for more than one week as molds grow rapidly, especially if the jars are kept in the dark.

METHOD I—A weighed portion of crude chicle (about 5 g.) is dried in a well-ventilated air bath for 5 hrs. at a temperature not above 50° C. As a container for the sample, a glass dish 2 or 3 in. in diameter with a ground glass lid is used. If the temperature in the oven rises, fusion will occur and evaporation of the water will be retarded. If the oven is poorly ventilated the drying will take longer. It is complete when two consecutive weighings vary not more than 0.5 per cent.

METHOD II—The moisture in crude chicle may be determined simultaneously with the determination of resins. Boiling acetone will remove resins and water from the sample by extraction. The extract in the flask is dried at 105° C. and the residue in the thimble is dried in a similar manner. The sum of these weights subtracted from the weight of the

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[1] Presented at the 54th Meeting of the American Chemical Society, Kansas City, April 10 to 14, 1917.

original sample will represent water. This method has given very satisfactory results in practice.

NOTE—If wet chicle is heated to 105° C. in an oven, a certain amount of mosture is driven off, the chicle fuses and becomes "tacky" and if this product is chewed it will be found to be quite rubbery. At such temperatures the gum undergoes a chemical change as is seen by its solubility in acetone and in alcohol. For these reasons the usual methods of determining water by heating in an air bath at 105° C. are not applied in the analysis of chicle. As soon as an attempt is made to chop up a block and granulate the chicle, the gum commences to lose water so that due consideration must also be given this fact.

VISCOSITY

The valuation of crude chicle by means of a viscosity test has, so far as I know, not been attempted by other investigators. This is probably due to the fact that it is very difficult to prepare a fluid mixture which would not settle out. The results here presented have been obtained by means of over 200 determinations and it is believed that the method is of practical value. The solvents used experimentally for suspending the chicle included xylol, benzol, toluol, turpentine and kerosene. Kerosene (boiling point above 140° C.) was finally chosen, as the loss by evaporation is negligible. Before proceeding with the test, commercial chicle must be dried for 12 hrs. in a vacuum at a temperature not exceeding 70° C.

METHOD—20 g. of the dry chicle are weighed off accurately to tenths of a g. and placed in a wire basket fitted in size for a "Joint Rubber Committee" extraction apparatus.[1] In the flask are placed 75 cc. of kerosene. The wire basket is made of 100-mesh wire gauze so that it retains the gritty and fibrous matter with which commercial chicle is contaminated. The weight of the residue in the basket will give some idea of the percentage of foreign substances in the crude chicle.

The liquid thus obtained by suspending strained chicle in kerosene is poured into a 100 cc. graduated cylinder. Fresh kerosene is now poured into the cylinder so that the total volume will have a concentration of 20 g. of strained chicle in a total of 100 cc. of liquid. After cooling the liquid to 20° C. it is introduced into the small tank of a Stormer viscosimeter.[2] The lower portion of the capsule of the viscosimeter is removed and filled with shot so that the total weight of this lower portion of the capsule together with the shot is exactly 20 g. As a matter of convenience the records of viscosity may be kept in terms of *Revolutions per minute.* The weight is allowed to fall for a definite number of seconds, taking care that the total length of cord is never unwound. The upper surface of the rotating cylinder in the viscosimeter should be adjusted in such a position as to be on a level with the upper edge of the projecting bracket in the tank which holds the test liquid.

Mr. Charles Kernahan, of this laboratory, who has assisted me in many of these determinations, reports that benzol appears to be a desirable medium for suspending the chicle in the viscosity test. It has the advantage that chicle may be boiled in it without exceeding a temperature of 81° C., thus precluding decomposition of the gum. The precaution which should be observed in the use of benzol is that the test should be carried out in a room having a temperature not much above 20° C., as there will otherwise be a considerable loss of solvent by evaporation.

ACETONE-SOLUBLE MATTER

The extraction of rubber and related gums with boiling acetone is carried out principally for the purpose of determining the percentage of "resins" in the material. In fact many analysts use these terms synonymously. The peculiar chewing properties of chicle are due to the presence of these resins so that a determination of their amounts and characters would seem to be of paramount importance to the industry. An idea of the resin content of the principal minor gums may be obtained from the following approximate percentages: Pontianak, 75; chicle, 60; gutta percha, 50; balata, 40; guayule, 20. One of the principal properties of the resin which affects the chewing quality of the gum is its melting point so that this should be determined in most cases.

METHOD—If the acetone extraction is carried out without regard to the moisture content of the chicle, the material is granulated so that it will pass through a wire screen of $^1/_8$-in. mesh. Five grams of the material are accurately weighed out and placed in a folded filter fitted for a Soxhlet siphon cup. The apparatus used is the Soxhlet extractor of the Joint Rubber Committee.[1] Acetone having a boiling point not higher than 65° C. is used and the extraction is continued for 5 hours. The acetone in the flask may be evaporated by placing the flask on a hot plate or it may be distilled off and the flask then dried to constant weight in the oven at a temperature not above 105° C. It is finally cooled in a desiccator and weighed. The residue is dried at 85° C. in the oven. The sum of the extract and the residue is now subtracted from the weight of the original sample. The difference is the moisture in the sample. If the acetone solution in the flask is allowed to cool before it is distilled off, it will be noticed that a large part of the resins has separated out in the form of a wax-like incrustation. After all the acetone in the flask is expelled and the temperature reaches 105° C. the residual resins appear amber-colored and quite clear. These resins are brittle at room temperature. The residue of gutta on the filter should be dried at temperatures not above 85° C., as it otherwise readily carbonizes. This is apparently due to the low "ignition temperature" of this gutta.

In 30 samples of chicle from Mexico, the resin content varied from 59.0 to 63.3 per cent with a grand average of 60.8 per cent based on the dry chicle. Twelve specimens of dried chicle which had an aver-

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[1] THIS JOURNAL, 9 (1917), 310.

[2] Seaton, Probeck and Sawyer, THIS JOURNAL, 9 (1917), 35, have presented much interesting data on the viscosity of varnishes and the limitations of the various viscosimeters.

[1] *Loc. cit.*

age resin content of 61.8 per cent were tested for viscosity according to the method previously described. The results showed an average of 276 revolutions per minute. Twelve other specimens which were examined showed an average resin content of 60.0 per cent and an average of 284 revolutions per minute. The rule then would seem to be that the R. P. M. is inversely proportional to the resin content, or rather that the viscosity is directly proportional to the resin content. This was in fact found to be the case for the particular conditions under which these determinations were carried out.

PROTEINS—The peculiar character of vegetable proteins, their complex chemical constitution and the fact that they do not crystallize all have combined to retard the investigation of this constituent. Spence has given considerable attention to these bodies so far as they occur in the rubbers prepared from Hevea, Funtumia and Ficus.

In a recent paper Spence and Kratz[1] have proposed a method for the determination of proteins in washed and dried rubber and it is planned by the present author to adapt this method, if possible, to the estimation of proteins in chicle.[2]

CARBOHYDRATES—Previous investigators have suggested that the sugars contained in chicle may be related to hexa-hydroxy-hexa-methylene. The monomethyl derivative of this sugar has a melting point of 192° C. and is found in the latex of *Hevea brasiliensis*. Plantation crepe Hevea rubber contains from 2.0 to 3.0 per cent of this substance. An investigation on the sugar content of various chicles is now in progress at this laboratory. A paper on this subject was published by Pickles and Whitfield[3] as early as 1911.

MINERAL MATTER

This determination is carried out with a sample of one gram, and in any case not more than two grams of dry chicle. An asbestos shield is used and a hole inserted so that the crucible bottom is exposed to the flame. At first a low flame is used so that the organic matter can volatilize without catching fire. After all the carbon has been burnt off, the crucible is dried and weighed in the usual manner. Of 25 specimens examined, the lowest value obtained was 3.9 per cent and the highest was 5.95 per cent of ash. The grand average was 4.53 per cent of ash.

It will be noted that this figure is much higher than that usually given for the ash content of washed and dried rubber. The highest values recorded for rubber are 1.0 per cent for *Funtumia*.

FERMENTATION OF CRUDE CHICLE

Mention should be made of the influence of fungi on crude chicle. These low forms of plant life do not attack the gum if it is kept in dry air, but if a small amount of moisture is present, the molds begin to flourish. Their nourishment is derived from the proteids, resins, and sugar which the gum contains. This results in a discoloration of the chicle, turning it pink or light buff in color, but it is not materially altered thereby. On the other hand, certain species of *Actinomyces* which occur in garden earth and canals are capable of assimilating the chicle-hydrocarbon with the result that its properties are so modified as to alter its chewing quality very decidedly. The principal varieties thus far recognized are *A. elastica* and *A. fustus*. The fermentation of chicle is also induced by the presence of uncoagulated milk in the pores of the block. In fact a piece of crude wet chicle, if chewed, will be found to taste quite acid.

INDUSTRIAL RESEARCH

The methods of the chewing gum industry have up to the present time been based largely on experience, but there is a distinct tendency toward a scientific study of the technical problems which arise. Some of these problems have already been successfully attacked and solved while others are still in a state of investigation. A review of these will be of value to those interested in these gums:

1—How can brittleness in the finished chewing gum be prevented?

2—How can the absorption of moisture by the finished gum be prevented?

3—What properties are most desired in a substitute for chicle?

4—Which is the best method for introducing flavors into a batch of gum?

5—What influence has heat on the chicle dough in the kettle?

6—What influence has the duration of the "cooking" on the dough in the kettle?

7—What influence have substitutes on the "keeping" qualities of the finished gum?

8—What influence have temperature and moisture on the finished gum during storage?

9—What are the advantages of drying or moistening the air in chewing gum factories?

10—What relation has the resin content to the chewing qualities of the chicle?

11—How can crude chicles be averaged in order to secure a finished gum of uniform characteristics?

12—What influence has the coagulation method on the quality of the crude chicle produced by the Sapoteros?

13—How can "stiff" chicles be softened and how can "soft" chicles be stiffened?

14—What influence have the several constituents of a chewing gum compound on the chewing quality of the finished gum?

15—How can the dirt and the bark be removed from crude chicle without destroying the desirable qualities of the gum?

16—How can low-grade chicles be improved?

17—What relation has the viscosity of chicle solution to the chewing properties of the gum?

18—How can rubbers and related gums be converted into plastic gums suited for chewing?

19—Can chicle be strained while in a molten condition without altering the chewing properties of the chicle?

20—Is the protein content of chicle a detriment or an asset?

APPENDIX

The Custom House statistics of the United States show that the gross imports of chicle and balata in 1912 to 1916 were as follows:

Year	Lbs. chicle	Lbs. balata
1912	7,782,005	1,517,066
1913	13,758,592	1,318,598
1914	8,040,891	1,533,024
1915	6,499,664	2,472,224
1916	7,346,969	....

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[1] Spence and Kratz, *Kolloid Z.*, **1914**, 262.

[2] Beadle and Stevens, *Analyst*, January, 1912.

[3] Pickles and Whitfield, *Proc. Chem. Soc.*, **27** (1911), 54.

In order to obtain a more correct idea of the importations it is suggested that the figures for these two gums be added and classed together. The present Tariff Act went into effect October 3, 1913, so that it was natural that large quantities of chicle should be imported before that time. The new act provided for a duty of 15 c. per pound on crude chicle and 20 c. per pound on refined chicle while balata was admitted free. This no doubt resulted in the importation of some chicle under the name "Balata" and caused the drop in the chicle imports from 1914 to the year 1915.

At this point it is also interesting to note that exports of finished chewing gum to foreign countries have risen from $179,000 in 1914 to $574,400 in 1916. This has been shipped principally to England and Australia. At a valuation of $0.80 per lb. this would represent approximately 718,000 lbs. of chewing gum or 179,000 lbs. of dry chicle. The amount of chicle imported, manufactured and consumed in the United States in 1916 was approximately 7,031,000 lbs., equal to over 28,124,000 lbs. of chewing gum. This represents a national consumption of over 844 million packages per annum.

THE RUBBER TRADE LABORATORY
325 ACADEMY STREET
NEWARK, NEW JERSEY

REVERSION OF ACID PHOSPHATE

By CARLTON C. JAMES

Received March 3, 1917

There seems to be an inclination of late among fertilizer and State control chemists to do more investigating of phosphates, their properties, and their effect upon soils and growing crops. Where State laws call for water-soluble phosphoric acid, careful investigation and attention is necessary, particularly in order that the different brands may not fall below guarantee. A recent article in THIS JOURNAL by Mr. E. W. Magruder[1] recalled some work which was done by the writer in 1910, upon the reversion of acid phosphate by lime, a matter which has claimed the attention of chemists in the Southeastern states for the last two or three years.

After having his attention called to a fertilizer from San Francisco, which had evidently undergone reversion during transit to the Hawaiian Islands, the writer undertook several experiments with different materials to find the effect these had upon the acid phosphate of lime.

To 475 g. of acid phosphate in three separate bottles were added 25 g. lime (CaO), 25 g. unground coral sand and 25 g. unground brown guano, respectively; that is, in each experiment there was added 5 per cent of the reverting agent to the superphosphate, which we may consider a maximum amount to use in practice. It should be explained that the unground coral sand is carbonate of lime of 95 to 98 per cent purity, and coarsely granular. The brown guano is a low-grade sandy phosphate from Laysan Island, formed by the action of bird droppings upon coral sand with which it is intimately mixed. These mixtures were allowed to stand 20 days, analyses being made of the water-soluble phosphoric acid from time to time as other work permitted. The following table shows the water-soluble phosphoric acid found in the mixtures at intervals after mixing.

TABLE I—PER CENT WATER-SOLUBLE PHOSPHORIC ACID IN MIXTURES OF ACID PHOSPHATE WITH

5 Per cent	Lime (CaO)	Coral Sand	Brown Guano
On mixing	21.37	21.37	21.37
After 2 days	20.83	21.08	21.24
After 5 days	20.18	20.75	21.16
After 12 days	19.69	20.59	21.00
After 20 days	19.12	20.51	21.00

This table shows that superphosphate in which there is 5 per cent coral sand reverts 0.62 per cent in 5 days or 0.86 per cent in 20 days. With brown guano the reversion is not as great, while with lime it is 3.75 times as much. If then in a fertilizer guaranteed to contain 10 per cent of phosphoric acid water-soluble, we should have 50 per cent acid phosphate of lime and 5 per cent calcium carbonate (coral sand), we should expect to find after 5 days that instead of 10 per cent water-soluble phosphoric acid it would contain only $10 - (0.62 \times 0.50) = 9.69$ per cent, the difference being caused by coral sand alone. In order that this fertilizer might show a 10 per cent water-soluble phosphoric acid content after 5 days, 51.5 per cent acid phosphate would have to be used originally. This example gives the effect of but one reverting agent, but it is sufficient to show that quite a material allowance has to be made in certain fertilizers to cover reversion during transit.

THE PACIFIC GUANO AND FERTILIZER COMPANY
HONOLULU, HAWAII

A RAPID METHOD FOR THE DETERMINATION OF WATER-SOLUBLE ARSENIC IN LEAD ARSENATE

By H. A. SCHOLZ AND P. J. WALDSTEIN

Received March 5, 1917

The method for the determination of water-soluble arsenic in commercial lead arsenate described by Gray and Christie[1] is very similar to the method used by the writers for factory control during the past three years.

The procedure follows: Weigh 0.5 g. of the dried and pulverized sample, or 1 g. of paste, into a 250-cc. volumetric flask. Add 200 cc. of recently boiled, distilled water and boil vigorously for 3 to 5 min. Allow to stand 10 or 15 min., cool, make to volume and filter through a dry paper. Ordinary, quick-filtering qualitative paper is used and there is rarely any difficulty in obtaining a clear filtrate. Measure 200 cc. into a 500-cc. Erlenmeyer flask, add a few crystals of potassium iodide and 7 cc. concentrated sulfuric acid, and boil down to about 50 cc. Dilute with cold water, make alkaline to methyl orange with sodium hydroxide, acidify with dilute sulfuric acid, and add an excess of sodium bicarbonate. Titrate with $N/20$ iodine solution.

This method was checked many times on lead arsenates of different compositions against the A. O. A. C. method[2] (24 hrs. digestion at 32° C.), and a few times against the 10-day method.[3] The results always either agreed or came higher by the boiling method. Table I gives a few typical results. The arsenates of lead used included the products of several other manufacturers and represent practically every known commercial method of manufacture.

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[1] THIS JOURNAL, **9** (1917), 155.

[1] THIS JOURNAL, **8** (1916), 1109.

[2] *J. of A. O. A. C.*, **1913**, Nos. 1 and 2.

[3] Bureau of Chemistry, *Bull.* **107**, Revised, p. 240.

Table I—Water-Soluble Arsenic Calculated as Per cent As_2O_5 on the Dry Basis

No.	A. O. A. C. Method 24 hrs. at 32° C.	Devoe & Raynolds Boiling Method	No.	A. O. A. C. Method 24 hrs. at 32° C.	Devoe & Raynolds Boiling Method
1	4.52	4.62	6	0.56	0.68
2	0.47	0.47	7	0.23	0.30
3	trace	0.06	8	0.18	0.21
4	trace	0.46	9	0.18	0.33
5	0.22	0.23	10	0.44	0.46

There is no provision made for the removal of lead, as we have never found water-soluble lead in more than traces in any sample of lead arsenate. Furthermore, as has been pointed out by Gray and Christie, there is great danger of volatilization of the arsenic by evaporating the solution to sulfuric acid fumes, as the results given in Table II will show. The extractions were made by boiling as in the method given above.

Table II—Water-Soluble Arsenic Calculated as As_2O_5 on the Dry Basis

	No. 1	No. 2
Evaporated to SO_3 fumes	2.40	1.61
Reduced and Titrated without Evaporation	3.56	2.50

The water-soluble arsenic in commercial lead arsenate very often is largely in the arsenious form. Commercial sodium arsenate and arsenic acid often contain small amounts of unoxidized arsenic trioxide, and this precipitates with the lead arsenate in a form which is very difficult to wash out with cold water, but which dissolves readily in hot water. This may be the reason why the boiling methods of Gray and Christie, and of the writers, and the hot water method of Robinson and Tartar[1] give higher results than the cold and 32° C. methods of the A. O. A. C.

By the method given a determination of water-soluble arsenic may be made in less than an hour, which is a very important consideration for factory control work.

The same method of extraction may be used for the determination of other water-soluble impurities.

Devoe and Raynolds Company
14–16 West Lake Street, Chicago

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[1] This Journal, 7 (1915), 499.

LABORATORY AND PLANT

SAFEGUARDING THE EYES OF INDUSTRIAL WORKERS[1]

The Seaman Gold Medal, gift of Dr. Louis Livingston Seaman, Trustee, is annually awarded by The American Museum of Safety for progress and achievement in the promotion of hygiene and the mitigation of occupational disease. This year the distinction of the Seaman Medal has been conferred upon the Julius King Optical Company, of New York, for scientific research and practical achievement in overcoming the harmful effects of ultra-violet and infra-red rays of light in connection with arc-welding and other industrial processes at very high temperatures.

For a number of years the necessity of protecting the eyes of workers against chips of steel, splashes of metal and flying particles of emery, concrete and other materials, has been recognized, and the wearing of an approved type of safety goggles made compulsory. A far more insidious and hazardous danger to eyesight is caused by certain invisible rays of light, such as the ultra-violet and infra-red rays, which are present in injurious quantities in the manufacture and working of iron and steel. These rays may cause electric ophthalmia.

Any light source over 2000° Fahrenheit is a distinct menace and when a temperature of 6400° is reached, such as is encountered in electric carbon arc-welding, the volume of ultra-violet radiation is so great as to impair vision permanently. On account of its destruction of animal tissue, these rays must positively be guarded against. Being invisible, their presence is detected by the operator only after harm has been done.

Until an investigation was made about three years ago, practically 90 per cent of all colored glass in goggles for industrial use was incorrect; and without a doubt a large number of blind men, or those unfortunates who are afflicted with cataract, would have their full sight to-day if they had been provided with scientifically correct colored glass.

One of the first forms of eye protection from glare was the wearing of blue glasses in the manufacture of steel, particularly in the open-hearth process. Glare is made up of non-injurious rays of the spectrum, namely green, yellow, orange, and red rays. As a matter of fact, blue is one of the worst colors which could possibly be selected for this process, as it allows ultra-violet, violet, blue and also infra-red rays to enter the eyes freely, cutting out only that part of the light which is essential to vision, but affording no protection from dangerous light.

The higher the temperature, the more rich it is in ultra-violet rays. At the temperature encountered in oxy-acetylene welding and cutting, which is about 4350° Fahrenheit, grave danger exists and the glasses formerly supplied by the oxy-acetylene companies, who manufactured and furnished the outfits, were without any scientific value whatever. They were using blue glass, as described, or else smoked lenses, which allowed a large proportion of injurious rays to enter the eye. Where a wrong color is used a much darker shade is necessary than if a correct color is prescribed.

All colors have been analyzed and tabulated, by spectral photography, so the relative value of each is known.

A temperature of 2000° requires a lens but slightly tinted, while a temperature of 6400° requires a lens so dark that one can barely see the sun through it. The Julius King Optical Company has plotted all colors on a photometric scale, the standard adopted being a white cloud illuminated by the sun, which may be looked at indefinitely without eyestrain. A temperature of 2000° of molten iron through a slightly tinted glass has the same effect on the eye as if the

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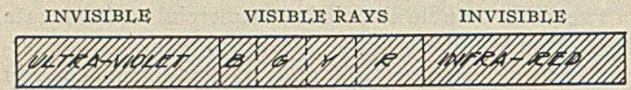
[1] Abstracted and adapted from the May, 1917, issue of "*Safety*" (p. 118 and supplement), published by the American Museum of Safety, 14 to 18 West 24th Street, New York City.



Harmful Harmless in Moderate Amounts Harmful

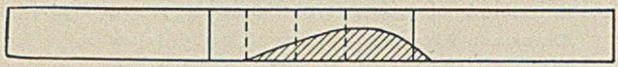
[B, G, Y, R areas printed Blue, Green, Yellow and Red in Original.]

AKOPOS Glass

Recommended for Temperatures around 2000° F. such as Gas Heating Furnaces, etc.

Light SANI-WELD Glass

Recommended for Temperatures around 3500° F. Oxy-Acetylene Cutting, Pouring Steel, etc.



Dark SANI-WELD Glass

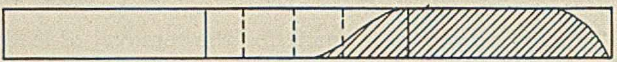
Recommended for Temperatures around 4300° F. Heavy Oxy-Acetylene Welding, Electric Furnaces, etc.

ARK-WELD Glass

For Temperatures around 6400° F. in Combination with AKOPOS or SANI-WELD (to eliminate infra-red rays). Correct for Iron or Carbon Arc Welding and for Electric Furnaces: in these Processes Face-burn will Result unless a Helmet is Used.

Clear "White" Glass

Should Not be Used where Temperature is over 1500° F.



Red Glass—Harmful

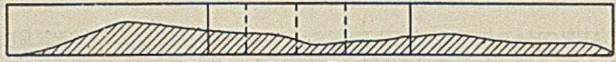
Should Never be Used as it Transmits Infra-Red and is Very Fatiguing to the Eye.

Green Glass—Incorrect

Should Not be Used as it Distorts Colors and is of Low Optical Value.

Cobalt-Blue Glass—Exceedingly Dangerous

Transmits Invisible Rays as freely as Clear Glass. Should be Abolished except for Open Hearth Temperature Judging where it is not Practical to Teach Melters a New Color.



Smoked Glass—Dangerous

Reduces Visible but Transmits Invisible Rays; Although sometimes Furnished with Oxy-Acetylene Outfits, it is about the Worst that could be Used for the Process.

wearer had nothing over the eyes, and was looking at a white cloud. The same photometric standard applies in looking at a temperature of 6400° through the darkest glass, the effect on the eye being the same.

These new values of lenses were determined by flowing colors over photographic plates. Spectral photographs were taken through this medium, the efficient ones being tabulated and reproduced in pot glass.

All of this research was conducted in what was practically an unknown field and it will be difficult to find any other line of work where more good has been accomplished in the prevention of ocular diseases, disturbances and actual loss of sight than has been accomplished by this patient research conducted with considerable expense of time, money and material.

The process of arc-welding requires protection not only for the eyes, but for the entire face and neck. Welders have experienced such intense eyestrain and face burns after a few minutes' work, that all sorts of crude shields have been devised. The majority of these, however, were heavy and cumbersome, being made of metal and leather; and all were inefficient and uncomfortable. Frequently, the workmen themselves selected glass to reduce the light intensity, but they were, of course, wholly ignorant of the fact that the character of the light caused more damage than its brilliancy.

Since metal is a conductor of heat and electricity, the Julius King Optical Company have constructed a helmet of fiber, finished within and without in dead black so as to minimize the danger from reflected light. The top of the head is protected by a fireproof cap, to which the helmet is pivoted so that it may be turned back out of the range of vision when it becomes necessary for the wearer to inspect his work or to move about. The lenses mounted in this helmet are a combination of "Ark-weld" and "Akopos" glass, the former to reduce the intensity and the latter to eliminate the injurious rays of the arc light.

As the lenses are of the proper scientific color, no danger exists from electric ophthalmia or other diseased condition of the retina or conjunctiva.

The accompanying drawing was adapted from the special colored supplement accompanying the May issue of *Safety*, and furnished through the coöperation of the Julius King Optical Company. It indicates quite clearly the transmission of the invisible dangerous rays of light through the ordinary colored glass, and their absorption by the "Akopos," "Sani-weld" and "Ark-weld" glasses. The kinds and proportions of the various parts of the spectrum transmitted are indicated by the shaded areas.

RECOVERY OF MOLYBDENUM RESIDUES

By Victor Lenher and M. P. Schultz

Received June 6, 1917

A number of methods for the recovery of molybdic acid residues have been suggested in the past few years. The scheme of Armstrong[1] consists in the precipitation of molybdic acid from the residues, while the procedures of Brown[2] and of Prescott[3] have in addition the removal of the phosphates by means

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[1] This Journal, **7** (1915), 764.

[2] *Ibid.*, **7** (1915), 213.

[3] *The Analyst*, **40** (1915), 390.

of magnesium salts. Both of these principles we have found in our hands to be efficient. We wish, however, to present an additional method which is based on a somewhat different principle, and in certain kinds of molybdate residues may be desirable. The method consists in the precipitation of molybdenum sulfide from a solution slightly acid with nitric acid by means of hydrogen sulfide or the formation of a sulfomolybdate solution by adding hydrogen sulfide to the alkaline solution of the "yellow precipitate" and subsequently adding hydrochloric acid to precipitate the molybdenum sulfide. Molybdenum sulfide when ignited gives MoO_3, which is in condition to be used again.

In applying the method to waste molybdate liquors which are usually quite strongly acid with nitric acid, the solutions should be strongly diluted or the excess of free acid should be in large part neutralized with sodium hydroxide, so that the limits of acidity should be between 0.1 and 0.4 per cent. Hydrogen sulfide gas is then passed through the solution. The sulfide settles more rapidly, however, if the solution is previously heated. The supernatant liquid can then be siphoned off and the sulfide washed with water, after which it can be filtered, dried and roasted.

When much iron is present in the liquors the sulfide should be washed with water containing hydrochloric acid to remove the iron completely.

The "yellow precipitate" is handled by dissolving in sufficient sodium hydroxide to make a solution just slightly alkaline to phenolphthalein. Should the precipitate be contaminated by iron, the ferric hydroxide produced by the addition of the alkali should be filtered off. The filtrate is then diluted and hydrogen sulfide conducted through the solution to saturation. Dilute hydrochloric acid is now added until an excess is present, when molybdenum sulfide separates. The sulfide of molybdenum can be filtered, washed with hot water containing dilute hydrochloric acid, dried and roasted in the air to molybdenum trioxide.

CHEMICAL LABORATORY
UNIVERSITY OF WISCONSIN, MADISON

NOTE: ORGANIC CHEMICAL REAGENTS FOR SCIENTIFIC AND TECHNICAL LABORATORIES

By ROGER ADAMS

Received June 7, 1917

During the last three summers it has been the custom at the University of Illinois to manufacture on a semi-commercial scale (1- to 2-lb. lots) certain organic chemicals, which had hitherto not been produced in this country and which were necessary for the researches in organic chemistry. Each year the number manufactured has been increased till at present satisfactory products have been developed for over forty of the common organic chemicals used primarily in theoretical organic research, but to some extent in technical laboratories. Thus it has been possible to supply the Illinois laboratories with many of the materials formerly imported from Germany.

The majority of these substances are not purchasable in the open market at the present time, so it was thought it might be a great aid to other laboratories if they had the benefit of the experiences at Illinois and the opportunity of purchasing such chemicals as might be desired at a price slightly above cost. In nearly every case the substances produced have been compared with Kahlbaum's products and in every instance the products have been found as pure, or purer.

Below is given a list of chemicals which have been manufactured, many of which are on hand at the present time. In continuing the manufacture of chemicals this summer, only those chemicals mentioned below, which are out of stock, will be made, unless there may be an outside demand for others. Processes for at least ten substances not included in the list will be studied also in the next few months.

Acetamide
Acetoacetic ester (ethyl)
Acetonitrile
Acetophenone
Anisole
Amyl bromide (iso)
Benzamide
Benzene sulfonyl chloride
Benzonitrile
Benzoyl acetone
Benzoyl chloride
Benzoyl cyanide
Benzyl alcohol
Benzyl bromide
Benzyl cyanide
Bromoacetyl bromide
Bromobenzene
Bromonaphthalene (alpha)
Dibromo (*p*) benzene
Dichloracetic acid
Dimethyl glyoxime
Diphenylmethane
Ethyl benzoate
Ethylene bromide
Ethyl oxalate
Glycocoll
Hippuric acid
Magnesium (especially prepared for use in the Grignard reagent)
Malonic ester (ethyl)
Malonic ester (methyl)
Mesitylene
Methyl oxalate
Methylene iodide
Nitrobenzoic acid (*p*)
Nitromethane
Oxalyl chloride
Phenyl acetic acid
Phenyl acetic ester (ethyl)
Phenyl alanine
Trimethylene bromide
Trimethylene chlorhydrin
Trimethylene cyanide
Trimethylene glycol

If there is a reasonable demand for any particular chemical, which has not been prepared here and which cannot be purchased from any commercial concern, the laboratories at Illinois will be glad to undertake such manufacturing at their expense and sell the product at a price slightly above the cost calculated from the past results.

The Division of Organic Chemistry at the University of Illinois has organized itself for this work, the preparation being carried out for the most part by the junior members of the staff and other graduate students in organic chemistry. These men receive from 25 to 35 cents per hour for their services. In this way it has been possible to retain many men who might earn much larger salaries outside, but who are willing to stay for this particular kind of experience. A number of other laboratories have offered to assist in this work, if necessary, so as to aid scientific and technical investigation as much as possible. Prof. P. A. Bond, of Cedar Falls, Iowa, has kindly offered to prepare sodium nitroprusside for the benefit of any who might need this substance. In addition to the above work, in conjunction with Prof. M. T. Bogert, information concerning the organic chemical reagents purchasable in this country is being collected. Quotations of prices on any of the substances above, or any information which it has been possible to obtain in regard to organic chemicals will gladly be given on request.

UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

AN EVAPORATING BATH OF SEA SAND HEATED BY STEAM

By P. P. Peterson

Received February 24, 1917

The apparatus herewith described has been found so convenient and useful in the laboratories of the Department of Soils at the University of Idaho that it is thought worth while to tell other chemists about it. It is made of coils of pipe in a bath of sea sand. The heat is supplied by superheated steam, the flow of which is controlled by a Sarco steam trap.

The tray (*A*, Fig. I) is made of No. 24 galvanized iron. Of course, it may be any size. Ours is 2 ft. square and 4 in. deep. *B* is a coil of $^1/_2$-in. iron pipe well fitted so that it can carry a pressure of 100 to 150 lbs. per sq. in. At the end of this pipe is a Sarco steam trap, *C*, which allows the escape of steam until a certain temperature is reached when it closes automatically. The coil *B* is covered with sifted sea sand of about the size that will pass a 20-mesh sieve and washed free from small adhering particles.

It is found that by the use of this bath a much more rapid evaporation can be obtained than with a hot water or steam bath. Aside from this the escape of large amounts of steam into the room and the noise often accompanying the same is avoided. To obtain the best results the sand should cover the coils to the depth of $1^1/_2$ to 2 in. so that the evaporating dish or casserole may be pressed down into it. When the hot sand is allowed to come up on the side of the evaporating dish the evaporation is greatly accelerated. A temperature of 140° C. can be obtained in the sand between the pipes. Over the hot plate, whether heated by a gas flame or electricity, this bath has the advantage that there is almost no danger at all of spattering. With the hot plate it is almost impossible to avoid this trouble.

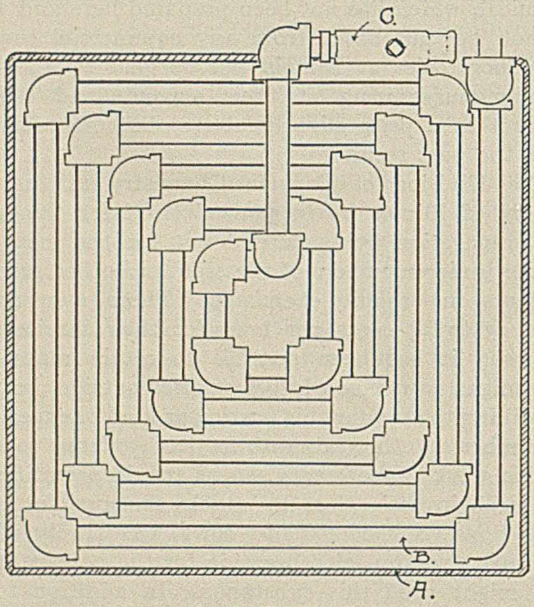


Fig. I—Top View

The objection that contamination from the sand is likely to take place may be raised and, of course, is to be taken into account. In this laboratory, however, it has been found that to avoid this contamination requires no more care than is necessary with the old style boiling water bath or the steam bath. Thorough washing of the sand to remove all small particles makes the avoidance of contamination rather easy.

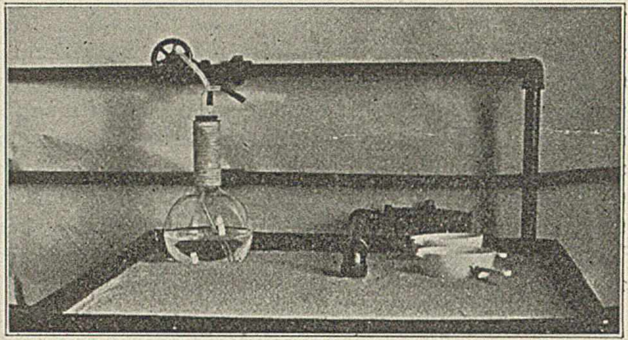


Fig. II—The Bath Complete

Fig. II is a cut of the completed bath.

Soil Fertility Laboratory
University of Idaho, Moscow

AN IMPROVED FORM OF A FUMELESS DIGESTION APPARATUS

By J. S. McHargue

Received February 23, 1917

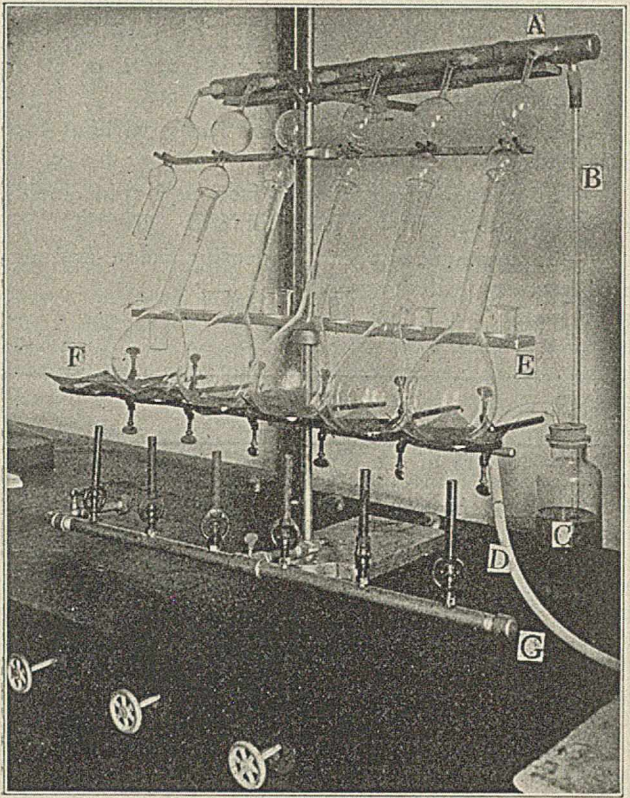
In a recent investigation involving a relatively large number of nitrogen determinations, it became necessary, on account of the lack of flue facilities, to make use of a Sy Fumeless Nitrogen Digestion Apparatus. During the time the nitrogen digestions were being made, a number of objectionable features to this particular apparatus were experienced. The writer has, therefore, enlarged and modified the Sy apparatus in such an advantageous manner as to consider the changes so made worthy of brief notice in the chemical literature.

The chief points in which the apparatus shown in the accompanying photograph differs from the Sy apparatus and the advantages gained thereby are as follows:

1—Increased capacity. Since most ready-made nitrogen distillation apparatus provides for 6 distillations to be carried on at the same time, there is a saving of time by having an equal number of digestions provided for.

2—The lead pipe and the absorption bottle is a more permanent and satisfactory arrangement for controlling and disposing of the acid fumes during digestion. Practically all the fumes are absorbed in the bottle which can be easily emptied and the acid recovered by evaporation, thereby effecting a saving of acid and the corrosive action on the drain pipes as well. The pump used in drawing the fumes into the absorption bottle is the ordinary type in general use in laboratories.

3—The shelf *E* holds 6 beakers which are placed beneath the lower end of the condensing bulbs, and catch the acid that drains from the condensing tubes after the digestion flasks are removed. After the digestion is stopped and the flasks become cool, a small amount of concentrated acid adheres to the inside of the condensing bulbs, which, after the removal of the digestion flask, absorbs moisture from the atmosphere and continues to drip until the acid becomes saturated with moisture.



It is advisable to wash out the condensing bulbs previous to starting a new set of digestions as the acid in the bulbs may in some cases absorb enough ammonia to affect the nitrogen estimation.

DESCRIPTION OF THE APPARATUS

A is a lead pipe $1^{1}/_{2}$ in. in diameter and about 28 in. long. It rests upon and is attached to a board, which is also attached to an adjustable clamp that can be moved back and forth on the iron rod that supports the lead pipe. The iron rod is also adjustable on the vertical rod of the iron stand and is easily lowered or raised to accommodate either long or short neck flasks. The lead pipe is sealed at each end and has 7 lead tubes 1 in. long and $^{1}/_{2}$ in. in outside diameter sealed into the pipe for connections. The 6 tubes on the side of the pipe are placed 5 in. apart and are connected with the upper end of the condensing bulbs by means of a short piece of rubber tubing. The seventh tube, which is placed near the end and at right angles to the 6 tubes on the side, connects, by means of rubber tubing to the glass tube *B*, which extends through the rubber stopper to near the bottom of the wash bottle *C*.

The rubber tube *D* is attached to one end of a glass tube bent at right angles, and extending through the rubber stopper in wash bottle *C*. The other end of the rubber tube is attached to a suction pump which draws the fumes through the water in the wash bottle *C*, where they are absorbed.

The adjustable shelf *E* holds 6 small beakers, which are placed so as to catch the few drops of acid that always drain from the lower end of the condensing tubes after the digestion flasks are removed.

F indicates the rings which support the digestion flasks. The rings are attached to a $^{1}/_{2}$-in. iron rod by means of clamps. The iron rod is attached to the vertical rod of the stand by an adjustable screw clamp.

G is a $^{7}/_{8}$-in. gas pipe carrying the 6 burners placed 5 in. apart and is attached to the iron stand at the base by means of a screw clamp.

Although the above apparatus has been in use but a short time, it has worked so well as to leave but little to be desired in the way of a fumeless digestion apparatus.

Department of Chemical Research
Agricultural Experiment Station
Lexington, Kentucky

A NOTE ON AN AUTOMATIC SUCTION ATTACHMENT FOR AN ORDINARY PIPETTE

By J. P. Schroeder

Received March 7, 1917

In analytical laboratories it is often necessary to measure a number of aliquot portions of a solution or equal portions of different solutions with a pipette. This process becomes tiresome, especially when the portions to be measured are large. The laboriousness of the operation can be done away with to a large extent by attaching to the pipette an ordinary three-way stopcock, as shown in the diagram, and using a vacuum to draw up the solution instead of sucking it up. The tube of the stopcock connecting with the other two leads (*a*, Fig. I) is connected to the pipette by means of a short piece of heavy-walled rubber tubing. This gives the apparatus rigidity. One of the other leads (Fig. I) is connected by means of ordinary rubber tubing of sufficient length to give freedom of movement, to the vacuum, while the third lead

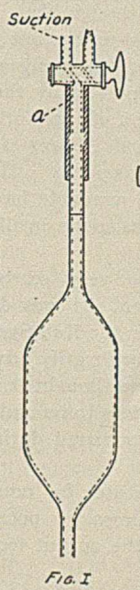


Fig. I

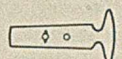


Fig. II

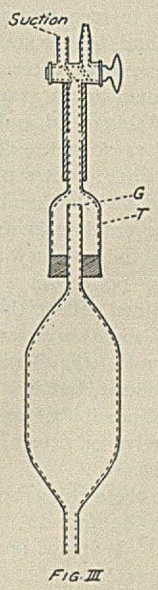


Fig. III

is left open to the atmosphere. The suction can readily be adjusted by placing a screw clamp on the rubber tubing.

To aid the operator in drawing the solution exactly to the graduation mark on the pipette a niche is filed on the surface of the stopcock on the edges of the hole (Fig. II) so the suction may be closed off gradually when the meniscus nears the graduation mark. By this means the adjustment may be made more readily than by the ordinary manipulation by hand.

By the arrangement shown in Fig. III the volume of solution is adjusted automatically. The stem of the pipette is broken off at the graduation mark *G* and a Gooch crucible filter tube, *T*, is attached by means of a rubber stopper as shown in the diagram. The manipulation is evident from the illustration.

The advantages of this arrangement are:

1—A large number of solutions can be measured in a minimum length of time.

2—The measurements can be made without tiring the analyst.

3—The meniscus can be observed from a point at right angles to the position of the pipette.

4—The solution is held automatically without loss until ready to be delivered.

5—The danger of drawing poisonous liquids, acids or alkalies into the mouth is eliminated.

6—The arrangement can be easily made and attached to any ordinary pipette.

U. S. Department of Agriculture
Bureau of Soils, Washington, D. C.

ADDRESSES

POTASH AND A WORLD EMERGENCY[1]

By W. C. Ebaugh

Without a doubt we are now passing through an epoch-making period in the world's history—epoch-making in national politics, in social changes, in economic conditions and in industrial revolutions. Things are done under the pressure of stern necessity that would have been deemed impossible by the average man five or ten years ago. Obstacles in the way of progress, either constructive or destructive, are swept aside by master hands, tremendous organizations or by embattled nations, and we cease to wonder at things that would have held the world's attention just the other day.

But even with all this one can observe some things that are not subject to increased production, even though they are in strong demand, for the simple reason that nature has not placed stores of the raw materials at our disposal in many places. Take platinum as an example. Russia is practically the only producer of this metal, and since the outbreak of the World War the price has soared. The *Engineering and Mining Journal* of April 7, 1917, quotes platinum at $102.50 per oz. In spite of this demand the quantities of platinum available have not increased, even though strenuous efforts are made in all parts of the world to locate new sources.

Similarly, potassium salts have become very scarce and prices obtained reflect the market condition. It was deemed bad enough some six or seven years ago when the Kali Syndikat, under control of the German government, arbitrarily advanced prices somewhat, but it is safe to say no one thought it within the realm of possibility for such new high prices to be multiplied by ten, twelve or fifteen, as has actually occurred during the past months.

Why are these things so? Cannot substitutes for potassium compounds be found? Cannot new sources of potash be discovered? Is it not possible to enlarge the output from our known sources?

Answering these questions is not difficult if we consider the uses for potassium salts, the place from which they have come and present international conditions.

Primarily potash salts are valuable for fertilizers. About seventy-five years ago Justus von Liebig and his co-workers pointed out the necessity of restoring to the soil the materials removed from it in the form of crops. One economist states it crudely thus: "For every fourteen tons of fodder carried off from the soil there are carried away two casks of potash, one of soda, a carboy of vitriol, a large demijohn of phosphoric acid, and other essential ingredients." In our recently settled lands we are inclined to ignore this fact, and simply take off crop after crop without using fertilizers. Our farmers in older communities, both here and abroad, have learned the folly of robbing their soil, and provide fertilizers to replace the inorganic substances removed.

"In the many-sided technical and industrial life of to-day there are but few enterprises that can dispense with the products of the potash industry. In a number of ways it is employed, as for example in medicine, photography, painting, dyeing, laundry work, bleaching, spinning works, soap manufacture, refrigeration, preservatives, electrotechnics, fireworks, explosives, matches, paper, glass, aniline colors, metallurgy, etc. Its use in agriculture is especially important. In 1909, the 6,900,000 metric tons of potash salts produced contained 675,330 metric tons of potash. This was used as follows:

	Metric Tons	Per cent
Agriculture	590,027	87.37
Industries	85,304	12.63

In the same year Germany used 53,281 metric tons in its industries and only two other countries used more than 5,000 tons in a similar way, *viz.*, the United States and France. In its agriculture Germany itself used more than one-half of the total potash employed for this purpose."

The fact that plants take up potash from the soil has been known for centuries. Wood ashes were called "potashes" and used for the preparation of soap and as a raw material for manufacture of various potassium compounds. One of the most highly prized potassium compounds prepared from wood ashes was saltpeter or niter, used in gunpowder, as a preservative, etc. Prior to the Napoleonic Wars potash was used for many purposes where soda is now employed, because the former was found in wood ashes, and the latter could be gotten only with difficulty. Then came Le Blanc's process for making sodium carbonate from salt, with hydrochloric acid as a by-product, and the demand for potash fell off. Glass and soap are now made from soda, rather than from potash, unless for special reasons. But sodium compounds cannot replace potash as a plant food substance.

A shortage of potash was felt in the two decades 1840 to 1860, following the acceptance of Liebig's doctrines on restoring soil fertility. Saline lakes, springs and wells were tried as sources of potash, but with poor results.

At Stassfurt, in northwestern Germany, a salt industry has been carried on for centuries. In order to increase the yields from this source, in 1837 the Prussian government undertook

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[1] Presented at the regular monthly meeting of the Utah Society of Engineers, Salt Lake City, April 18, 1917.

deep boring operations for rock salt, which was discovered in 1843. Between 1851 and 1856 the first shafts were sunk. Great was the disappointment because "bitter salts," and not rock salt, were found. It was not long, however, until the true value of these "waste salts" as a source of potash was recognized, and in 1861 the first potassium chloride factory at Stassfurt was erected. From that time to the present Stassfurt deposits have supplied practically all of the potash used throughout the world.

STASSFURT DEPOSITS

A glance at the diagram shown herewith reveals the way in which the various layers of salts are found. It will be noted that potassium salts are not found *at the surface.* This should be borne in mind when we talk about discoveries of potash in our western country. As potassium salts dissolve readily in water they are transported to lakes or the ocean, except in so far as they may be ingested and used by plants. Water from Great Salt Lake illustrates this.

It is supposed that in early geological ages North Germany and adjacent countries were an inland lake or sea, similar to our own Lake Bonneville; and from this residual lake at Stassfurt, left after evaporation through the milleniums, there separated out annually 3 to 5 inches of salt and thin layers of gypsum and anhydrite. These can be counted like rings of yearly growth in trees, and indicate a period of 10,000 years required for the formation of this salt deposit. Finally the mother liquors themselves crystallized out, giving rise to rock salt mixed with polyhalite, kieserite and carnallite as indicated. The same salts can be obtained by the evaporation of seawater and saline lakes, only in different proportions. These deposits were then buried by dust, which now is found as the "salt clay" immediately above the potash salts. In subsequent ages anhydrite and shales were laid down, and then extensive folding and pressure occurred. That climatic conditions at the time these salt beds were formed were far different from what they are to-day is indicated by van't Hoff's calculations that often temperatures of 73° C. (163° F.) occurred.

TABLE I—NATIVE POTASSIUM SALTS

NAME	Formula	Potash (K_2O) Equivalent
Carnallite	$KCl, MgCl_2, 6H_2O$	16.9 per cent
"Hartsalz" (Mixture of Sylvinite and Kieserite)	....	....
Sylvinite	$KCl, NaCl$	35.4
(Kieserite)	$MgSO_4, H_2O$	....
Schönite	$K_2SO_4, MgSO_4, 3H_2O$	27.0
Polyhalite	$K_2SO_4, MgSO_4, 2CaSO_4, 2H_2O$	15.6
(Boracite)	$6MgO, 8B_2O_3, MgCl_2$	....
(Anhydrite)	$CaSO_4$	....
Kainite	$KCl, MgSO_4, 3H_2O$	29.0
Orthoclase	$KAlSi_3O_8$	16.9
Leucite	$KAlSi_2O_6$	21.6
Alunite	$KAl_3S_2O_{11}, 3H_2O$	11.4
Granites, Porphyries, etc.	....	3 to 8
Leucite Rocks	....	5 to 10

The individual salts found at Stassfurt have the names, formulas and potash content given in Table I: the average compositions of the crude and manufactured salts are given in Table II.

TABLE II—AVERAGE COMPOSITION (PERCENTAGES) OF STASSFURT SALTS

SALTS	NAME OF SALT	K_2SO_4	KCl	$MgSO_4$	$MgCl_2$	$CaSO_4$	NaCl	Insoluble	Water	Av. K_2O
CRUDE (as mined)	Kainite	....	22.3	20.8	2.3	4.4	44.6	4.4	5.6	14.1
	Carnallite	....	15.5	12.1	27.5	1.9	22.4	0.5	26.1	9.8
	Sylvinite	1.5	26.3	2.4	2.6	2.8	56.7	3.2	4.5	17.4
CONCENTRATED (as manufactured)	Potash Fertilizer, 20%	2.0	31.6	10.6	5.3	2.1	40.2	4.0	4.2	21.0
	Potash Fertilizer, 30%	1.2	47.6	9.4	4.8	2.2	26.2	3.5	5.1	30.6
	Potash Fertilizer, 40%	1.9	62.5	4.2	2.1	2.4	20.2	3.1	3.6	40.4
	Potassium Sulfate, 96%	97.2	0.3	0.7	0.4	0.3	0.2	0.2	0.7	52.7
	Potassium Sulfate, 90%	90.6	1.6	2.7	1.0	0.4	1.2	0.3	2.2	49.9
	Potassium Magnesium Sulfate	50.4	....	34.0	....	0.9	2.5	0.6	11.6	27.2
	Potassium Chloride (Muriate) 90/95%		91.7	0.2	0.2	...	7.1	0.2	0.6	57.9
	Potassium Chloride (Muriate) 80/85%		83.5	0.4	0.3	...	14.5	0.2	1.1	52.7

The Stassfurt salts are mined by the room or pillar method, about 25 per cent of the salt being allowed to remain as pillars, and the stopes filled with sand or waste. The penetration of water to the deposits is fatal, for caving, loss of salt and destruction of surface property results. In parts of the Stassfurt district one can see humps and hollows on the surface, with houses and churches standing at all angles, caused by water getting to the underlying salt.

The crude salts are sold largely as fertilizers, but immense amounts are refined in the "potassium chloride factories." By recrystallization under definite conditions of concentration and temperature there are made potassium chloride, potassium sulfate, potassium magnesium sulfate, Glauber's salt, magnesium sulfate (Epsom salts), magnesia, bromine, boric acid, etc.

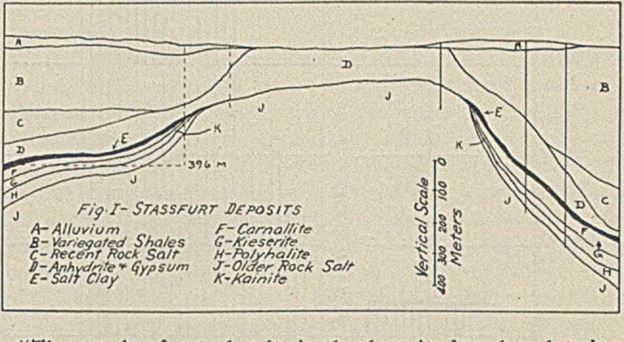
Fig. I- STASSFURT DEPOSITS

"The supply of potash salts in the deposits found to date is so great that even in the case of greatly increased production it will suffice for much more than a thousand years."

"Kali Syndikat has more than 70 establishments and employs more than 30,000 miners and workmen."

"The majority of the carnallite and about 1/6 of the kainite and sylvinite salts are concentrated."

During the last twenty-five years the production of salt at Stassfurt has grown by leaps and bounds, the total production in 1909 being approximately ten times what it was in 1882. In the former year more than $25,000,000 worth of potash salts were produced, including:

Potassium Chloride (80 per cent KCl)	349,890 tons
Potassium Sulfate (42 per cent K_2O)	70,580
Potassium Magnesium Sulfate	38,100
Poorer grades, used chiefly in Germany	3,547,420

In 1912 the exports from the German Empire and the imports into the United States were:

METRIC TONS:	Exported from Germany	Imported into U. S.
Crude Potassium Salts	1,300,559	650,297
Potassium Chloride	286,528	190,775
Potassium Sulfate	85,452	35,366
Potassium Magnesium Sulfate	48,540	14,172
TOTAL	1,721,079	890,610(*a*)

(*a*) Equivalent to 65 cars of 100,000 lbs. capacity each, 6 days per week.

The prices of "Potassium Muriate," 1913 to Mar., 1917, are given in Table III and shown graphically in Fig. II.

The potash production in the U. S. during 1916 is given in Table IV. A similar report for 1915 showed a small quantity produced—equivalent to about one week's consumption, and valued at $350,000. Fig. III enables one to compare the imports of potash before the war with the production in the United States during 1916.

From the above it can be seen that Germany literally bored into a *natural monopoly* of the first rank when prospecting at depth was done at Stassfurt some seventy years ago. Her preëminence in this field is therefore assured until equally im-

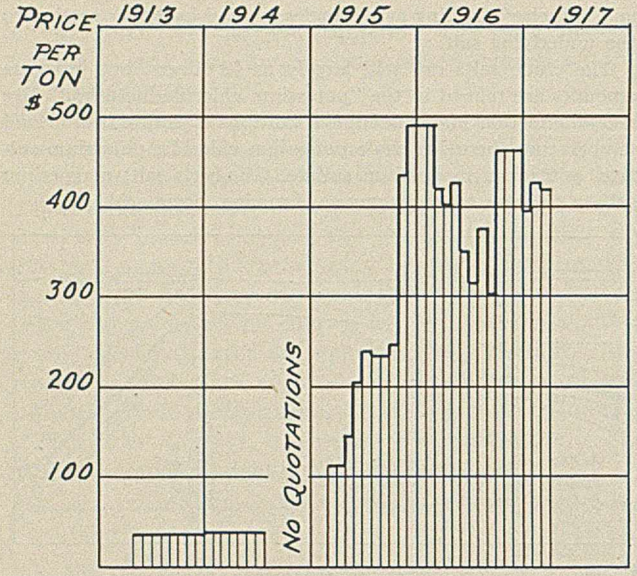

FIG. II—PRICES FOR "POTASSIUM MURIATE" (80%)

portant finds are made elsewhere, or until methods are evolved for producing potash commercially from other sources.

TABLE III—PRICE PER TON OF POTASSIUM MURIATE (BASIS 80 PER CENT)

1913	Month	1915	1916	1917
$38.55	January	Nominal	$490	$390–400
	February	Nominal	490	425–430
1914	March	(?)	415–420	415–425
Jan.-July	April	(?)	400	...
$38.55	May	$135–155	425	...
	June	200–216	350	...
Aug.-Oct.	July	230–250	300–325	...
No quotation	August	220–250	350–400	...
	September	220–250	300	...
Nov.-Dec.	October	245–250	450–475	...
Nominal	November	435	450–475	...
	December	480–500	450–475	...

TABLE IV—POTASH PRODUCTION (SHORT TONS K_2O) IN U. S. DURING 1916

(*Data compiled by U. S. Geological Survey*)

Approximate Total Production(*a*)		10,000
A—MINERAL SOURCES		5,750
Natural salts or brines(*b*)	3850	
Alunite and Silicates, including furnace dust	1900	
B—ORGANIC SOURCES		3,070
Kelp	1100	
Pearl ash (*c*)	220	
Miscellaneous industrial wastes	1750	

(*a*) Equivalent to about two weeks' consumption.
(*b*) Largest output from Nebraska alkali lakes.
(*c*) 23 out of 70 establishments reported.

Potassium compounds are very widely scattered throughout nature. That potash constitutes an important part of plant ashes shows that it is in practically all soils to some extent. The composition of saline lakes and of the ocean indicates the important rôle the circulation of atmospheric water plays in removing it from the soil. As is well known, potash in plants and circulating waters gets there from the slow decomposition or weathering of certain potash-bearing minerals, chiefly silicates like feldspars and micas. At once the suggestion arises, why do we not manufacture potash from the same sources? An immense amount of investigation has been given to the problem, but thus far with no marked commercial success. The fact that to-day, almost three years after supplies of potash from Germany have been cut off, the price of potash is ten times what it used to be, is ample proof of this statement.

As sources of potash, feldspars—especially orthoclase, $KAlSi_3O_8$—have been tried. These minerals contain from 1 or 2 up to 16 or 17 per cent potash. Immense tonnages of orthoclase too impure for use in good ceramic products would be available for potash work. The leucites of Wyoming and Idaho are even better than feldspars for potash extraction. Far more abundant than either feldspars or leucite are granites, syenites, porphyries, lavas and other primary rocks, but their potash content is lower and difficulties in the way of treatment have not been overcome. Especially valuable for potash would be many tailings dumps—if the materials could only be "unlocked" chemically, and the one or two hundred lbs. of potash contained in each ton converted into merchantable forms economically. There are patents galore covering proposed processes, but none seem to work out commercially. Among such methods might be mentioned decomposition by treatment with (*a*) alkaline carbonates, (*b*) lime or magnesia, (*c*) acids, (*d*) calcium carbonate and ammonium salts, (*e*) calcium, strontium, barium or magnesium chlorides or oxychlorides, (*f*) calcium fluoride (fluorite), (*g*) water and carbon dioxide under pressure at high temperatures (an effort to effect in a short time what nature accomplished in the course of centuries), (*h*) high temperature, quenching, pulverizing and action of acids successively, etc.

One of the most complete papers covering the economic feasibility of producing potash from feldspathic rocks was published by Cushman and Coggeshall.[1] According to these authors a 100 ft. cube of impure feldspar containing 10 per cent of potash would have in it 17,000,000 lbs. of this substance, valued at $100,000 before the war. One ton of it, with only a 75 per cent extraction, would have given $5.00 worth of potash. By the use of modified cement mill equipment these authors believed that ground feldspar and burnt lime, properly moistened with calcium chloride solution, could be granulated, burned in rotary kilns to convert the potash into potassium chloride, and then this salt leached out, recovered by concentration and crystallization, and a product obtained that would run 70–80 per cent potassium chloride. With a 300-ton mill using three 100-ft. rotary kilns, with feldspar delivered at $1.00 a ton and lime costing $2.33 a ton, they estimated that a product running 50 per cent K_2O (equivalent to potassium muriate, base 80 per cent) could be made for $31.30 per ton. This would allow a slight profit even under ante-bellum conditions. The fact that nothing has been heard about the scheme's going into actual operation may be significant.

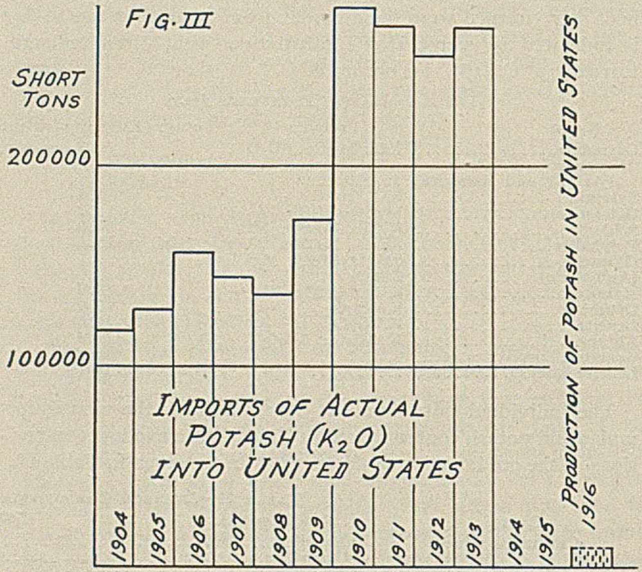
FIG. III

But strange to relate, the only way for eliminating potash economically from materials such as feldspars, rocks, clays, etc., seems to be by getting it as a by-product from other commercial operations. To illustrate, potash is volatilized from the raw mixture fed into cement kilns, and the dust collected from cement stacks constitutes a source of potash of no mean proportions. The Cottrell system of electrostatic precipitation of solids and liquids from gases is very effective in this connec-

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[1] THIS JOURNAL, 7 (1915), 145.

Table V—Composition of Solids from Saline Waters

		Ocean	Great Salt Lake			Salduro, Utah		Owen's Lake	Searle's Lake
		Challenger	Allen	Talmage	Macfarlam	Gale (1916)		Stone	Ross
		Expedition	(1869)	(1889)	(1909)	Brine	Salts	(1905)	(1912)
Chlorine	Cl	55.292	55.99	56.54	52.23	.....	....	24.82	37.02
Bromine	Br	0.188	....	....	...	.....	....	...	0.094
Sulfate	SO_4	7.692	6.57	5.97	6.65	.....	....	9.93	12.96
Carbonate	CO_3	0.207	....	....	...	.....	....	24.55	6.70
Borate	B_4O_7	.....	....	....	...	.....	....	0.14	3.00
Sodium	Na	30.593	33.15	33.39	34.64	.....	....	38.09	33.57
Potassium	K	1.106	1.60	1.08	3.66(?)	0.76–1.03	2.85–4.0	1.62	6.06
Calcium	Ca	1.197	0.17	0.42	0.39	.....	....	0.02	....
Magnesium	Mg	3.725	2.52	2.60	2.14	.....	....	0.01	Tr.
Salinity		3.30–3.74	14.994	19.558	18.39	.....	....	...	....

tion, as is illustrated at the Riverside, Cal., plant. The addition of chloride or fluoride of calcium seems to assist in expelling potash from the raw mix. It has been found also that dust collected in preheating stoves or ovens at iron blast furnaces sometimes contains important quantities of potash.

Near Marysvale, Utah, are immense deposits of alunite, a basic sulfate of aluminum and potassium, with potash contents varying from almost nothing to twelve or fourteen per cent. A plant erected by the Mineral Products Company has now been making potassium sulfate from alunite for more than a year by a process very simple, but also very wasteful. Briefly it consists in burning or roasting the alunite in rotary kilns such as are used in cement plants, allowing part of the sulfur to escape as sulfur trioxide (and probably dioxide) through the stack, expelling potassium sulfate in a volatile condition by subsequent firing at a high temperature, or leaching the residue for the removal of potassium sulfate and recovery of the salt by evaporation. The alumina and silica are now treated as waste products. In the present condition of the market such a method can be carried on profitably, but under normal conditions it would be ruinous economically. The owners of the Marysvale plant recognize this fact, and have spent large sums of money, as well as much time and effort, in endeavors to convert their waste products into valuable by-products. It is said that the plant produces 25 to 30 tons of potassium sulfate daily.

It might be remarked parenthetically that many persons make the serious mistake of supposing that native alum or aluminite (not alunite) is a valuable source of potash. This mineral is a basic sulfate of aluminum, usually with more or less iron, and contains no potash. Because of its astringent taste it is easily recognized, and samples without number have been submitted to examination, but no potash has been found. Even pure common or potash alum, $KAl(SO_4)_2.12H_2O$, contains only about 10 per cent of potash (K_2O), and is a product of chemical factories, not of the earth.

Under present conditions efforts have been directed toward recovering potash from wood ashes, sage brush, beet residues and other organic wastes. A favorite scheme seems to be to burn or char carefully, usually in kilns or retorts, and then leach the residue with water, filter and evaporate. Many high hopes are blasted when the dollars and cents side of the processes comes to be worked out.

According to Harlow and Bradley the U. S. Census showed the *world* production of potash in 1890 from wood ashes as 20,000 tons. The census for 1900 gave the cost of a barrel (650 lbs.) of potash as $18.25 and its selling price as $25.00.

The composition of wood ashes is said to be:

	Mean	Maximum	Minimum
Potash (K_2O)	5.5	10.2	2.5
Phosphoric Anhydride (P_2O_5)	1.9	4.0	0.3

Sage brush contains 5 to 7 per cent of potash, and its ashes are said to run 20 to 30 per cent of this constituent. The authors draw the conclusion that wood ashes could be made in lumbering districts and utilized for the extraction of potash with assured profit.[1]

Particularly disappointing must have been the results of attempts to recover potash from seaweed or kelp along the Pacific Coast. This proposed source has been under investigation for some years by the U. S. Department of Agriculture, and at least four large plants were constructed by corporations used to handling affairs in a big way. It was stated that practically limitless tonnages of kelp could be cut annually, and that an inexhaustible supply of potash was thus assured. Special machinery for harvesting the kelp, loading it upon barges and treating it at the factories was devised and constructed, but statistics for 1916 show how far realization has fallen below expectation. For example, the plant of the Hercules Powder Company at San Diego has utilized only 1000 tons of wet pulp per day instead of 1500 to 2000 tons, and experience to date indicates that only 22,000 tons a year are available as against an official estimate of 696,000 tons.[1]

The last source of potash to be mentioned is one of particular interest to us in the intermountain country, *viz.*, saline waters. It has long been known that water from Great Salt Lake and other land-locked seas or lakes contains potash in considerable amounts, and that sea-water itself contains appreciable quantities (see Table V). In the early part of this paper it was shown that the Stassfurt deposits themselves resulted from the evaporation of such an inland sea during milleniums long since past.

Unfortunately, potassium salts are not found anywhere in concentrated form, as is the case at Stassfurt. On the contrary, evaporation must be resorted to in order that sodium salts may be removed to a great extent before potassium compounds can be recovered in even a very impure condition, and more or less complicated methods of treatment are required to prepare concentrated potassium salts. Plants are now operating on mother liquors from salt ponds at Saltair, Utah, Searle's Lake and Owen's Lake, Cal., and on certain salt deposits at Salduro, Utah, 112 miles west of Salt Lake City.

Facts and figures shown in this paper lead to the inevitable conclusion (*a*) that independence of the United States from a foreign source of potash is a "consummation devoutly to be wished," (*b*) that thus far most extensive surface prospecting by private parties and government agents has failed to locate soluble potash deposits of any value, (*c*) that certain potash extraction plants of the "war baby" type have sprung up and can continue operations only as long as importations from Europe are stopped or under price conditions essentially higher than those obtaining prior to July, 1914, (*d*) that slight additions to potash supplies can be looked for from the utilization of cement kiln and blast furnace dusts, distillery and sugar factory wastes, wood ashes and wool scourings, and (*e*) that a service of incalculable benefit to mankind will be rendered by the discoverer of a process whereby soluble potassium compounds can be made cheaply from feldspar, leucite and other silicates containing potash.

The "World Emergency" confronting us to-day is therefore not one of militarism or national politics only: it is one of economic independence also. Because Germany alone is favored with deposits of potash salts; because nitrates are found in commercial quantities only in the dry regions of western South America; because Russia has the distinction of producing practically all the platinum mined—for these reasons shall scientists and engineers the world over accept things as they are and do

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[1] See This Journal, 8 (1916), 105.—[Editor's Note.]

[1] *Eng. & Mining Jour.*, Feb. 24, 1917, pp. 103 and 333.

nothing to meet the great emergency? By no means! Economic campaigns more alluring and important than any planned by military leaders are called for, and the rewards to be reaped are almost beyond conception. Already special alloys have been prepared for use as substitutes for platinum. The "fixation of nitrogen," or its conversion from inert, free nitrogen of the atmosphere into valuable products like ammonia, nitrates, and cyanides, is a commercial success. But the greatest of the three desiderata remains an unsolved problem, *viz.*, how can immense stores of potash locked up in our feldspars, leucites and many rocks, be freed from their "entangling alliances," and made available to our manufacturers and—most important of all—to our farmers? The problem is not necessarily incapable of solution, but prolonged, persistent, painstaking effort, with ample provision for large scale experimenting, are needed. The Napoleonic Wars gave us cheap soda; will the World War of a later century give us cheap potash?

809 Kearns Building
Salt Lake City, Utah

THE RECOVERY OF POTASH FROM BEET-SUGAR HOUSE WASTE LIQUORS[1]

By H. E. Zitkowski

The recovery of the residual values from beet-sugar waste liquor has been the subject of serious investigation even prior to the war. However, the abnormally high potash prices of the past few years have brought about renewed efforts in this direction.

FUNDAMENTAL CONSIDERATIONS

During the 1916 season approximately 6,000,000 tons of sugar beets were produced in the United States. In all probability a materially greater tonnage will be produced this year, and the possibilities for increased production in the immediate future are promising, though this phase of the problem is so intimately related to the tariff, the agricultural labor supply, and ruling prices of other agricultural products, that prophecy is fruitless.

The composition of the beet, and therefore its content of potash, is variable from season to season and in different localities and soil conditions. The following analyses of beets from three widely separated localities in the United States can serve as a basis.

	Colorado	California(*a*)	Wisconsin(*a*)
Moisture	78.36 per cent	63.99 per cent	74.37 per cent
Dry substance	21.64	36.01	25.63
Ash (carbonate)	0.89	0.88	.....
Total nitrogen	0.199	0.254	0.1817
Sugar	15.40	25.60	18.7
Mineral Matter (Per cent on Beets)			
Cl	0.102	0.065	0.040
SO_3	0.028	0.034	0.024
P_2O_5	0.046	0.121	0.023
K_2O	0.320	0.269	0.320
Na_2O	0.097	0.106	0.089
CaO	0.032	0.078	0.041
MgO	0.058	0.051	0.047
$Fe_2O_3.Al_2O_3$	0.042	0.014	0.027
SiO_2	0.005	0.016	0.036

(*a*) Both the California and Wisconsin samples were several days in transit to the laboratory at which the analyses were made, and undoubtedly lost considerable moisture by evaporation, which consequently increased the percentage content of dry matter. Aside from that the California sample was abnormally high in sugar content.

From an agricultural and economic view-point—aside from the sugar—the nitrogen, phosphoric acid and potash content of the sugar beet is of more than passing importance. Accepting the average of the three analyses herein reported as the average for the entire production, the 6,000,000 ton crop of beets of 1916 contained:

Nitrogen	Phosphoric Anhydride	Potassium Oxide
12,700 tons	3,780 tons	18,180 tons

Investigations indicate that in extracting the sugar values by the diffusion process approximately 60 per cent of the nitrogen and 90 per cent of the phosphoric acid and potash content are extracted with the sugar and pass into the process, the rest remaining with the pulp. As this pulp is now completely utilized for live stock feeding purposes, the plant food values of this pulp are not lost to agriculture except in so far as farmyard manures are inefficiently utilized.

Of the plant food values extracted and now in the juices phosphoric acid is completely eliminated as calcium phosphate, and to date largely wasted. A part of the nitrogen content is eliminated as coagulated protein and otherwise, together with the phosphoric salts. The potash, however, is not eliminated from the juices by the usual processes of purification and is found in the final molasses, *i. e.*, the mother liquors, from which sugar cannot be further recovered by direct crystallization, and for this condition potash salts are partly responsible.

The production of molasses from beets is somewhat variable from season to season, but an average percentage production for the United States will be somewhere between 5.5 to 6.0 per cent on beets. With a six millon ton crop of beets this totals 330,000 to 360,000 tons.

A study of a series of thirteen samples of American beet molasses as reported in *Sugar*, Vol. 18, No. 4, indicates an average content of 1.69 per cent nitrogen and 4.66 per cent potassium oxide (K_2O).

On this basis the beet sugar molasses production of the past campaign contained between 15,400 and 16,700 tons of K_2O, which checks fairly closely with the figures above estimated. Of the total beet molasses production perhaps 5.0 per cent under normal conditions, but under present conditions double this amount or more, is used in alcohol production and the still residues, containing the potash, are concentrated and usually enter the fertilizer trade and are, therefore, not lost to the general economy.

Approximately 40.0 per cent of the total molasses production is used for stock feeding purposes, in part direct as such, but by far the greater part is mixed with some absorbent feed, frequently beet pulp, either fresh or dried, and also many of the fodders. The potash values in this case are recovered in proportion as the manurial values from these feeding operations are recovered.

The remainder of the United States molasses production, perhaps 45.0 per cent of the total (during the past season from 148,000 to 152,000 tons) is desugarized, that is, sugar is extracted in marketable form. It is this portion of the beet crop that contains the possibilities of potash production in commercial form at the sugar factories.

STEFFENS PRECIPITATION PROCESS

The process now used almost exclusively in this country in extracting sugar from this molasses is known, after its inventor, as the Steffens precipitation process, in which sugar is precipitated as tri-calcium saccharate.

Procedure—Molasses of about 80.0 per cent solids is diluted to 10 to 12 per cent solid content, cooled to about 15.0° C. and under suitable means for cooling and stirring, finely powdered calcium oxide is dusted into the solution. If the conditions essential to the process are adhered to, 90.0 per cent or more of the sugar is precipitated as a calcium compound and is removed from the mixture by filtration. The filtrate, now with a content of solid matter of 5 to 7.0 per cent contains practically all of the potash originally in the molasses and also variable percentages of sugar not precipitated above. The sugar in solution is probably present in the form of di-calcium saccharate, $C_{12}H_{22}O_{11}.2CaO$. If this cold filtrate is heated to 85° C. approximately 60.0 per cent of the sugar in solution is precipitated as a calcium saccharate probably according to the following reaction:

$$3C_{12}H_{22}O_{11}.2CaO \rightleftharpoons 2C_{12}H_{22}O_{11}.3CaO + C_{12}H_{22}O_{11}$$

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[1] Presented at the Buffalo Meeting of the American Institute of Chemical Engineers, June 20 to 22, 1917.

The reaction is reversible and on cooling the saccharate formed dissolves: hence it is necessary to filter at the precipitation temperature.

This, known as the "Hot Saccharate" process, is now quite generally used to recover from the solution additional sugar values which are not readily and economically recovered by the first step or cold process.

The filtrate, now known as Steffens hot waste water, still contains from a few hundredths to 0.4 or 0.5 per cent of sugar, some lime, practically all of the potash and most of the other non-sugars present in the molasses. This is the waste liquor forming a potential potash supply.

PRESENT USES OF WASTE LIQUORS

In several instances where the sugar company controls agricultural lands in quantity adjoining the factory, these waste liquors, together with other residues, are used to irrigate the lands. This is perhaps the most economical method of utilizing the residual values, as all of the potash and phosphoric acid and nearly all of the nitrogen of the beet can be returned to the soils, but this is practical only in isolated instances, and only about 8.0 per cent of the total beet crop is handled in this manner.

In still other of the irrigated sections where the residual waters are discharged into existing streams and the streams are subsequently diverted for irrigation purposes some of the values may be inadvertently utilized, but in any event the losses to the economy of the state must be very considerable by this method of disposal.

In most cases the waste residues are sent into settling basins, the clear effluent of which reaches the streams and is carried away. Efforts had been made even before the war to recover these values, and owing to the stimulus of high potash prices of recent years the work in this direction has been followed with more than usual vigor. However, the problem has its difficulties.

Since the hot waste water as produced is very dilute, containing 96.0 per cent or more of water, it is necessary to concentrate it. As produced it contains 0.2 to 0.5 per cent of free lime, CaO, which will foul the evaporating surfaces if not removed. This is readily enough accomplished by carbonating (injecting CO_2 gas) and filtering.[1]

The carbonated and filtered waste water varies in composition with the season, locality and factory practice, but the following is typical:

PERCENTAGES: Moisture	Dry Substance	Carbonate Ash	Sugar	Organic Non-sugar	Nitrogen	Potash K_2O
97.00	3.00	1.00	0.30	1.70	0.16	0.35

This indicates at once that the content of values is low, the cost of evaporation comparatively great, and also that, under normal conditions, when the value of a unit of nitrogen is two or three times that of a unit of potash, the nitrogen values are as great or greater than those of the potash contained in these waters. Up to a content of 50 to 55 per cent dry substance this water can be readily enough concentrated in multiple effect evaporators, and quadruple as well as quintuple effect evaporators have been used very successfully. With a content of more than 55 per cent dry matter the liquor begins to salt out and foul the heating surfaces. However, beyond this point the material can be readily enough concentrated still further, and brought to a dry state by the use of one of the various types of vacuum drum dryers. The trouble is to keep the material dry.

The dried material containing 10 to 12 per cent of K_2O and 5.0 per cent nitrogen is so exceedingly deliquescent and absorbs atmospheric moisture so readily that it becomes fluid in a very short time.

Various absorbents have been used to overcome this difficulty, one of the most successful being dried slaughter-house wastes, which incidentally are deficient in potash so that the two materials complement one another. Ultimately this may prove to be a direction in which considerable quantities of the sugar-factory waste waters will be utilized, but unfortunately only a few beet-sugar factories are now located within reasonable distance of the meat packing centers so that the cost of freight enters.

In some localities small quantities of 50 to 55 per cent dry substance have been disposed of in tank car lots directly to the agricultural industry as a liquid fertilizer. In other instances it is urged to sell the liquid fertilizer direct to the farmer for use by saturating barn manure with it. It is doubtful whether material quantities can be disposed of in this form at present.

With present potash prices the nitrogen values have lost their relative importance with the result that in at least one instance these have been sacrificed in order to obtain a product comparatively high in potash content, which would permit its shipment considerable distances to the potash consuming centers.

When the Steffens water is concentrated to about 55.0 per cent dry substance it can be quite readily ignited and charred, owing to its high content of sugar and other organic matter, its own content of combustible matter then furnishing most of the necessary heat. The char, or crude ash, thus produced contains from 30 to 35 per cent potassium oxide, but only traces of nitrogen. This procedure is economically justifiable only with present potash prices. In other directions experiments are being made towards a recovery of the potash salts in comparatively pure form, at the same time saving the nitrogen values.

The above roughly covers the efforts made in the recovery of the values of the beet-sugar liquor residues.

PROGRESS IN RECOVERIES

Technically, the recovery of the potash values from these liquors is a comparatively simple and perfectly feasible problem. It is simply one of evaporating the dilute liquors as economically as is practical, charring the residue to produce the crude ash and leaching and recrystallizing if this is desired. The quantities of water to be evaporated, however, are large, the necessary equipment costly, and such a procedure has commercial possibilities only during war prices.

Now it is true that almost any sugar factory could have paid for a potash recovery plant in one year with present potash prices, but the war may end any time and leave a lot of very costly equipment on hand, especially as the cost of such equipment, evaporators, boilers, etc., is abnormally high at present. Then also a beet-sugar factory operates seasonally only: the average length of the operating season is only about 100 days, and the earnings must be made during this short period. But at that some progress is being made, and at least one concentrating plant is under construction and several others under consideration and more of the values will be recovered during the 1917 campaign than during the past.

However, in these instances a recovery of all the values in the liquors is aimed at, not the potash values only. This will be touched briefly below.

Approximately the disposition of the potash in the sugar-beet crop grown in the United States at present is as follows:

Returned to Farms in Pulp	10.0 per cent
Found in Molasses Produced	90.0 per cent

The potash found in molasses is distributed as follows:

To Alcohol Plants	10.0 per cent plus
Used as Molasses Feeds	40.0 per cent plus
Desugarized	45.0 per cent plus

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[1] It might be stated that during the past campaign in one case these waters were concentrated by the direct gases from an oil fire passing upward through a sheet metal gradier over which the waste liquors flowed. In this case removal of the lime was not necessary as the heat transfer was brought about by direct contact without an intervening metallic surface. This method of evaporating is prohibitive as to costs under normal conditions.

This leaves under control of the manufacturers only about 40.0 per cent of the potash content of the beet which on the basis of a six million-ton crop amounts to between 6800 and 7500 tons of K_2O.

This quantity is now disposed of as follows:

Directly to the soil as factory sewage	20.0 per cent
Concentrated to 50–55 per cent dry substance and sold to fertilizer factories	5.0 per cent
Concentrated and calcined to a crude ash	5.0 per cent
Discharged into streams (representing the stock of values now lost)	70.0 per cent

Thus far the subject has been considered from the angle of recovering the potash for the chemical industries or the potash and nitrogen as fertilizers only. That does not by any means exhaust the possibilities. Beet-sugar molasses and therefore the waste water contains a great number of substances which in themselves are valuable or may serve as the mother substance for valuable products. The possibilities can here be touched on only very briefly.

GERMAN TREATMENT OF WASTE LIQUORS

Even in the case of potash and nitrogen it appears from the experience of Europe that the general economy is served best by combining these into a more valuable product. From Germany it is reported that by the Bueb process of destructive distillation the waste liquor of molasses desugarizing processes operating by the strontium process, in that country, produce annually 5000 tons of potassium cyanide and 5000 tons of ammonium sulfate. Steffens waters can be similarly utilized and a United States patent has been granted for such a process.

The molasses waste liquors contain a whole series of organic acids which can be recovered and are valuable to industry.

The nitrogen of these waste liquors occurs in various forms, partly as a plant base of which the principle is betain, which has found some application in medicine. A large part of the nitrogen content exists in the form of amido acids. These it has been shown by Effront can, by suitable fermentation processes, be split into ammonia and a mixture of volatile fatty acids, acetic, propionic and butyric. Recent investigations in this country indicate that a mixture of the high boiling point ketones valuable in cellulose technology can be prepared from this liquor.

Ehrlich insists that the amido compounds present in considerable quantities in beet molasses waste liquors are the mother substances of fusel oil, more particularly amyl alcohol, and suggests extracting these compounds and utilizing them to increase the fusel oil production. This indicates only a few of the possibilities. While it is not claimed that beet molasses may yet prove another coal tar, chemically it may be almost as interesting.

But little has been done in developing the waste liquors values in this country. The reasons are various. Not the least lies in the fact that sugar is a sort of national and international political football. Between duties, bounties, premiums, special international agreements (as, for instance, the Brussels Conference) and competition with the tropics, the beet sugar industry in the United States has never felt sufficiently safe to venture in new directions.

At the outbreak of the present war the outlook was particularly dark. The tariff had been lowered, and a duty-free sugar clause enacted to go into effect May 1, 1916. Fortunately, this latter clause was repealed before going into effect.

What the development of the future may be will depend more upon legislation following cessation of hostilities than present high prices and in this respect the beet-sugar industry is not differently situated than most other chemical industries in this country.

American Beet Sugar Company
Rocky Ford, Colorado

THE INFLUENCE OF PIGMENTS ON RUBBER[1]

By Maximilian Toch

Rubber has a strange analogy to linseed oil and China wood oil, and although as far as we know the chemical compositions of rubber and the drying oils are totally different, this analogy holds good for reasons that we cannot explain. In 1904 I delivered a lecture on the chemistry of the rubber pigments before the American Chemical Society, and I published it privately, for I knew at that time that it should not be taken as final on account of my limited knowledge of the subject, but in thirteen years I have learned a little more on the subject so that I am able to-night to give you some facts which should be helpful.

The rubber industry thirteen years ago was insignificant, that is to say, if rubber and its compounds had been entirely destroyed from the face of the earth we would not have suffered very seriously for any great length of time because matters would have adjusted themselves, with perhaps some inconvenience, in less than a year. The loss of hard rubber would probably not have been felt for any great length of time, owing to the fact that celluloid and some of the lighter metallic alloys would have replaced it, but to-day, we face a different situation. Take the automobile industry alone, which I am informed ranks third in size and money invested in the United States, and the rubber industry sixth or seventh in size and investment in the United States, and you will plainly see that without rubber tires the automobile industry could not exist with the same measure of success.

At the Eighth International Congress of Applied Chemistry held in New York in September, 1912, Dr. Duisberg showed a piece of synthetic rubber, made in Germany, which weighed perhaps 20 kilos or more, and two automobile tires, made from this synthetic rubber, which had traveled 4000 miles, and apparently this rubber was as good or better than the natural. But if our information is correct, synthetic rubber is only a laboratory product, and the Central Powers are suffering tremendously for the want of rubber in warfare, for without it no staff officer can travel any great distance and ambulance work becomes a hardship and a menace with tires made of any other material, so that we must conclude that artificial or synthetic rubber is not yet a commercial success. The submarine that has been making several trips between Germany and the United States took back a cargo of platinum and rubber, indicating that rubber is an essential without which certain industries cannot hope to make much progress.

We accept the composition of rubber as being a terpene composed of C_5H_8, but rubber as it is derived from the latex of the fig tree is much more complex and contains an appreciable quantity of oxygen; yet when the resins are extracted and we have a clean, elastic mass of the Para type there is no question of the composition of this mass being C_5H_8, or perhaps $C_{10}H_{16}$.

The difference between hard rubber and soft rubber is a question of degree, vulcanization and percentage of sulfur. If we were to draw a hexagon of hard rubber and soft rubber we would have to conclude that the sulfur combination of rubber has two eutectics.

Rubber comes to the manufacturer now in a fairly pure state. Raw rubber contains moisture and foreign substances to a very large extent, all of which must be removed before the rubber is vulcanized. When cleaned rubber is mixed with from 3 to 5 per cent of sulfur and placed in a vulcanizer under pressure for several hours a soft rubber is the result, that is to say, it has a greater elasticity than the raw material from which it has been made and a distinct combination has taken place between the terpene and the sulfur. If, however, from 30 to 35 per cent of sulfur is added to the rubber and the pressure and heat con-

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[1] Address before the Syracuse Section of the American Chemical Society, Syracuse University, Syracuse, N. Y., April 13, 1917.

tinued for a longer period, a hard substance is the result which we know as hard rubber or vulcanite. The soft vulcanization to which I have referred is never a permanent material, that is to say, after the lapse of a few years, more or less, the rubber loses its elasticity and becomes brittle. The hard product, which contains from 30 to 35 per cent of sulfur, has been known to last for many years.

In 1912 the battleship "Maine," which had been lying in the mud 25 feet below the surface of the water in Havana harbor, was, as you remember, uncovered and the remains of the wreck were floated and taken out to sea and buried. The War Department and the Navy Department suggested at the time that I make an examination of the materials of which the ship was built to see the amount of deterioration that had taken place in 13 years. I duly reported on the condition of the metal and wood, and to my very great surprise all the rubber packing used in the pumps was as pliable and as perfect as the day on which the ship was sunk. I brought back several samples of this rubber packing, and they are still to be seen in the chemical museum of the College of the City of New York. It would therefore indicate that rubber in any form is perfectly preserved if kept away from oxygen, and this demonstrates a strange analogy: that rubber and many metals have the same characteristics and are preserved in the absence of oxygen.

There is a third method of vulcanization used for soft elastic articles such as toy balloons, rubber gloves, finger tips, dress shields and materials of that description. This is done by sheeting the rubber, cutting it or pressing it into the size of its ultimate shape and subjecting it to the vapor of sulfur chloride, but owing to the fact that the rubber will take up more sulfur and chlorine than it needs, articles of this type do not last as long as those that have a definite amount of either sulfur or chlorine in their composition. Bisulfide of carbon is used as a carrier for the chloride of sulfur, and unless the rubber article is thoroughly treated with ammonia or afterwards rinsed in some other dilute alkaline liquid, a mixed acid is formed, which tends to rot or destroy the rubber so made.

The rubber industry is still empirical to a large extent, and much of this has been due to the fact that the practical superintendent of the rubber factory, like many a practical man who has no fundamental education, resents the interference of the laboratory in his methods, but this will be overcome to a large degree when the practical superintendent will have been raised from the ranks of the research laboratory.

The rubber in pure form, that is to say, mixed only with sulfur and vulcanized, is not used to a very large extent in the arts. Of course, certain materials like dental dam, elastic bands, high-grade inner tubes, and a few such articles must be exempted. In fact, I can include the rubber portion of the football. As a rule, the rubber bladder which is enclosed in the leather case is generally made of a very high type of pure vulcanized rubber only, but all the other articles must of necessity be compounded with either fillers or reinforcing pigments.

Please observe carefully that there is a great difference between the ordinary filler of rubber and the reinforcing pigment. If you take an ordinary article of commerce like a rubber door mat this may be composed of only 7 or 8 per cent of pure rubber, the balance being reclaimed rubber and heavy fillers; but, on the other hand, if we take an automobile tire and inner tube it is quite important that fillers should not be used but reinforcing pigments should be used, for an automobile tire is now sold entirely on its merits and in many instances a guarantee is given as to its longevity. In due course I shall describe to you one of the reinforcing pigments which has so improved automobile tires as to increase their mileage from 2500 to 5000 miles.

The principal fillers used are barytes, whiting, Paris white, clay, ground slate, silicious hematite, silicious black oxide of iron, and many of the minerals of these types.

The principal reinforcing pigments are sulfide of antimony, litharge, precipitated barium sulfate, precipitated barium carbonate, vegetable black, carbon blacks free from grease or oil, alum-free ultramarine blue, red lead, sublimated zinc lead, zinc oxide, and lithopone. There are a number of others which I shall also describe.

FILLERS

Barytes is the natural sulfate of barium, which is crystalline and of itself has no chemical effect on any rubber composition as it is insoluble and infusible under ordinary conditions. It is, however, usually coarse, and there is some objection to it on account of its specific gravity, which averages 4.6.

Whiting and *Paris white* are the same, for they are both calcium carbonates. In time these materials are inclined to harden rubber, but one of the defects of the calcium carbonates is the amount of moisture that is adherent to them.

Clay is silicate of alumina and has the same defects as whiting if not more so, owing to the moisture which it contains and which is very likely to produce microscopic blowholes.

Ground slate as an earth consists of silicate of alumina containing iron and magnesia and is only to be recommended, after having been thoroughly dried, for coarse, cheap rubber materials.

Silicious hematite is a native oxide of iron containing about 30 per cent silica and 70 per cent iron oxide, Fe_2O_3. Sometimes, depending upon the locality, the iron content may run lower or higher. It is not to be recommended on account of its high specific gravity and on account of its coarseness.

Silicious black oxide of iron is really a black slate which contains a fairly large amount of magnetic iron oxide. It is used only with materials as a "make-weight."

REINFORCING PIGMENTS

I am giving only a list of those that are used in large quantities, for there are many other materials with which this paper does not deal, as, for instance, the colors like chromium oxide, chromate of barium, chromate of zinc, sulfide of arsenic, and the blacks made from various carbonized materials.

Sulfide of antimony is one of the most important of the reinforcing pigments. This may contain no sulfur and be a pure antimony sulfide, or may contain as high as 17 per cent of sulfur. In this respect it has a great analogy to ultramarine blue, where the sulfur content and its stability as a chemical compound increases the life of the rubber rather than decreases it.

Litharge is the monoxide of lead, forms lead sulfide in the vulcanizing process, and, like antimony, produces a more or less soft rubber, practically the same as it does when used as a pigment with linseed oil. Red lead, which is a higher oxide of lead (Pb_3O_4), has a directly opposite effect on both rubber and linseed oil, for in time it produces a very hard, brittle rubber.

Precipitated barium sulfate, which is sold under various names, is either good or bad, depending entirely upon the method of its manufacture. If it is a straight barium sulfate made from a mixture of two materials which produces barium sulfate, and the precipitate washed and dried, it is one of the best reinforcing pigments which we have. If it is a by-product, however, it may contain oxide of barium and occluded moisture, which in a rubber tire would be harmful instead of producing good effects. This material is very largely known under the name of blanc fixé, tyre-lith or permanent white, and has almost entirely superseded, among the better manufacturers, the use of barytes.

Precipitated barium carbonate—The same is true of barium carbonate that is true of barium sulfate, excepting that barium carbonate can be decomposed. In an acid atmosphere it is not as good as barium sulfate.

The *vegetable blacks* are all carbons produced from either the roasting and reducing of willow, peach kernels, shells of nuts, and the like, and have a very slow drying effect on rubber; but in this connection carbon black is superior when free from grease or oil, and although it retards curing just as it retards drying in linseed or China wood oil, it inversely prolongs the life of the rubber.

Sublimed zinc lead has come into use only within the last ten or twelve years. It varies in composition from 5 per cent of sulfate of zinc and 95 per cent of oxide to 50 per cent of sulfate of zinc and 50 per cent of oxide of zinc. At all events, it has the great advantage over white lead that it contains no combined moisture and is not likely to produce blowholes, although it blackens in a heated mixture of sulfur and sulfur compounds even though some authorities claim that it does not do so.

Zinc oxide is one of the most valuable reinforcing pigments in the rubber industry and perhaps ranks higher than lithopone. It has a distinct hardening effect on rubber in time, but can be altogether regarded as a perfectly stable compound.

Lithopone is a mixture of zinc sulfide and barium sulfate and always contains a small percentage of zinc oxide. It is very largely used in the rubber industry to replace zinc oxide, although it is less of a reinforcing pigment. It has the unfortunate habit of turning gray when exposed to sunlight, but it turns white again when allowed to remain in the dark for a considerable length of time.

Magnesium carbonate is a spreader or extender, and when pure has no bad effect on rubber. It is used largely for making rubber more filmy and gives somewhat the effect of satin to sheet rubber.

Ferric oxide red, which is a pure Fe_2O_3, is sold from a bright scarlet to a cherry color. When pure it has no effect on rubber, but when impure, containing a small amount of acid, it is deleterious.

Ferric oxide yellow is a hydrated oxide of iron and silicate of alumina, either natural or artificial. When absolutely dry and finely powdered it is very useful where a small percentage of rubber enters into the composition of the material made.

English vermilion is a sulfide of mercury largely used, and although its price is somewhat prohibitive in most articles, it is the only brilliant red color we have and is not injurious to rubber.

Graphite is a carbon, the purer forms consisting of 90 per cent carbon (graphitic) and 10 per cent silica and silicates. It cannot be regarded as a filler for it improves rubber for mechanical uses, exerts no bad influence and lengthens the life and usefulness of many rubber materials in which it is used.

I have not dwelt on the aniline dyes which are used, nor on the resinate and oleate colors, as this is really a separate subject and cannot be treated to-night. In a few words, however, I may say that the resinate aniline dyes have a decided use as a rubber coloring and are not as harmful as the oleate dyes. However, for toy balloon work and materials that are not supposed to last long, there is a decided use for some of the "lakes" in the so-called "cold-cure" method.

320 Fifth Avenue
New York City

INDUSTRIAL WASTE DISPOSAL[1]

By Harrison P. Eddy

While there are various waste materials resulting from the industries, the term "industrial wastes" has come to mean the liquid wastes from the processes employed in industrial establishments. In England they are called "trade wastes"—a term not quite as applicable in this country, although occasionally used. Neither the human excrement of operatives nor their wash waters are comprehended in this term, although in many cases there is no effort to prevent their admixture.

ORIGIN OF INDUSTRIAL WASTES

Many industries employ great quantities of water for various purposes such as condensing, washing of raw stock, dilution of chemicals, transportation and application of materials and the washing and rinsing of finished products. Some of these uses do not defile the water and it can be discharged at will, as for example, many condenser waters. Other uses result in a very great change in the character of the water and render it unsuitable for discharge into some waterways.

In paper mills, after the digestion of the raw stock with strong chemicals, there remain the liquors, highly charged with mineral and organic substances, but for which the manufacturer has no further use. He therefore seeks to get rid of them in the most expeditious and least expensive manner. The fibrous stock is then washed and large quantities of wastes are discharged from the washers, more or less highly charged with substances like those already mentioned. From the paper machines come great quantities of water carrying fine fiber, clay, coloring matter and other substances depending upon the character of paper made and the processes employed.

In tanneries, pure water is indispensable, but after use it is highly colored, charged with spent chemicals and loaded with organic matter. Its burden of impurity is partly in suspension and partly in solution. Wastes from different processes within the same tannery often react upon one another, throwing out of solution substances which in their new physical condition may be deposited in waterways to their detriment. Some tannery wastes of themselves are so resistant to bacterial action that they do not readily putrefy, yet when diluted with the waters of a natural stream they may become most offensive.

The wastes of woolen mills vary radically from those of paper mills and tanneries, yet they may be the cause of just as serious complaints. The grease and soaps from the scouring of the wool, the spent dye liquors, the soaps from the cloth-washing and the rinse waters in the aggregate, are of great quantity, highly colored, turbid, charged with suspended matter and quite capable of transforming an attractive stream into an unsightly, foul-smelling and quite unattractive waterway.

Instances like the foregoing might be multiplied almost without end. Some of the other industries which have encountered difficulties in the disposal of wastes are wire-drawing and galvanizing works, carpet mills, dyeing and bleaching works, strawboard factories, slaughtering and packing houses, breweries, distilleries, gas works, chemical and explosive works and mines and coal washing plants.

EFFECTS OF WASTES UPON WATERWAYS

The ingredients of industrial wastes may be grouped in three main classes:

(1) Floating and suspended matter.

(2) Substances in solution, in colloidal condition and in an extremely fine state of suspension.

(3) Bacteria.

Floating and suspended substances may render the waters into which they are discharged, unsightly, and cause deposits. Such deposits, if of organic matter, often deprive the overlying water of a large proportion of its natural content of dissolved oxygen which is necessary for the maintenance of biological equilibrium and the prevention of putrefaction. Decomposition is accompanied by the generation of large quantities of gas, some of which is entrained in the mud until it has accumulated sufficiently to enable it to buoy up large masses which may be seen floating for a time upon the surface of the water only to be broken up and redeposited upon the liberation of the gases.

Dissolved substances almost always accompany the suspended matter in industrial wastes. Sometimes they are much more troublesome. They, too, cause the depletion of the oxygen supply, usually through the action of the bacteria of decomposi-

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[1] Read at the Buffalo Meeting of the American Institute of Chemical Engineers, June 20, 1917.

tion. Particularly objectionable and difficult to treat are those wastes containing large quantities of very finely divided suspended matter and colloidal substances. Usually impurities of this class pass along with the waters of the stream into which they are discharged and do not form deposits. However, under some circumstances such ingredients are coagulated and thrown down, sometimes by the reaction of wastes of one process with those of another, and at others by natural physical, chemical and biological processes going on in the waters.

Most industrial wastes contain bacteria. These may not be pathogenic germs. In fact, they may be decidedly helpful in the problem of disposal, rather than harmful. There are abundant opportunities in some of the industries, however, for the pathogenic organisms to escape in the liquid wastes and thus contaminate the waters into which such wastes are discharged. One of the most dreaded organisms which may be spread about in this manner is the anthrax bacillus, sometimes present in hides, skins and wool. This organism is very hardy and appears to maintain its virility through its spores for many years.

Excrementitious matter from operatives is often combined with the industrial wastes and thus the entire flow may be rendered bacterially dangerous.

Wastes may cause objectionable conditions in many ways, depending upon their character and the size and condition of the waterway into which they are discharged. They may contaminate a water supply, render a stream unsightly and objectionable in appearance, cause putrefying deposits, render the natural waters putrid and offensive, poison or otherwise kill fish, and injure vegetation. Strange and contradictory as it may sound, complaint is frequently made that wastes are killing vegetation and about equally often that they are so encouraging the growth of vegetation as to do serious damage. If one complaint doesn't apply the other usually does.

It might appear that as the industries are the offenders in this field of activity, there would be few complaints from them of the conditions produced by the discharge of industrial wastes. Just the contrary is true. One of the most common complaints comes from the manufacturer to the effect that an upper riparian industry is rendering the water unfit for use in his plant.

SELECTION OF FACTORY SITES

Enough has been stated to show how wide-spread is the trouble in disposing of industrial wastes. When about to establish a new industry or plant, the proprietors usually make thorough investigation of the quality of the water available for their use. The extent of the supply is also generally investigated and often such collateral questions as the amount of power derivable from the passing stream. But how infrequently do they make even a superficial study of the problem of wastes disposal. Yet this may be a greater and more difficult problem than that of water supply.

Expenditures of $100,000 or $200,000 for wastes treatment plants and of $25,000 to $40,000 annually for the operation of such plants are becoming more and more frequent. Capitalizing the annual expenditure of $25,000 at 5 per cent and adding $100,000 for construction cost, making no allowance for depreciation, it appears that the industry might have expended as much as $600,000 in procuring a site which would not have entailed the necessity of wastes treatment.

The selection of a suitable site for an industry producing large quantities of wastes is a matter of much importance. Even though conditions at the outset appear to be favorable they may be materially altered by establishment of new industries down stream or by an increase of riparian population below the plant.

TREATMENT OF WASTES

When it is impracticable to afford the wastes sufficient dilution to prevent the production of unsatisfactory conditions, it becomes necessary so to modify the character of the wastes that they will not cause complaint.

One often hears that wastes cannot be so treated; that if a way were known the manufacturer would gladly adopt it. This impression that the wastes cannot be successfully treated is in many cases not true and it may be accepted that they can be so treated as to remove their objectionable and deleterious properties before their discharge into natural waterways.

On the other hand, such treatment may be and often is a very expensive undertaking and one from which the manufacturer naturally shrinks on this account and also because he personally is not familiar with the process or processes necessary to the accomplishment of the object.

Perhaps the most important step in the solution of this problem is the determination of the extent of treatment necessary to meet the requirements of the case. To answer this question intelligently it is necessary to know the character and quantity of the wastes produced, the character of, and conditions surrounding the waterway into which they are being discharged, and their effect upon the waters in question.

The next step is to determine how best to treat the wastes to accomplish the necessary results at a minimum cost and, in any event, one which is not prohibitive. There have been instances when the plant proposed for such treatment would have cost a sum about equal to the value of the entire industrial plant of which it was to become a minor part. Such a suggestion is absurd and tends to reduce or extinguish the respect of the manufacturer for the party making the suggestion, for the officials trying to enforce the laws and even for the laws themselves.

For the removal of suspended matter, screening may suffice under some conditions, while others may require the more complete removal by sedimentation. When the substances in suspension are of very light specific gravity and finely divided it may be necessary to resort to chemical precipitation.

Some dissolved matters may be removed by chemical precipitation, while others can be modified in character by chemical treatment without actual removal. If they are organic and subject to putrefaction, bacterial action may be required for their oxidation, as in sewage treatment.

Certain wastes are bacterially dangerous and it may be necessary to destroy the pathogens even where the suspended and dissolved matters would cause no harm. In such cases the treatment of the wastes may be all that is essential, while in others it may be necessary even to treat the raw material as has been suggested in the case of anthrax-infected hides.

It should not be inferred from this discussion that a single process can be selected for each case, for it often requires several to accomplish the desired result.

At one plant where the author's firm has supervisory charge of the wastes disposal department, no less than seven steps have been employed at one time. These are: degreasing of a portion of the wastes, sedimentation of the wastes, chemical treatment of the settled effluent, filtration of a portion and dilution of the remainder of the chemical effluent and finally the introduction of chemicals to prevent the exhaustion of the supply of oxygen in the river.

VARIATION OF TREATMENT FROM TIME TO TIME

The process adopted should in many cases be varied from time to time to take advantage of favorable or to offset unfavorable conditions. The volume of business being done may materially affect the quantity of wastes produced and correspondingly make the condition dictating treatment more or less exacting. Industrial processes frequently are changed requiring modification in the treatment methods.

In winter temperatures may be sufficiently low to retard or even prevent putrefaction under conditions which in summer would transform a natural waterway into a stinking slough. In spring there are usually large volumes of diluting water which may make bacterial oxidation in filters unnecessary, at a time when the filters would be working under most unfavorable conditions.

All of these and innumerable other conditions must be taken into consideration if success is to be attained at a minimum cost.

ADVISABILITY OF ANTICIPATING COMPLAINT

In many cases industrial establishments which are now of great size have grown from very modest beginnings, often from merely a room or two adjacent to a water privilege which was the primary reason for the selection of the site. As the business has grown through the decades conditions have entirely changed. What was an abundant supply of water not only for industrial purposes but also for the dilution of the wastes, has now become barely adequate for industrial purposes alone and the entire flow now passes through the plant and perhaps through several plants more recently built. Thus the entire stream has become a river of industrial wastes rather than, as originally, a natural river into which a minor quantity of industrial wastes was discharged.

In all such cases there has been a collateral increase in the resident population. Now there are villages along the river where formerly were wooded lands and pastures. Such development has brought with it demands for parks and other recreation facilities, including the improvement of the natural stream for boating and perhaps for bathing purposes.

Under some conditions a proscriptive right may be acquired to make certain uses of the waters of the river, even though they be more or less hostile to the enjoyment of some privileges or to lower riparian owners. The proscriptive right is often advanced in defense of the practice of discharging untreated industrial wastes into waterways and their consequent pollution. Many of the industries, particularly in the eastern part of the country, are of very long standing. The continuous operation of an industrial plant devoted to the same general kind of work for more than a century, can be cited in numerous instances. In comparatively few cases, however, can it be shown that such industries are operating under conditions substantially identical with those of prior decades. Either the character of the business has changed so that processes are different and industrial wastes are greater, or less in quantity and decidedly altered in character, or the business as a whole has become much greater with a corresponding increase in the quantity of industrial wastes. These changes make it exceedingly difficult in most cases to establish a proscriptive right to the acts of which complaint is made.

It should be borne in mind that in no case can one acquire a right, by proscription or otherwise, to create a nuisance. This fact has been the stumbling block upon which many an effort to secure or maintain privileges, through court decisions, has been defeated.

The paramount lesson to be gained from experience in these matters is that it is wise to anticipate complaint of objectionable conditions whether from lower riparian manufacturers influenced by difficulties caused by the character of the water, from a community complaining because of odors and objectionable appearance of the stream, or from the farmer whose cattle will not drink the water, whose crops are killed because of inundation by polluted waters, or whose ditches and natural brooks have become so overgrown with vegetation due to the fertilizing ingredients of the water having their origin in industrial wastes, that they will no longer serve their purpose.

The prudent manufacturer will make it a part of his routine business to observe carefully the effect of the discharges from his plant upon the character of the water in the river, not alone in his immediate vicinity, but for a considerable distance downstream. When conditions become noticeably objectionable he will take measures to remedy them, at the same time maintaining the valuable privilege of utilizing the stream for the disposal of his wastes, to as great an extent as is compatible with the public good and the reasonable use of the waters by lower riparian manufacturers. Such a policy, if intelligently pursued in many cases, will result in avoiding expensive litigation. More important than this, however, is the fact that by maintaining the waterway in a reasonably satisfactory condition the hostility of lower riparian dwellers may be avoided. Where such a feeling is aroused by objectionable conditions, it may exert itself through legislation or through litigation in such a manner as to require the establishment of exceedingly rigid restrictions as to the use of the river or even drive the industries away. Numerous instances of the latter can be cited.

NEPONSET RIVER CONDITIONS

One of the most interesting illustrations of the industrial wastes disposal problem is that of the Neponset River Valley near Boston in Massachusetts. This river rises about 22 miles from Boston Harbor, into which it discharges. Its natural drainage area is 114.14 sq. mi. and it also receives one-third of the flow of the Charles River at Dedham, equivalent to the drainage from 66.2 sq. mi. The total tributary area is therefore 180.3 sq. mi.

The normal yield of the drainage area is probably about as follows:

MONTH	Mil. gal. daily	Cu. ft. per sec.	MONTH	Mil. gal. daily	Cu. ft. per sec.
January	216	334	July	31	49
February	304	470	August	45	69
March	492	762	September	40	62
April	356	551	October	76	117
May	190	294	November	135	209
June	84	130	December	176	272
Monthly Average..............................				178	276

The actual flow is much more uniform than the natural flow would be because of the regulating effect of the storage reservoirs.

The State Department of Health reported at one time that there were about 30 mills discharging more or less wastes into this river. Before prohibitory statutes were passed, one wool scouring concern abandoned its location. Some manufacturers diverted a portion of their business to other plants and one abandoned the manufacture of one line of goods, thus avoiding the production of large quantities of liquid wastes which were very difficult to treat.

Eleven manufacturers have provided sedimentation tanks and ten have constructed strainers and filters of cinders, coke or sand. Some have adopted chemical precipitation as a means of improving the efficiency of natural sedimentation. Treatment plants have been provided in nearly all cases where the wastes require treatment, some of which have been described by the writer.[1]

In 1902 the Massachusetts Legislature passed an act directing the State Board of Health,

> "......to prohibit the discharge of sewage..........or every other substance which may be injurious to public health or may tend to create a public nuisance or to obstruct the flow of water, including all waste or refuse from any factory or other establishment where persons are employed, *unless the owner thereof shall use the best practicable and reasonably available means to render such waste or refuse harmless.*
>
> "Section 2. The Board shall consult and advise with any such owner at his request or of its own motion as to the best practicable and reasonably available means of rendering such waste or refuse harmless, having regard to the circumstances and requirements of the situation and to the industrial interests involved." (Chap. 541, Acts of 1902.)

It is interesting to note that it was the intention at the time this original act was passed, to have reasonable regard for the manufacturing industries, not requiring them to go to extremes in the treatment of their wastes unless the exigencies of the

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[1] "The Cleaning Up and Improvement of a Stream Polluted by Sewage and Trade Wastes," *Engineering & Contracting*, August 9, 1916.

situation required. In other words, incorporated into this statute was the "rule of reason."

At the time of the passage of this statute industrial wastes treatment in this country was in its infancy and progress in improvement of conditions in the Neponset Valley was naturally somewhat slow. In 1906 it appears that public sentiment had been so aroused that it was possible to pass an act in which the "rule of reason" was much less evident than in the earlier act. The only reference to it in the 1906 act was that the Board was to advise the owner of the factory as to the "*best practicable and reasonably available means of rendering the wastes or refuse harmless*." The clause "having regard to the circumstances and requirements of the situation and to the industrial interests involved" was omitted from this act.

During the next 10 years many efforts were made to secure additional and usually more drastic legislation, in spite of the fact that the manufacturers expended large sums of money in an effort so to modify their wastes before their discharge that they should not endanger the public health nor tend to create a nuisance. Perhaps the culmination of these efforts may be said to have been embodied in a proposed act—Senate 113—presented to the Legislature for its consideration in the year 1916.

> Section 1. Any person, firm, corporation or group of individuals who shall cause, either directly or indirectly, the pollution of the waters of any river in this commonwealth, shall be punished by a fine of not more than one hundred dollars for every day which said pollution continues after notice from the health commissioner that such nuisance be abated.
>
> Section 2. A river shall be held to be polluted within the meaning of this act whenever by the introduction or discharge into its waters of any foreign or deleterious substance: (*a*) it shall give out any noxious or offensive smell, odor or vapor, which condition is a menace to the public health; (*b*) it shall become discolored in such a way as to be unsightly or offensive; or (*c*) it shall become poisonous or dangerous to fish or animal life subsisting therein, or to live stock using the same as a drinking place; (*d*) it shall become injurious to vegetation in its vicinity.
>
> Section 3. The health commissioner of Massachusetts shall be charged with the enforcement of the provisions of this act and shall determine when the waters of any rivers are being polluted as aforesaid.
>
> Section 4. All acts or parts of acts inconsistent herewith are hereby repealed.

There are several provisions in this act which would be exceedingly oppressive if applied with literal interpretation of the act and without reading into it the rule of reason. One of these is the provision for a fine not to exceed $100, for every day which the pollution continues after notice from the Health Commissioner that such nuisance be abated. In some instances, even if prosecuted with diligence, plants for the elimination of those ingredients of wastes which caused the pollution, could not have been built in less than six months' time.

Aside from the broad scope of the specifications of a polluted river within the meaning of this act, the Health Commissioner was charged with its enforcement and apparently made the sole judge to determine when the waters of the river were being polluted, as specified by the act. Should such an act be found constitutional, which is subject to some doubt, it would apparently deprive the alleged offenders of their rights to a hearing before the courts of justice.

Happily, this act was not passed and is introduced here merely as an example of the extent to which industries or communities may go after they have become thoroughly aroused by long-continued objectionable conditions. It is confidently believed that such drastic legislation can always be avoided, and probably also its suggestion forestalled, by prudent foresight on the part of manufacturers in preventing objectionable conditions caused by the discharge of their untreated wastes.

PROGRAM FOR SOLUTION OF PROBLEM

In many cases where manufacturers have been confronted with a serious problem in connection with the disposal of their industrial wastes, they have been inclined to attempt its solution without first acquiring a clear understanding of the scientific principles involved, either in the production of the conditions which caused the trouble or in the processes available for the treatment of the wastes to render them less objectionable. The treatment of industrial wastes usually is a subject entirely different from that with which the manufacturers have to deal in their usual business and in which they are primarily interested; all other matters, such as the treatment of waste liquors, being of only secondary interest and importance from their point of view. They have, therefore, often selected a plant poorly adapted to the use they desired to make of it. Sedimentation tanks, for example, are often found which are entirely inadequate for the purpose, although this process is most simple. All sorts of filters have been designed and constructed, but usually without the remotest conception of the scientific principles involved in the treatment which they were intended to accomplish.

Another fruitful source of misdirected energy has been the desire to recover from the wastes ingredients of value such, for example, as the grease and fertilizing ingredients in municipal sewage. Industrial wastes, like sewage, often contain ingredients which have a market value, and every encouragement should be afforded to the recovery of such products. As economic conditions change in the future there will be a greater need of economizing in this direction, and it is to be expected that processes will be devised for the profitable recovery of such ingredients. The fact that such processes may not be available at the time the problem first presents itself, but will probably be available at some future time, is not a justifiable reason for making no effort for its solution.

Whenever an industry is confronted with a problem of this kind, a program for its solution should be carefully worked out before making expenditures upon construction. In fact, the studies necessary to the preparation of such a program may disclose other means of solution, involving relatively small cost.

First a study should be made of the waterway, to note its condition and physical characteristics, such as size, velocity of flow, depth and temperature, and a similar study of wastes to determine their quantity and character. With the information gained in this manner it will be possible to form an opinion as to the extent of treatment required to meet existing conditions.

Next, the kind of treatment and the plant required to provide such treatment, should be determined. The methods selected should be those required to give the results which may be desired within a reasonable period of time in the future when perhaps conditions may have become decidedly different from those obtaining at the time the investigation is made. Such methods should always be selected and reported with the clear reservation that new and better processes may subsequently be devised.

Following the selection of methods should be the construction of plant. Here it may be wise to proceed progressively, building first the system of drains required for the collection of the wastes and for their discharge at a single point. After this has been done further investigations based upon the measurement and analyses of the combined wastes, may be desirable. When the collecting system shall have been completed, it will be possible to provide the first part of the treatment process, such for example as screening or sedimentation. After this has been accomplished, still further investigations may be desirable to determine, first, the efficiency of the plant already installed and, second, the next process of treatment which should be provided and the probable results to be obtained.

However much or little may be required, it is important to build in accordance with an intelligently devised plan and in harmony with such additional processes as may follow. Thus many expensive mistakes will be avoided and advantage taken of all opportunities to provide an economical arrangement of plant. The following of such a course will often result in avoiding expensive pumping of the wastes, or the treatment of excessive quantities due to the inclusion of relatively clean waters which may not require treatment under the local conditions.

The final step, and undoubtedly the most important, is the intelligent operation of the plant. Whether the processes involved are simple or complex the supervision and control of operation should be based upon a knowledge of the conditions in the river, the character of the wastes and the scientific principles involved in their treatment. The object to be attained and extent of treatment necessary at the time of its accomplishment should be kept constantly in mind. Many thousands of dollars in the cost of operation may be saved in this manner.

METCALF AND EDDY
BOSTON AND CHICAGO

THE ECONOMIC RESOURCES OF THE KANSAS CITY ZONE[1]

By ARTHUR J. BOYNTON[2]

Hardly more than half a century ago—and within the memory of many—the line indicated by the present eastern boundary of Kansas, Nebraska and Oklahoma marked the frontier of the Indian country. It is indeed difficult for the minds of the present generation to grasp the extraordinary transformation which has been made in this territory in such a comparatively short period of time.

Kansas City enjoys what might be called, for lack of a better term, extraordinary *"nodality"*—a natural center from which radiate or to which converge practically all of the important lines of trade and communication of the extensive southwest territory.

The population of the city since 1900 has more than doubled. To-day the population of the combined cities of Kansas City, Missouri and Kansas City, Kansas is estimated at nearly 400,000. Assessed valuations of property have increased from $79,000,000 to over $210,000,000.[3] Post-office receipts have jumped from $748,000 in 1900, to over $3,589,318, and the mail matter handled in 1916 was nearly four times that of 1900.

Kansas City received from the adjacent territory during the last year over 115,649,800 bushels of grain of which wheat alone constituted 77,785,650 bushels. The State of Kansas alone in 1916 raised a wheat crop of 99 million bushels valued at practically $135,000,000. This state ranks first in winter wheat production, and is only occasionally exceeded by North Dakota with the spring variety.

The shipments of live stock to the Kansas City stockyards from the surrounding country in the year just past total 131,812 car-loads,[3] of 7,323,528 animals, of which 2,177,468 were cattle and nearly 3,000,000 were hogs. Over 5,000,000 packing animals were slaughtered in the local packing plants during the year 1916.[3]

Bank capital in 1900 was short of $5,000,000 while to-day it exceeds $26,000,000. No better index of the expanding business of a commercial center is to be had than that of bank clearings. These since 1900 have increased more than sixfold and for 1916 totaled the enormous sum of $4,953,778,690. Kansas City to-day ranks *sixth* in bank clearings and is exceeded only by New York, Chicago, Philadelphia, Boston, and frequently surpasses St. Louis.

As a railway center Kansas City is second only to Chicago in the number of lines entering the city and the size of territory which these serve.

The Kansas City Zone is primarily occupied with what might be called the *extractive industries*, and among these, of course, stands agriculture as first in importance.

NUMBER AND VALUE OF LIVE STOCK
Report of Kansas State Board of Agriculture for 1916
Report of Oklahoma State Board of Agriculture for 1916
Missouri Red Book 1915

	KANSAS, 1916		OKLAHOMA, 1916		MISSOURI, 1915	
	Number	Value	Number	Value	Number	Value
Horses	1,056,124	$120,398,136	742,750	$63,133,750	1,084,000	$77.560,000
Mules & Asses	296,007	37,000,875	282,347	27,670,006	329,000	32,571,000
Milk Cows	1,077,067	68,932,288	488,004	26,840,220	837,000	45,533,000
Other Cattle	2,200,848	94,636,464	1,143,245	43,443,310	1,555,000	60,490,000
Sheep & Goats	181,481	1,134,256	39,687	448,435	1,416,000	8,213,000
Swine	1,576,568	18,918,816	1,039,474	7,484,214	4,565,000	31,986,000
Total Value of Live Stock		$341,020,835		$169,019,935		$276,353,000

A summary of these figures gives a total value of live stock for these three states alone of $786,393,770 and their crops are valued at $768,006,583. Thus the total value of crops and live stock based on the farm values (not the values at primary markets) reaches the huge sum of $1,554,400,353. The gross value represented in crops and live stock on the farms of Kansas amounted to $712,209,311.

This is the state's second best record in agricultural products, which was exceeded in 1914 by about $5,000,000. The value of its live stock is the largest ever reported, exceeding the best prior year (1915) by $30,000,000.

The wheat crop for this state in 1916 was the second largest in the history of the state and was worth $134,615,300. Its quality was extra fine and the average price received by the growers is the highest reported since 1872.

The value of animals sold for slaughter in 1916 amounted to $68,762,369. The income from poultry and eggs alone was $12,466,694. Attention should be called to the great and increasing value in Kafir, milo, feterita, and sorghums and to the recently introduced grasses and fodders in the dry sections of the state, now amounting in value to nearly $20,000,000. The alfalfa crop of 3,581,201 tons was worth $30,907,618, and had it been marketed during the winter and spring would probably have brought nearly twice that amount. These forage crops, none of which were originally native to the state, and most of which have but recently been introduced, represent some of the striking achievements of the agriculture of this section.

The increase of dairy products is another hopeful sign pointing to more intensive agriculture. These products were valued at over $14,460,000. A most notable gain is recorded in the figures for condensed milk during the past year, the amount and value of the product being nearly seven times larger than it was in 1915.

This section of the United States is still committed to the extensive system of cultivation. Commercial fertilizers, if indeed any fertilizers, are but little used. But little attention in a practical way is given to soil analysis and conservation. The farmer is, however, concerned with all those methods of cultivation aiming to conserve the moisture; with all the new crops suitable for the region; with improved machinery to reduce costs of farm operation and with the best and most profitable breeds of live stock. How long these virgin soils will respond with their natural fertility under present systems of cultivation remains to be seen. Already greater and greater demands are being placed upon the soil. For increasing yields, resort must be had to more and more intensive methods of cultivation.

The general opinion prevails that the wealth of the surrounding territory is embodied largely in the products of the wheat, corn, live stock and other agricultural belts. Few, unfamiliar with the region, appreciate the rapid industrial expansion which the district has made in the past ten or fifteen

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[1] Address delivered at the 54th Meeting of the American Chemical Society, Kansas City, April 11, 1917.

[2] Professor of Economics, University of Kansas, Lawrence.

[3] Annual Statistical Report, Board of Trade, 1916, Kansas City, Missouri.

YIELD AND VALUE OF LEADING CROPS

	Kansas, 1916		Oklahoma, 1916		Missouri, 1915	
	Yield (Bu.)	Value	Yield (Bu.)	Value	Yield (Bu.)	Value
Wheat	99,384,760	$134,615,307	27,541,398	$40,627,861	26,475,327	$ 25,669,634
Corn	62,127,191	51,886,272	55,769,404	42,391,950	220,235,191	123,640,144
Oats	29,177,688	14,199,056	16,880,288	8,346,212	24,148,135	9,096,452
Barley	6,049,777	4,206,175	.....	956,000	11,917	10,129
Rye	737,217	769,895	.....	.....	192,250	171,102
Cotton	.....	.....	628,685 Bales	51,011,955	23,478,492	2,512,199
Kafir	5,095,052	4,988,078	9,974,074	6,893,916	......	.....
Milo	1,188,482	1,163,996	4,316,597	3,214,630	......	.....
Sorghum	3,088,005	11,281,760	511,601	3,540,583	......	903,656
Alfalfa	3,581,201 Tons	30,907,618	856,622	9,598,795	......	.....
Hay	1,648,963 "	11,250,422	182,223	1,430,042	4,386,385	39,117,508
Broom Corn	4,796 "	790,984	40,900	6,112,500	1,066,515	53,858
Irish and Sweet Potatoes	4,653,819	4,271,643	.....	1,134,786	5,104,000	2,960,320
Peanuts	.....	.....	458,692	412,822	......	.....
Dairy Products	.....	12,007,965	.....	.....	......	.....
Total Value of All Farm Products		$371,188,476		$177,504,262		$219,313,845

years. The increase in values of manufactured products has been stimulated by the development of great oil and gas fields and by those industries which have been made possible by cheap fuel.

INDUSTRIES

According to the last census, slaughtering and meat packing, with flour and grist mill products, made up about three-fourths of the total value of the manufactured products of the State of Kansas. The industry of slaughtering and meat packing owes its development chiefly to the fact that the district lies in the heart of the corn belt of the United States, to the low cost of winter-keep where live stock grazes on fields of winter wheat and cured grasses, and to the extensive introduction of alfalfa. This section accordingly is unsurpassed for stock-raising by any equal area in the country.

The census of 1910 credited 12.1 per cent of the total value of the slaughtering and meat packing products of the United States to the State of Kansas, and only one state, Illinois, ranked ahead of Kansas in this respect. The 35 establishments gave employment to 24 per cent of the average number of wage-earners and reported products valued at $165,000,000. All of the principal packers have large establishments in Kansas City, Kansas. After Chicago, the local industries are the largest units in the United States. One of these concerns reports 45 edible and 24 inedible products in the category of their output.

An industry ancillary to that of meat packing with all its varied by-products, that of soap-making, is gradually becoming one of the most permanent and important of the immediate locality. Receiving their chief raw materials from adjacent packing and rendering establishments, the concerns engaged in this industry are to-day manufacturing a substantial output. Peet Brothers (manufacturers of soaps and glycerin) and Proctor and Gamble have both large, well equipped, up-to-date factories in Kansas City, Kansas. While no definite statistics are available, it is estimated that probably 15,000 to 16,000 boxes of soap are daily produced. Besides soap, glycerin should also be mentioned as an important product.

The flour and grist mill industry is second in importance among the manufacturing industries of the Zone. Due to its first rank as a winter-wheat-producing state, Kansas ranks third among the states of the Union in the value of flour mill and grist mill products. There are at present over 500 milling establishments in the state.

PETROLEUM

The preliminary estimates of the United States Geological Survey indicated the quantity of crude petroleum produced and marketed in the oil fields of the United States in 1916 at 292,300,000 barrels.[1] Later figures place this total production for 1916 at 306,297,600 barrels.[2]

The Mid-Continent, or Oklahoma-Kansas field produced 122,671,767 barrels—conservative figures—which is 40 per cent of the United States product for 1916. About 30 per cent is assigned to California and the remainder (30 per cent) to the Appalachian, Lima-Indiana, Texas, and other fields. As nearly as can be ascertained, taking the amount of crude oil in storage, the average pipe-line runs and the estimated amount of oil shipped to scattered consumers, computations show the oil production of Kansas in 1916 to be 11,530,478 barrels. The potential production of Kansas at the present time is approximately 100,000 barrels per day.[1]

PETROLEUM INDUSTRY OF THE UNITED STATES—PRODUCTION IN 1916
(*Oil, Paint and Drug Reporter*, Feb. 9, 1917, **91**, No. 7, 85)

Fields	Million Barrels 1916	1915	1914
Eastern	20 Million	20 Million	22 Million
Ohio-Indiana	2	3.9	4
Illinois	16	15	19
Kentucky-Tennessee	1	0.499	0.516
Mid-Continent	122,671,767	121,988,915	101,002,263
Gulf Coast	21	20	11
Texas Panhandle	8	5	8
Northern Louisiana	11	14	12
California	91	89	102
Wyoming	8	5	4
Other States	0.205	0.2	0.180
Total	306,297,760	298,137,631	287,119,667

Oklahoma's crude production for 1916 amounted to 111,141,280 barrels, or a total for the two states (as previously stated) of 122,671,767 barrels for the year.[1] Up to the present time the total production for the Mid-Continent field since its discovery on the introduction of pipe lines in 1900 has amounted to 762,174,158 barrels, of which 47,829,947 are credited to Kansas and 714,334,211 were credited to Oklahoma.

PRODUCTION OF THE MID-CONTINENT FIELD SINCE 1900
(*Oil, Paint and Drug Reporter*, Feb. 9, 1917, p. 107)

Pipe Lines	Kansas	Oklahoma	Total Mid-Continent by Years
Prior to 1900	438,000	4,225	442,379
1900	68,000	6,100	74,714
1901	169,000	10,000	179,000
1902	295,000	36,500	331,000
1903	931,000	140,000	1,071,000
1904	4,236,000	1,367,000	5,603,000
1905	3,892,000	8,561,000	12,454,000
1906	3,075,000	18,618,000	21,649,000
1907	3,331,000	42,830,000	46,161,000
1908	2,473,000	45,801,000	48,274,000
1909	1,032,000	46,975,000	48,007,000
1910	1,129,000	52,300,000	53,429,000
1911	2,907,000	56,425,000	59,332,000
1912	2,182,000	51,425,000	53,607,000
1913	2,171,000	63,575,000	65,746,000
1914	3,850,000	97,242,000	101,092,000
1915	4,115,000	117,883,000	121,998,000
1916	11,530,000	111,141,280	122,671,000
Total	47,829,947	714,334,211	762,174,158

The stock of oil in storage in the Mid-Continent field at the end of 1916 increased to 97,917,458 barrels, a gain of over 3 million barrels, practically the amount put in storage by the Butler County pools of Kansas. Oklahoma, it is reported, had over 86 million barrels in storage at the end of the year.[2]

OIL WELLS

More oil wells were drilled in the Mid-Continent field in 1916 than in any previous year except one (11,494 in 1913): 11,241

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[1] *Eng. and Min. J.*, Jan. 6, 1917, p. 23.

[2] *Oil, Paint and Drug Reporter*, Feb. 9, 1917, p. 85.

[1] *Oil, Paint and Drug Reporter*, Feb .9, 1917, p. 107.

[2] *Ibid.*, Jan. 6, 1917, p. 107.

wells were drilled in the past year: 7601 in Oklahoma and 3640 in Kansas.[1] The rise in price of crude oil to $1.55 led to rapid drilling and with market quotations such as these, extraordinary prices were paid for leases, wild speculation followed, and test holes were drilled immediately.

In the beginning of 1916 there were 3,848 producing wells in Kansas and at the end of the year there were 5,476 producing oil in the State, connected with pipe lines. Others should be added, including some of the large producers, which as yet have not been connected with any pipe lines. This increase of wells again shows the rapidity with which the Kansas division of the field has advanced during the past year.

In three years from January 1, 1914, to January 1, 1917, the number of producing wells in the Mid-Continent region has increased from 20,256 to 43,417 which graphically tells the story of the wonderful development of this remarkable oil field.[2]

Of the 11,241 wells drilled in the Mid-Continent field in 1916, 9,274 were successful oil producers, 476 were gas wells, and 1,491 were failures. This was the largest number of producing wells ever drilled in a single year in the Mid-Continent field. It is significant also that while the largest number of successful oil wells in the history of the field were drilled last year, the actual yield of the field was also the largest in its history.

WELLS DRILLED IN THE MID-CONTINENT FIELD
(*Oil, Paint and Drug Reporter*, Jan. 6, 1917, p. 109)

	In Kansas	In Oklahoma	Total for Mid-Continent Field
1905	1488	2535	4023
1906	730	3146	3876
1907	486	4234	4720
1908	473	3021	3494
1909	510	3340	3850
1910	486	4370	4856
1911	511	4445	4956
1912	1012	5982	6996
1913	2180	9314	11494
1914	2394	8259	10653
1915	1123	4725	5848
1916	3640	7601	11241
Total for the Field			81154

CHARACTER OF WELLS DRILLED IN 1916

	Oil	Gas	Dry	Total
Kansas	3167	116	357	3640
Oklahoma	6107	360	1134	7601
Mid-Continent Field	9274	476	1491	11241

One other feature of this remarkable field should receive our attention. Of the 81,154 wells drilled in this territory since the beginning of operations, 43,417 are still producing after fifteen years, indicating that 37,737 were either gas, dry, or have since become exhausted.[3]

When it is remembered that this field has been in active production for fifteen years or more, this is a remarkable record: 53.5 per cent of total wells still drilling and only 46.5 per cent gas, dry or exhausted.[3]

It is significant also that in 1916, with the vast amount of wild-cat drilling in all parts of Oklahoma and Kansas, 86.7 per cent of all wells drilled were successful oil or gas producers.

OIL REFINING

Of the 302 refineries in the United States—with a daily capacity of one million barrels crude oil—the Mid-Continent field has 74, or 24 per cent, 71 of these being independent companies and 3 Standard Oil companies.[4] This is exceeded only by California with 76, 57 only of which are active and 19 idle. The Standard has invested $8,000,000 or more in their three refineries at Neodesha, Kansas, Sugar Creek, Missouri, and Norfolk, Oklahoma. Their capacity of crude oil consumption per day is given at 60,000 barrels. The 71 independent refining companies, of which the Sinclair Syndicate, the Doherty Syndicate, Cosden & Co. and the International Refining Company are most prominent, have invested over one hundred million dollars in their plants. They utilize over 150,000 barrels of crude oil per day. The refining operations of the field represent then, for all concerns, an investment of $111,099,720 in 74 plants, with a total daily consumption of 213,815 barrels of crude oil.[1]

This gives the Mid-Continent field, in capital invested, plants, and output, about one-fourth of the refining business of the whole United States.

MID-CONTINENT REFINING, 1916
(*Oil, Paint and Drug Reporter*, Jan. 6, 1917, pp. 113, 115)

	Approximate Investment	Daily Average Crude Used in 1916 (Barrels)
71 Independent Companies (all since 1904–5)	$99,599,720	148,815
Independent Plants now Building	3,500,000	5,000
Total Independents	$103,099,720	153,815
3 Standard Refineries (Standard Group)	8,000,000	60,000
Final Total	$111,099,720	213,815

	Built	Investment	Daily Consumption
STANDARD REFINERIES:			
Norfolk, Okla. (Carter Oil Company)	1916	$3,500,000	40,000
Neodesha, Kans. (Standard Oil)	1892	1,500,000	7,500
Sugar Creek, Mo. (Standard Oil)	1907	3,000,000	12,500
		$8,000,000	60,000

Attention has been called to the profitableness of refining this Mid-Continent oil due to the high yield of gasoline, often as high as 30 per cent, which percentage depends very largely on methods of distillation, whether oil is fresh or stored, and the variations in crudes of the same pool.

NATURAL GAS

Closely associated with the oil production of this territory is that of natural gas. The importance of this natural gas belt in localizing and developing the zinc, cement, and glass industries in a definite district cannot be overemphasized. The near-by supply of cheap gas has made possible and profitable these industries in Kansas and Oklahoma. These states, according to the latest authoritative figures available (1914), produced 22,627,507,000 and 78,167,414,000 cu. ft., respectively, a total of 100,794,921,000 cu. ft.[2]

The total natural gas production for the United States for the year was estimated at 591,866,733,000 cu. ft. This would credit the Oklahoma-Kansas field with about 18 per cent of the supply of the United States. Oklahoma and Kansas are exceeded only by West Virginia, Pennsylvania, and Ohio in the supply of natural gas.

The annual value of this important fuel in this district is placed at nearly $12,000,000 and was utilized by 250,104 domestic consumers and 3030 industrial plants. A substantial portion of this gas was piped out of the states and consumed in Missouri.[2]

A recent state investigation by the Kansas Academy of Science made by Mr. W. W. Swingle—perhaps the most recent data available—shows that Kansas alone in 1916 produced over 25,000,000,000 feet of gas (25,402,521,000).[3]

NATURAL GAS PRODUCED IN 1914 (M. CU. FT.)
("Mineral Resources of the United States," 1914, pp. 751 to 781)

	M. Cubic Feet	Producers	Domestic Consumers	Industrial Consumers	Value
Total for U. S.	591,866,733	...	...	.....	$94,000,000
Kansas	22,627,507	353	187,714	1,079	3,300,000
Oklahoma	78,167,414	437	62,390	1,951	8,000,000
Total for Kan. & Okla.	100,794,921	790	250,104	3,030	$11,300,000

NATURAL GAS WELLS DRILLED IN 1914
("Mineral Resources of the United States," 1914, p. 757)

	Productive Dec. 31, 1913	Drilled in 1914			Abandoned in 1914	Productive Dec 31, 1914
		Gas	Dry	Total		
U. S.	33,345	3,836	1,306	5,142	2,088	35,093
Kansas	2,297	445	219	664	481	2,261
Okla.	1,052	388	182	570	235	1,205

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[1] *Oil, Paint and Drug Reporter*, Jan. 6, 1917, pp. 113, 115.

[2] *Ibid.*, Jan. 6, 1917, p. 109.

[3] *Ibid.*, Jan. 6, 1917, p. 107.

[4] *Eng. and Min. J.*, Jan. 6, 1917, p. 23.

[1] *Eng. and Min. J.*, Jan. 6, 1917, p. 23.

[2] "Mineral Resources of the United States," 1914, p. 751.

[3] *Topeka Capital*, March 8, 1917.

The State, according to this investigation, could easily have produced a third more (35,000,000,000 feet) during the year if all the wells had been piped. Many of the wells have been capped, especially in Butler County, the new oil field of the State.

The total number of gas wells drilled in the past year were reported to be 112, as against 361 in 1915.

Output of Natural Gas in Kansas by Counties for 1916
(*Topeka Capital*, March 8, 1917)

County	Wells 1915	New Wells 1916	Total Production, 1916 Cubic Feet
Allen	13	7	324,072,000
Anderson	4	0	376,987,000
Butler	27	35	6,967,369,000
Chautauqua	26	17	1,817,516,000
Cowley	15	0	660,313,000
Elk	6	0	422,410,000
Franklin	33	3	717,626,000
Greenwood	11	2	679,178,000
Labette	12	0	1,897,317,000
Miami	5	2	925,967,000
Montgomery	148	34	6,272,150,000
Neosho	43	6	894,960,000
Wilson	12	3	3,112,744,000
Woodson	6	0	307,108,000
Other Counties	0	3	26,804,000
Totals	361	112	25,402,521,000

The significance of this valuable natural fuel for domestic and industrial consumption, especially in cement plants and zinc smelters and in the manufacture of glass and brick can be readily appreciated. In this connection the expansion of the casing head gasoline industry also must not be overlooked: 17 million gallons of gasoline were obtained from this source in Oklahoma in 1914.

ZINC SMELTING AND REFINING

The great zinc-producing region, known as the Joplin District in Southwestern Missouri and extending into Kansas and Oklahoma, constitutes one of the great mineral sources of wealth of the Kansas City Zone. From this region—a few adjoining counties—in 1916, an exceptional year to be sure, zinc and lead-ore shipments were made valued at $36,439,420.[1]

Output and Value of the Miami District in 1916
(*Engineering and Mining Journal*, Jan. 6, 1917, p. 28)

Total Production	Lbs.	Value
Zinc Concentrates	110,236,816	$4,867,193
Lead Concentrates	30,653,990	1,237,114
		$6,104,307

The production of spelter by ore smelters in the United States in 1916 equaled 672,000 tons (of 2000 lbs.), the product of 41 smelters operating 52 works, containing 209,786 retorts, of which 190,331 were in operation. During the last quarter of 1916 these plants were producing spelter at the rate of 734,000 tons per annum.[2]

Production of Spelter (Ore only) in Tons (2000 Lbs.)
(*Engineering and Mining Journal*, Jan. 6, 1917, p. 24)

States	1916	1915	1914
Arkansas	7,622	....	....
Colorado	8,812	8,984	8,152
Illinois	181,253	161,665	130,587
Missouri and Kansas	151,446	111,052	53,424
Oklahoma	165,086	111,405	92,467
East	158,081	114,036	85,682
Total	672,300	507,142	370,312

From the above table it is seen that of the total production of the United States in 1916—672,300 tons—Missouri, Oklahoma, and Kansas contributed 316,532 tons, or 47 per cent of the total output of the whole country.

This remarkable growth of the smelting and refining of zinc since 1889 is due largely to the discovery of gas and oil and the presence of coal in the same locality as the zinc ore.

The value of products for Kansas according to the census of 1910 amounted to nearly one-third of the total value of products of this industry for the entire United States. At that time Kansas ranked first in number of establishments and in value of products for the zinc industry. Since that date some change has occurred in relative output.

Value of Ore Shipments, Lead and Zinc in Joplin District in 1916
(*Engineering and Mining Journal*, Jan. 6, 1917, p. 27)

In Missouri (Jasper County)	$25,913,880
Total for Missouri	29,134,430
In Oklahoma (Ottawa County)	4,780,960
In Kansas (Cherokee County)	2,432,640
In Arkansas (through Joplin)	91,390
Total	$36,439,420

SMELTING ESTABLISHMENTS AND RETORTS

This district possesses 34 smelting establishments, 17 being in Kansas, 14 in Oklahoma, and 3 in Missouri. These operate 119,848 retorts, or 57 per cent of the retort capacity of the United States.[1]

As previously stated, cheap natural gas, oil, and coal in the Pittsburg district, all adjacent to the zinc, thus minimizing costs of transportation, have localized the smelting operations in a relatively small area.

Zinc Smelting Capacity of the Kansas City Territory
Number of Retorts at the End of the Year or Building
(*Engineering and Mining Journal*, Jan. 6, 1917, p. 25)

Name	Situation	1915	1916
American Spelter Co.	Pittsburg, Kans.	896	896
Amer. Zinc, Lead & Smelting Co.	Dearing, Kans.	4,480	4,480
Amer. Zinc, Lead & Smelting Co.	Caney, Kans.	6,080	6,080
Bartelsville Zinc Co.	Bartelsville, Okla.	5,184	7,488
Bartelsville Zinc Co.	Blackwell, Okla.	...	8,800
Bartelsville Zinc Co.	Collingsville, Okla.	10,080	13,440
Chanute Spelter Co.	Chanute, Kans.	1,280	1,280
Cherokee Smelting Co.	Cherokee, Kans.	896	896
Eagle-Picher Lead Co.	Henryetta, Okla.	...	3,000
Edgar Zinc Co.	Carondelet, Mo.	2,000	2,000
Edgar Zinc Co.	Cherryvale, Kans.	4,800	4,800
Granby Mining & Smelting Co.	Neodesha, Kans.	3,760	3,760
Henryetta Spelter Co.	Henryetta, Okla.	600	3,000
Iola Zinc Co.	Concreto, Kans.	660	660
Joplin Ore & Spelter Co.	Pittsburg, Kansas	1,440	1,792
J. B. Kirk Gas & Acid Co.	Iola, Kans.	3,440	3,440
Kusa Spelter Co.	Kusa, Okla.	3,710	3,720
LaHarpe Spelter Co.	Kusa, Okla.	...	4,000
Lanyon Smelting Co.	Pittsburg, Kans.	448	448
Lanyon-Starr Smelting Co.	Bartelsville, Okla.	3,456	3,456
Missouri Zinc Smelting Co.	Rich Hill, Mo.	...	448
National Zinc Co.	Bartelsville, Okla.	4,260	4,970
Nevada Smelting Co.	Nevada, Mo.	672	672
Oklahoma Spelter Co.	Kusa, Okla.	...	1,600
Owen Spelter Co.	Caney, Kans.	1,280	1,920
Pittsburg Zinc Co.	Pittsburg, Kans.	910	910
Prime Western Spelter Co.	Gas City, Kans.	4,868	4,866
Quinton Spelter Co.	Quinton, Okla.	...	1,340
Tulsa Fuel & Manufacturing Co.	Collingsville, Okla.	6,232	6,232
United States Smelting Co.	Altoona, Kans.	3,960	4,600
United States Smelting Co.	Checutah, Okla.	...	4,480
United States Smelting Co.	LaHarpe, Kans.	1,924	1,926
United States Zinc Co.	Sand Springs, Okla.	5,680	8,000
Weir Smelting Co.	Weir, Kans.	...	448
	Kans. 17		
	Okla. 14		
	Mo. 3		
Total for Kansas, Okla. & Mo. Establishments	34	8,2996	119,848
Total for the United States		155,388	211,126

COAL

The Pittsburg district in Kansas mined 6,860,988 short tons of coal in 1914, valued at $11,238,253, giving employment for 12,448 employees 192 days in the year. Oklahoma produced in the same year 3,998,613 tons and Missouri 3,935,980 tons, a total of 14,795,581 tons for the district.[2]

Kansas has mined, since 1869, 136,557,749 tons and since 1880, Oklahoma is reported to have produced 63,462,777. These figures for production are relatively small, to be sure, when compared with the output for the entire country, but the supplies are of great local importance for fuel for the railroads, the chief consumers; for steaming purposes in manufacturing plants and for domestic use. Coal competes in the district with petroleum and natural gas in many plants and for general heating purposes.

Much criticism is still made of methods of mining in this section. The "reprehensible practice" of "shooting off the solid" still persists in large degree—76.9 per cent of the total output for Kansas being mined by this method, 5.3 per cent by steam shovels, and 16 per cent by hand. Machine mining methods have not made much progress in the district.

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[1] *Eng. and Min. J.*, Jan. 6, 1917, p. 27.

[2] *Ibid.*, Jan. 6, 1917, p. 24.

[1] *Eng. and Min. J.*, Jan. 6, 1917, p. 25.

[2] "Mineral Resources of the U. S.," p. 596.

PORTLAND CEMENT

Kansas ranks third in number of cement plants, there being 10 within the state, which is exceeded only by Pennsylvania with 20 and Michigan with 11. The output of these 10 active establishments in 1914 was 3,431,142 barrels, valued at $3,180,669.

GLASS

The development of the glass industry in this part of the country is, like zinc and cement, due to the available supplies of natural gas, a cheap and particularly desirable fuel for this purpose. Starting about fifteen years ago the industry has gradually grown, in varying sized plants, throughout the gas belt. The last census placed Kansas eighth in rank in the value of its glass products.[1]

GYPSUM

The demand for gypsum in the crude form for manufacturing Portland cement, and in other forms for paint, for land plaster, and for calcined plaster, is a steady and growing one. Kansas mined 80,774 tons of raw gypsum in 1914 and possesses four gypsum establishments or mills. Oklahoma mined 113,103 tons and had six establishments. The Kansas product is mostly calcined, the form of greatest value, and is utilized for wall plaster, plaster of Paris, etc.: 47,877 (short) tons of calcined plaster were marketed from Kansas in 1914, and the value of all gypsum products was estimated at $278,343. Oklahoma's product was worth $312,856 or a total value for the two states of $591,199.[2]

SALT

Another resource, but of greater value, deposited with gypsum in this territory, due to the withdrawal or evaporation of the sea, is salt. Kansas is one of the four states credited with the production of salt, and has ranked fourth at the last three censuses in the value of this product.[3] The state maintains this rank both in the quantity and value of salt marketed in 1915. Michigan, New York, and Ohio are the only states which exceed Kansas in production, with 12,000,000, 11,000,000, and 5,000,000 barrels, respectively. Kansas produced in 1915 3,765,164 barrels, valued at $1,035,879, or about 10 per cent of the output, and approximately 20 per cent of the value of salt produced in the United States. (38,231,496 bbls. were marketed in the United States in 1915 valued at $11,747,686.)[4]

The ten salt-producing plants, including brine and rock, are located in the central part of the state. Four of these mine rock salt. Evaporated salt production is centralized at the city of Hutchinson, with other establishments at Lyons, Anthony and Sterling. Deep wells are sunk to the salt beds often hundreds of feet below the surface, water is forced down to the beds and then pumped to the surface where the brine is evaporated. Open pans, grainers, and vacuum pan methods are used.

According to a recent report of the United States Geological Survey,[5] 600 feet of rock salt have been encountered by the Short Grass Oil and Gas Company, in Clark County. The top stratum, 60 feet thick, was struck at a depth of 690 feet and was capped with 12 feet of limestone. The next lower bed 158 feet thick was separated from the first by a thin bed of limestone. Below these the beds varied in thickness from 5 to 30 feet. No water was encountered from 500 to 2900 feet. From 3300 to 3700 feet a great deal of strong brine was encountered, making casing necessary to that level.

Incidentally in this connection should be mentioned the Solvay Process plant located at Hutchinson, Kansas, the only establishment of this character in this part of the country. Sodium chloride, constituting of course the main raw material, is converted into sodium bicarbonate or cooking soda. Present conditions and outlook seem to promise a substantial and increasing market for the output of this establishment. Mention should also be made of the demand for sodium carbonate in the adjacent territory for glass and soap manufacturing, for paper making, and for water softening processes.

CLAY PRODUCTS

Omission should not be made of the valuable clay products, and their potential possibilities, which this region affords. As time goes on these resources are destined to become more and more valuable. For Kansas alone their value, as last reported, was estimated at $1,905,961.[1] Vitrified brick constituted the principal output, and was 31 per cent of the value of all clay products. Over 40 establishments, rather widely scattered, were producing vitrified, common, front, fancy, and fire brick; drain tile, sewer pipe, terra cotta, tile, and stoneware. The adaptability of the available fuels of the district, particularly gas, for this special form of industry, is apparent.

The desirability of these bulky and yet very valuable products in a commonwealth is evident to all. They are absolute essentials in the life of any settled community. Their great weight and bulk and relatively low value per unit precludes their shipment by rail unduly long distances. Instead of foregoing, in a measure, their consumption or being subjected to well-nigh prohibitive freight rates, the Kansas City Zone is abundantly supplied with all of these products which make for the increased diversification and satisfaction of material wants.

KANSAS CITY A LOGICAL MUNITION CENTER

In these belligerent times our attention is called to the fact that Kansas City is one of the logical munition centers of the United States.

The fats and oils derived from the packing plants and the cottonseed from adjacent states are making for the rapid development of soap manufacturing. Glycerin being a by-product of soap-making, one element, and a very important one, is here present for manufacturing of explosives. Close by, the roasting of zinc sulfide, the so-called blend or concentrates, leads, of course, to great possibilities in the production of sulfuric acid. It only remains to combine the two constituents thus produced here in increasing quantity, namely, glycerin and sulfuric acid, with nitric acid to furnish a substantial output of nitroglycerine, the basis for explosives and munitions.

For use in zinc and lead mining we observe these acids and glycerins produced locally, being shipped separately in bulk to the Joplin district, there to be combined into explosives suitable for mining operations. Glauber's salt is also sent in quantity to the glass factories of Kansas there to be mixed with sands, etc., in the making of glass.

POTENTIAL INDUSTRIES

A discussion of industries and resources would not be complete without at least passing reference to what many, qualified to judge, designate as potential industries of the Kansas City Zone.

The enormous quantities of wheat, corn, potatoes and canes, which are and can be produced, suggest the great possibilities of starch production in this territory. These same raw materials can also be made the foundation for enormous outputs of industrial alcohol, which is so rapidly becoming a basic and primary product the country over.

The great supply of hides from packing plants has suggested possibilities in the establishment of tanneries in various centers. It is maintained that tanning extracts or powders might profitably be shipped into this territory from bark-producing sections and at less expense than is incurred in transporting the heavy raw hides to the present tanneries. What the future holds for such an enterprise here remains to be seen.

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[1] "Census of Manufactures," 1910, p. 681.

[2] "Mineral Resources of the United States," 1914, p. 261.

[3] "Census of Manufactures," 1910.

[4] "Mineral Resources of the United States," 1914, p. 291.

[5] *Ibid.*, p. 265.

[1] "Mineral Resources of the United States," 1914, p. 500.

Similar suggestions are frequently made regarding the possibilities for cotton and woolen manufactures and the exceptional facilities for similar textile plants, due to unequaled railway connections which the district affords. Apparently their absence is primarily due to unavailable capital, and even more, perhaps, to a lack of the particular qualities and training of an industrial population adapted to these special industries.

With all the economic activities and possibilities which Kansas City territory possesses in the production of many concrete goods, partially or completely made ready for consumption, our survey would not be complete without attention being called to the facilities for moving and financing the products of these expanding enterprises.

The Kansas City Zone is served by a railway net which, with its management, is doing its part with deserving credit to facilitate the transportation of all these products from farms and mines and factories. Kansas City enjoys the schedules and rates of Missouri River basing points, and the radiating lines serve the territory and all interests concerned with uniform satisfaction. It can be maintained, I think, that in no section of the United States are the railroads doing more to coöperate with the legitimate enterprises of a territory than here in the Kansas City Zone.

Similar recognition should also be given to the banking facilities of Kansas City and the surrounding towns. Here is located one of the Federal Reserve Banks and also some of the strongest National Banks of the country. Here was early and successfully established a system of country clearings. The agricultural communities are particularly well supplied with banking facilities as evidenced by the exceptionally large number of state and national banks in all the smaller towns and cities and their universal patronage. Again, the vital connection and sympathetic coöperation of these financial institutions with the productive enterprises of the territory are fortunately one of the conspicuous features of our expanding economic life. Nowhere in the United States is banking on a more democratic basis.

In conclusion, one cannot refrain from here expressing and emphasizing the opinion that after all other explorers and exploiters have passed in review before us, last of all must come the greatest of all adventurers—Science. Pioneering days of the old order are past. More and more the necessity of the methods of science becomes apparent in the exploitation of productive processes. The go-as-you-please, rule-of-thumb, hit-or-miss methods of skimming the surface, with all their incidental wastes, are fortunately going here as elsewhere, and passing, we hope, forever. This present national crisis is but the last of warnings, all too little heeded. More and more we must call upon science to supplement the obvious gifts of nature and to reveal the wealth of materials and supplies which she has hitherto concealed.

But to apply scientific methods, funds, and increasing funds, of capital are necessary to utilize or make available the more productive, round-about methods of production. Contrary to the oft-repeated popular opinion, most industries are to-day undercapitalized. Scientific discoveries are outstripping the supplies of capital in the race of achievement. What sums of capital might not be utilized to-day were they only available!

The "hurtful forcing process" may be socially and economically undesirable if accompanied by wastes of natural resources, but the forging ahead of scientific discovery and utilization must ever be encouraged and kept far in advance in the procession.

The physical scientist and the economist unite, I am disposed or at least venture to think, in substantial agreement on this proposition: The world stands more and more in need of scientific discovery, while on the other hand nothing is more apparent than the necessity of increasing the funds of capital, coupled with intelligent business direction, to give life and effectiveness to these discoveries.

In the march of economic development, Science must blaze the way, and adequate supplies of Capital must support its programs. Assuming the brains to direct them, Science will determine the course of our future material achievements and Capital the degree of their realization.

University of Kansas
Lawrence, Kansas

THE NEW ZINC FIELDS OF KANSAS-OKLAHOMA[1]

By Winthrop P. Haynes

Received May 12, 1917

A short night trip by rail from Kansas City takes one into the heart of the largest zinc-producing district of the Central States, and of the United States too, for that matter, because statistics of production for 1915 credit the Central States with 47 per cent of the spelter production of the United States, and place Missouri at the head of the list of the states producing spelter (metallic zinc).

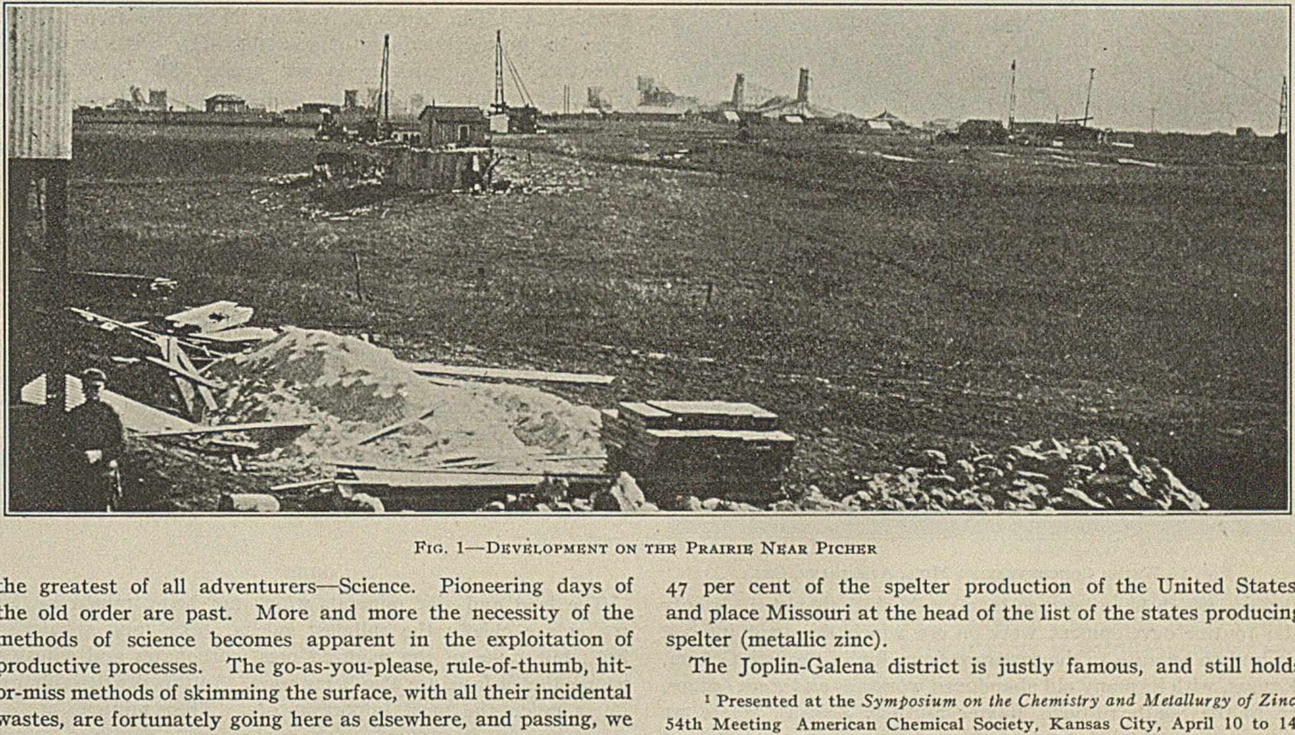

Fig. 1—Development on the Prairie Near Picher

The Joplin-Galena district is justly famous, and still holds

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[1] Presented at the *Symposium on the Chemistry and Metallurgy of Zinc*, 54th Meeting American Chemical Society, Kansas City, April 10 to 14, 1917.

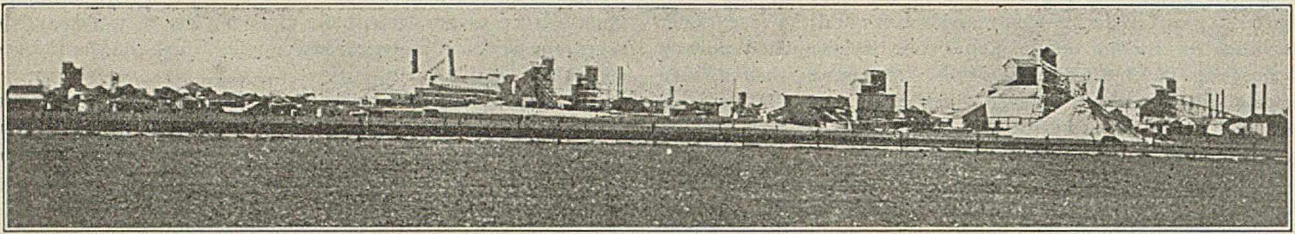


Fig. 2—Picher, Oklahoma: A Booming Zinc Town, Jan., 1917

its place in the front ranks of the zinc-producing region but public interest is now being diverted to the Southwest into the new field.

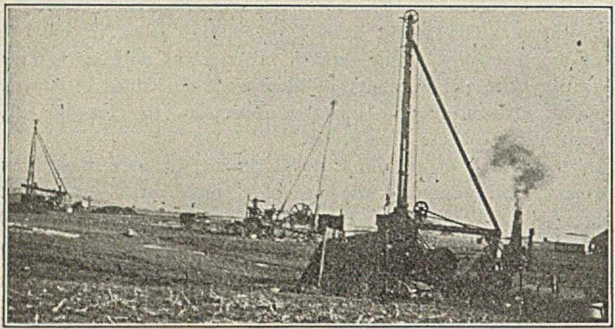


Fig. 3—Drilling Rigs Prospecting for Zinc Ore Near Picher

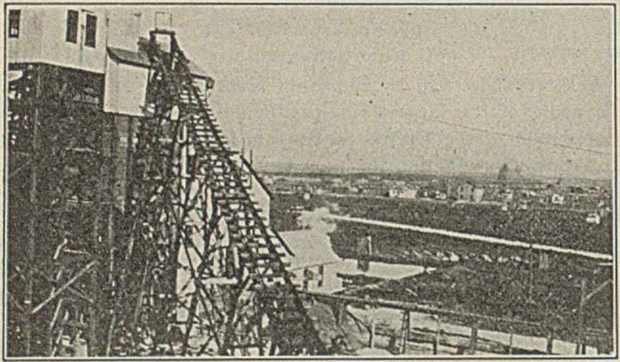


Fig. 4—Development Near Admiralty, Okla., Jan., 1917

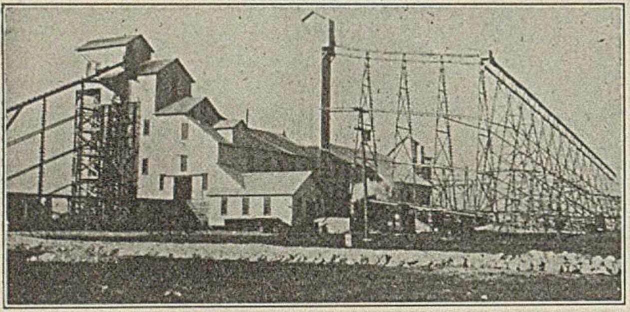


Fig. 5—Welsh Concentrating Mill, Admiralty, Okla.

We shall, therefore, pass from the great dumps and expensive underground workings of the Webb City-Carterville regions, which have been so long established that there is only the routine development work on ore which does not interest us, and go by auto to the eastward from Joplin through Galena, Kansas, with its many old abandoned workings and great dumps, on to the South through Baxter Springs, Kansas, where we see many autos with parties of men driving about as if bent on important business. Star drilling rigs are seen scattered over the country and they become more numerous as we approach the Oklahoma line. Near the State boundary are some new mills under construction. Others are already in operation, and we realize that we are in the new zinc fields at last. We go about two miles south into Oklahoma to what looks like a large city with many tall buildings, but find that it is really the town of Picher, which has had a wonderful growth in the past few months and is daily spreading out into the prairie. New concentrating mills of galvanized iron are being built, shafts being dug, and drilling going on (see Figs. 1 and 2). Small wooden shacks and prairie schooners cluster about the borders of the town, and have spread so far that they merge with the neighboring town of Admiralty, which shows the same mushroom-like growth.

It is a very inspiring sight to one who is used to seeing things old and stable, to get into a real boom town and observe the rush and hustle of all the people. We realize that this is part of the old Indian Territory where the Indians were given land at one time considered of little value. Now there is great effort to lease the land, and many of the Indians are very well off from their leases and royalties on production. The rows of small portable drilling rigs of the Star type first interest the visitor (see Fig. 3). They are prospecting the leases to determine the depth of the ore body and its thickness and extent. By systematic drilling a fairly accurate estimate of the amount of ore can be made, and thus this development work is removed from a gambling chance to a fairly safe mining proposition. The depth of drilling is comparatively slight, being in the neighborhood of 300 feet, and so the expense of this thorough prospecting is not great. The large number of concentrating mills indicates to a certain extent the number of small companies operating. It also indicates the great demand and high price paid for the zinc at the present time (see Figs. 4 and 5).

GEOLOGIC FORMATION AND STRUCTURE

The rocks which outcrop at the surface of this region consist of shales and limestones of late Paleozoic age. The western part of the district contains rocks of Pennsylvanian age which are represented on the map (Fig. 6) by diagonal shading. In the unshaded part of the map the rocks at the surface are of Mississippian age. Numerous wells, shafts, and drill holes have furnished data in regard to the strata below the surface. A vertical columnar section in northwestern Oklahoma[1] gives us the succession of strata shown in Fig. 7. The region lies on the northwestern flank of the Great Ozark uplift and therefore the strata have a general dip to the west and northwest.

ORES

The lead and zinc minerals which are being mined in this region are chiefly the sulfides: galena, PbS; and sphalerite, ZnS; but some of the oxidized ores, carbonates and silicates, nearer the surface, are also being used. In this district sphalerite is much the most important ore. These minerals are all

[1] Oklahoma Geological Survey, *Bull.* **9** (1912).

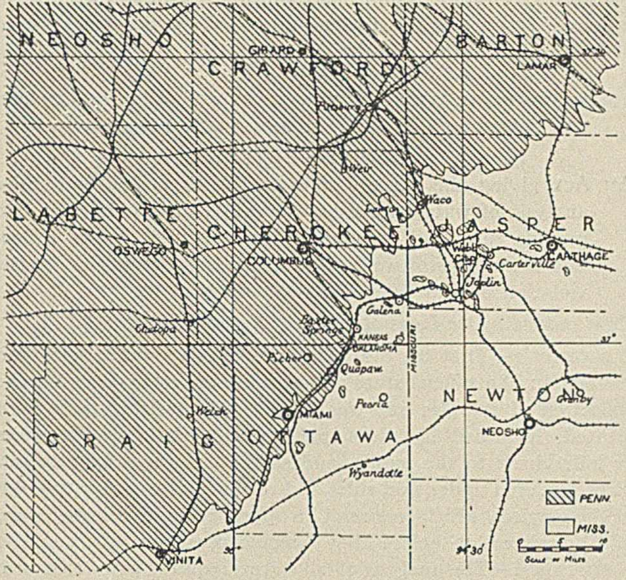
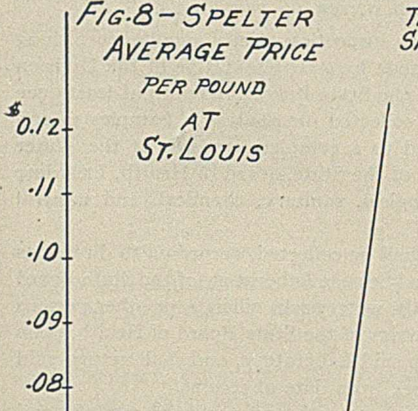


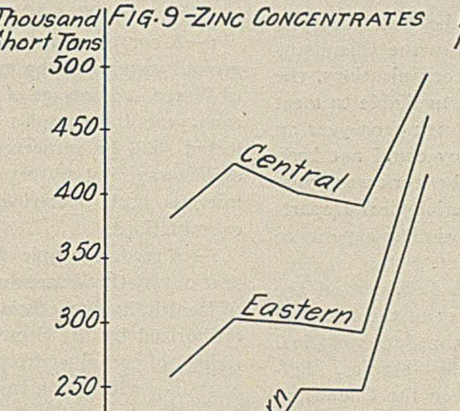
FIG. 6

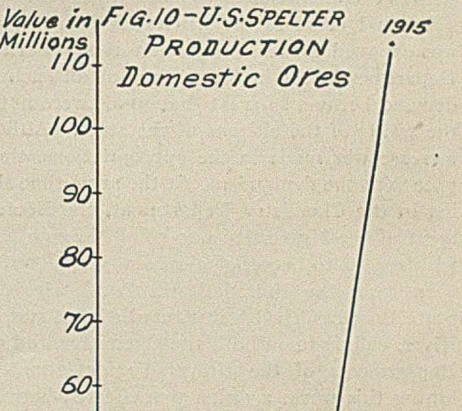
found in the Boone formation (chiefly the cherty middle member), and occur in two forms: the common type being known as the "sheet ground" deposits, or "blanket veins," which are developed parallel to the bedding planes of the strata in which they occur, and often have great lateral extent; and the "runs" which are inclined and located in disturbed zones in the strata. The ore in the "runs" is usually of much higher grade than that in the "sheet ground," but the "runs" are of much less extent.

ORIGIN

A great many eminent geologists have worked on the problem of the origin of these ores, but no perfectly satisfactory theory has been evolved as yet. The theories up to date may be grouped under three different heads. They are: (1) that the minerals were deposited by ascending waters; (2) that they were deposited by descending waters; and (3) that they were deposited by ascending and later concentrated by descending waters. The presence of small amounts of these minerals in the formations above and below the Boone chert would favor any of these theories. The latest and most detailed work on this subject is by Mr. C. E. Siebenthal,[1] who believes that the circulation of the underground waters in this district has been upward, and that the ore minerals were concentrated from the scattered minerals chiefly in the Cambrian and Ordovician rocks.







PRODUCTION

The increased production of metallic zinc (spelter) in the United States since the outbreak of the war and its great increase in value is well shown by the accompanying diagrams: Fig. 8 shows the enormous jump in the average price of spelter from 1914 to 1915, and this high price has kept up to the present time. Fig. 9 shows the increased production of all of the groups of the states, with the beginning of the war, and the greater demand for zinc. Fig. 10 shows the relations of the production to the increased value for these same years. The figures on the production for the year 1915 show that the Joplin district produced 643,380,000 lbs. of zinc concentrates valued at $23,419,103, and 329,088,000 lbs. of metallic zinc valued at $40,806,912. The Joplin sphalerite concentrate ores average more than 57 per cent of zinc, while those from Montana average about 45 per cent; those from other places are lower than this. There was an increase of nearly 50 per cent in the quantity of zinc and zinc-lead ores treated in 1915.

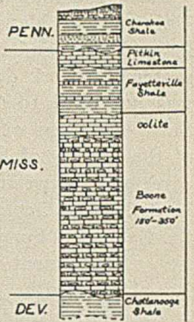


FIG. 7

CONCLUSION

Unquestionably this new zinc district has a much higher grade ore than that of the Joplin region, as seen from the ore being run through several of the large mills at Admiralty and Picher. It is from 15 to 20 per cent sphalerite. This means that great profit can be made even with rather expensive and careless handling of the ore.

When the price of zinc drops with the decrease in demand after this war, it will be necessary for these many small companies with their multitude of mills to consolidate and get down to the maximum production and minimum cost basis which enables the older mines of the Joplin district to operate profitably with their rather low-grade ore.

UNIVERSITY OF KANSAS
LAWRENCE, KANSAS

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[1] U. S. Geological Survey, *Bull.* **606** (1915).

THE LEGAL STATUS AND THE CHARACTER OF WORK DONE BY THE KANSAS STATE BOARD OF HEALTH WATER AND SEWAGE LABORATORY[1]

By C. C. Young

Since the foundation of the Chemistry Department at the University of Kansas, water analyses had been made by Professor Bailey and members of his department and considerable systematic work done by Professor Bartow and others, but it was not until 1906 that any real survey of the waters of the State of Kansas was attempted. At that time, an investigation of the quality of Kansas waters was prosecuted under a joint agreement between the Kansas State Board of Health and the United States Geological Survey, Horatio N. Parker representing the Geological Survey and Dr. E. H. S. Bailey, of the Chemistry Department of the University, representing the State Board of Health.

The funds available for this investigation were limited, but a very satisfactory report was made in *Water Supply Paper* 273.

As the organic law of the State provides that all scientific work of the State Board of Health shall be done at the University, the headquarters were naturally provided by the Board of Regents.

From October, 1906, to February, 1908, the work in the laboratory was carried on by Dr. F. W. Bushong and Archie J. Weith.

So much educational work had been done by Mr. Parker in the field with its coincident newspaper notices that a demand grew up among the people of the state for examinations of their water supplies. About this time, the Legislature passed the first of the water and sewage laws, which gave over to the State Board of Health supervision of water supply and sewage, including the purification of water and treatment of sewage. This necessitated some laboratory facilities for the Engineer of the State Board of Health. Consequently, it was found impracticable by the University to discontinue the Water Laboratory, which had been founded for the work done in conjunction with the United States Geological Survey.

When I came to the University in 1908, the water analysis was assigned to me as a portion of my work in the Chemistry Department. As in the history of all such organizations, the demand became so great that funds were not available to meet the wants of the citizens of the state. Although each year an increase was made in the appropriations, they could not keep pace with the demands. At the same time the work was growing in the Chemistry Department, the Bacteriological Department of the University was going through a similar experience with regard to bacteriological analysis of water.

In 1912, the United States Public Health Service and the State Board of Health instituted a joint survey of the Missouri River, calling upon both the Chemistry and the Bacteriological Departments of the University for laboratory studies. Following this work, a union was effected between the Chemistry and Bacteriological Departments forming a Water Laboratory of the University of Kansas, which was to do such work as the State Board of Health required and make a study of the sanitary water conditions of the state.

In a short time this organization was rendered ineffective on account of lack of sufficient funds to meet the ever-increasing demands for routine examinations of water supplies, so in 1915 a proposition was put before the Board of Administration of the University of Kansas whereby a bill was to be introduced founding a Water and Sewage Laboratory of the State Board of Health, and providing for the support of the Laboratory by fees collected for the analyses, and as it was intended to abandon the work on account of this condition, it was fortunate that this bill became a law.

The law as finally passed is as follows, with the rules and regulations that were drawn up and approved by the State Board of Health and Board of Administration.

....

RULES AND REGULATIONS OF THE STATE BOARD OF HEALTH FOR THE COLLECTION OF SAMPLES AND ANALYSIS OF WATER[1]

Session Laws of 1915—House Bill No. 503

AN ACT giving the State Board of Health power to require analysis of waters furnished or sold to the public, and to provide rules and regulations for said analysis and collection of samples of water, and to prescribe penalties for the violation of said rules and regulations.

Be it enacted by the Legislature of the State of Kansas:

SECTION 1—That the State Board of Health small make and publish, in the official state paper, rules and regulations for the collection of samples and analysis of water, either natural or treated, furnished by municipalities, corporations, companies or individuals to the public, and shall fix the fees for any services rendered under said rules and regulations to cover the cost of the services, which fees shall be approved by the State Board of Administration before they become operative.

SECTION 2—The analysis of all waters required in the rules and regulations shall be made at the Water and Sewage Laboratory of the State Board of Health in the University of Kansas, and the fees collected under the provisions of this act shall be turned into the state treasury for the benefit of said laboratory of the University of Kansas.

SECTION 3—That every corporation, railway, common carrier, company or individual that shall fail to comply with the rules and regulations prescribed by the State Board of Health under this act shall be deemed guilty of a misdemeanor and upon conviction shall be fined not less than $50 nor more than $500.

SECTION 4—This act shall take effect and be in force from and after its publication in the official state paper.

RULES AND REGULATIONS GOVERNING COLLECTIONS OF SAMPLES AND ANALYSIS OF WATER FROM CITY SUPPLIES FURNISHING GROUND WATER TO THE PUBLIC

1—A complete sanitary inspection of city supplies furnishing ground water shall be made by a representative of the Division of Water and Sewage of the State Board of Health at least once each year and samples collected for analysis. Samples so collected shall be subjected to a complete analysis at the Water and Sewage Laboratory of the State Board of Health, including microscopical, bacteriological, sanitary, chemical, and mineral examinations.

2—A second sample shall be collected, according to directions sent out by the Water and Sewage Laboratory of the State Board of Health, by city officials, waterworks officials, or other persons authorized by the Secretary of the State Board of Health, upon receipt of container from said Laboratory, and shall return said container within one week from date of receipt.

3—Results of these analyses with any pertinent remarks and advice shall be reported to the person whose name is signed to the information blank and to the Secretary of the State Board of Health.

4—As many additional analyses shall be made as are deemed necessary by the Engineer of the State Board of Health to show the quality of the water.

(1) Analyses of proposed city supplies shall be made upon request to the Water and Sewage Division of the State Board of Health.

5—Fees for service rendered under these rules and regulations for ground water supplies shall be payable July first of each year to the Director of the Water and Sewage Laboratory of the State Board of Health at the University of Kansas, Lawrence, Kansas.

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[1] Presented at the Kansas City Meeting of the American Chemical Society, April 10 to 14, 1917.

[1] Published in the Topeka State Journal, June 14, 1915.

6—Fees have been fixed, based upon the population of the cities. The population of a city shall be taken from the preceding state enumeration:

Population of Cities	Fees
Under 500	$12.50
500– 1,000	20.00
1,000– 2,000	25.00
2,000– 3,000	30.00
3,000– 5,000	35.00
5,000–15,000	40.00
15,000 and up	50.00

RULES AND REGULATIONS GOVERNING COLLECTIONS OF SAMPLES AND ANALYSIS OF WATER FROM CITY SUPPLIES FURNISHING SURFACE WATER TO THE PUBLIC

(2) Analyses of chemicals used in water purification shall be analyzed upon request.

1—A complete sanitary inspection of city supplies furnishing surface water shall be made twice annually, and tests of the operation of the plant shall be carried on at the time of these inspections by a representative of the Division of Water and Sewage of the State Board of Health.

2—Samples shall be collected weekly, according to directions of the Water and Sewage Laboratory, by city officials, waterworks officials or other persons authorized by the Secretary of the State Board of Health from the raw and finished treated water and sent to said Laboratory for analysis in containers furnished.

3—Results of these analyses, with any pertinent remarks and advice, shall be reported to the person whose name is signed to the information sheet, and to the Secretary of the State Board of Health.

4—City officials shall be required to keep any data on the operation of purification plants that may be required by the Division of Water and Sewage of the State Board of Health. This data shall be transmitted to the Engineer of the Division upon his request.

5—Fees for the services rendered under these rules and regulations pertaining to surface water supplies shall be payable July first of each year to the Director of the Water and Sewage Laboratory of the State Board of Health at the University of Kansas, Lawrence, Kansas.

6—Fees have been fixed, based upon the population of the cities. The population of a city shall be taken from the preceding state enumeration:

Population of Cities	Fees
Under 1,500	$30.00
1,500– 3,000	50.00
3,000– 6,000	90.00
6,000–10,000	100.00
10,000 and above	150.00

RULES AND REGULATIONS GOVERNING COLLECTION OF SAMPLES AND ANALYSIS OF DRINKING WATER SUPPLIED BY COMMON CARRIERS

1—Sanitary inspection of the sources of supply and methods of handling water furnished by common carriers to the public within the state at points where they have privately owned supplies shall be made twice annually by a representative of the Division of Water and Sewage of the State Board of Health.

2—Samples shall be collected at the time of inspection from the sources of supply and the place where trains are watered. Samples so collected shall be subjected to complete analysis in the Water and Sewage Laboratory of the State Board of Health in accordance with the standard adopted by the United States Treasury Department for drinking water supplied to the public by common carriers in interstate commerce.

3—Results of these analyses shall be reported to the proper railroad official, to the Secretary of the State Board of Health, and to the Surgeon-General of the United States Public Health Service.

4—In case a water supply furnished by common carriers to passengers in the State does not meet the requirements of the standard of the Treasury Department, and repairs or improvements on the supply are made with the approval of the Division of Water and Sewage of the State Board of Health, one additional analysis shall be made without cost to the common carrier.

5—Railroads or common carriers shall file with the Water and Sewage Laboratory of the State Board of Health a list of all places in the State of Kansas where passenger trains are furnished with water for drinking purposes, and the said laboratory shall be notified at once in case any change is made in the source of supply or method of handling the water.

6—The fees for the services rendered under these rules and regulations pertaining to railroads or common carriers shall be payable July first of each year to the Director of the Water and Sewage Laboratory of the State Board of Health at the University of Kansas, Lawrence, Kansas.

7—The fee for analysis shall be $30.00 annually for each place where passenger trains are furnished with water to be used by passengers.

RULES AND REGULATIONS GOVERNING COLLECTION OF SAMPLES AND ANALYSIS OF WATERS SOLD OR FURNISHED TO THE PUBLIC FOR DOMESTIC CONSUMPTION IN BOTTLES OR OTHER CONTAINERS

1—All plants for the preparation of water for sale or distribution in bottles or other containers for domestic consumption and the sources of water supply shall be inspected twice annually by a representative of the Division of Water and Sewage of the State Board of Health and samples collected for complete analysis by the Water and Sewage Laboratory of the State Board of Health.

2—Bottles or other containers in which water is sold or furnished to domestic consumers must be sterilized before refilling. The method of sterilization shall be passed upon and approved by the Water and Sewage Laboratory of the State Board of Health, subject to approval by the State Board of Health.

3—Processes of purification of waters that are to be sold or furnished for domestic consumption must be passed upon and approved by the Water and Sewage Laboratory of the State Board of Health, subject to approval by the State Board of Health, before the water can be sold or offered for sale.

4—Any company, corporation or individual outside of the State of Kansas preparing water for sale or distribution within the State of Kansas shall file full information with the Water and Sewage Laboratory of the State Board of Health at the University of Kansas, Lawrence, Kansas, as to the sources of supply and methods of sterilization of bottles, and equipment for handling the water, and shall collect samples twice each year, according to directions, in containers sent out by the Water and Sewage Laboratory of the State Board of Health, and return same at once for complete analysis, carriage charges prepaid.

5—Reports of analysis shall be made to the person signing the information blank and to the Secretary of the State Board of Health, and permits shall be issued by the Secretary of the State Board of Health for the sale of water based upon the results of analysis and inspection and the recommendations of the Division of Water and Sewage of the State Board of Health.

6—The fees for the services rendered under these rules and regulations pertaining to bottles and treated waters shall be payable July first of each year to the Director of the Water and Sewage Laboratory of the State Board of Health at the University of Kansas, Lawrence, Kansas.

7—The fee shall be $30 annually for each source of supply from which water is bottled.

In case a person, company, corporation, institution or municipality believes that a decision of the Division of Water and Sewage of the State Board of Health is unjust or unfair in any matter pertaining to the administration of the rules and regulations herein contained, he shall within thirty days have the privilege of appealing to the State Board of Health as a whole, and said State Board of Health shall approve, set aside or modify the decision of the Division of Water and Sewage.

Fees collected under these rules and regulations shall be distributed over the expenses of collection and shipping of samples, and making of analyses, under the direction of the State Board of Health, subject to the approval of the Board of Administration of Educational Institutions.

RULES AND REGULATIONS GOVERNING COLLECTION OF SAMPLES AND ANALYSIS OF ICE SOLD FOR DOMESTIC CONSUMPTION[1]

1—Corporations or individuals selling artificial ice for domestic consumption shall submit to the Water and Sewage Laboratory of the State Board of Health complete information concerning the source of water supply used for the manufacture of the ice and a detailed description of the process involved.

2—A fifty (50) pound cake of ice manufactured shall be shipped to the Water and Sewage Laboratory of the State Board of Health, Lawrence, Kansas, each year for complete analysis. Results of these analyses shall be reported to the person whose name is signed to the information sheet and to the Secretary of the State Board of Health.

3—Artificial ice shall contain less than 100 bacteria per cubic centimeter and no organisms of the *Bacillus coli* group in one cubic centimeter. If the ice does not meet these requirements it shall be sold for refrigeration purposes only and not for domestic consumption.

4—Corporations or individuals harvesting natural ice shall file full information with the Water and Sewage Laboratory of the State Board of Health with regard to the source of the ice and method of storage.

5—A fifty (50) pound cake of the ice shall be shipped to the Water and Sewage Laboratory of the State Board of Health during March or April each year for complete analysis.

6—Natural ice properly stored shall contain less than 100 bacteria per cubic centimeter and no organisms of the *Bacillus coli* group in one cubic centimeter. If the ice does not meet these requirements it shall be sold for refrigeration purposes only and not for domestic consumption.

7—County Health Officers and, in cities of the first class, City Health Officers, shall furnish the Water and Sewage Laboratory of the State Board of Health with lists of ice dealers in their districts.

8—Fees for the services rendered under these rules and regulations pertaining to ice supplies shall be payable by the manufacturer or owner of the ice plant January first of each year to the Director of the Water and Sewage Laboratory of the State Board of Health at the University of Kansas, Lawrence, Kansas.

9—Fee shall be $15 annually for each source of supply of ice which is sold for domestic consumption.

....

We have been operating under this law and these rules and regulations since July 1, 1915, with the result that an organization has been built up that is handling expeditiously all of the work required and it has been possible to make several investigations of more or less importance.

In addition to the routine work, each member of the staff has been carrying on some research work, which was absolutely impossible under the old régime, as ample funds were never available.

The Board of Health and the University were agreeably surprised to find that there were very few complaints against the fee proposition and no organized opposition to the law in the Legislature that just closed.

County, City and Health Officers have felt free to call upon the laboratory to make investigations in their districts and in some instances have submitted a large number of samples for examination. The Engineers of the State Board of Health have worked in conjunction with the city officials in collecting these samples, so that the field data have been accurately and scientifically collected.

During the first year, the laboratory made approximately 6,000 complete bacteriological and 800 chemical analyses. In addition to this, we have examined a large number of filter sands, alums, limes and hypochlorites and made any other special analyses that would tend to improve the operation of water purification plants.

WATER AND SEWAGE LABORATORY
LAWRENCE, KANSAS

SOME MACHINERY EMPLOYED IN THE MANUFACTURE OF GLUE[1]

By ARTHUR LOWENSTEIN

In view of the fact that most of the improvements in the glue industry—at least so far as they pertain to distinctive improvements in equipment used in the manufacture of glue in this country—have taken place largely in that portion of the industry devoted to the chilling, cutting and spreading of glue, that which follows in this paper will be limited to this phase of the subject. In other words, it is not the purpose of the writer to treat on the preparing of raw glue stocks, the chemical treatment of such stocks and their subsequent cooking and evaporation, but rather on the product after it has left the evaporator.

The progress made in the glue industry in this country has been very gradual, and most glue manufacturers have been exceedingly conservative in adopting new equipment.

The old method of handling glue after it leaves the evaporator and this method is still in use to a considerable extent, consists in running the concentrated glue solution into wood, galvanized iron or zinc pans or "coolers" (such material being used to avoid staining the jelly with rust), and chilling these pans by means of running water, or usually in a refrigerated room, after which the product is removed either by cutting or by dipping the pans in hot water. The cakes formed in this manner are then either run against wires or knives. The Clyde cutting machine when originally invented marked a distinct advance in the method of cutting glue. The Clyde machine is of the wire-cutting type, made single or double, and is probably the most satisfactory machine of this type.

In some cases the chilled glue is chopped into blocks and then each block placed in a contrivance where, by the pressure of a lever, knives or wires descend on the cake of glue and cut the block into sheets.

Knife cutters will cut heavier jellies than the wire cutters, and this is desirable during the summer period. One of the objections raised against the knife cutters is that they "do not separate tops and bottoms."

Glue jellies when cut too stiff show a roughened surface, the appearance of which is unfavorable when dried.

After having been chilled and cut by any of the methods cited, the glue is spread by hand on nets.

The old system of chilling glue requires a chilling room sufficiently large to store several days' production of glue in coolers. It has frequently been found desirable in designing a glue plant using this method to arrange the chill-room so that outside temperatures can be used when suitable. The jellies must not be kept too long in these coolers, as even at low temperatures molds develop and depreciate the quality of the glue.

The principal objections to these methods of chilling and cutting glue have been that they require (1) considerable space for cooling room; (2) an excessive amount of refrigeration where

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[1] Approved by State Board of Health, October 4, 1915. Published in the Topeka State Journal, October 15, 1915.

[1] Presented at the Buffalo Meeting of American Institute of Chemical Engineers, June 20 to 22, 1917.

only a limited surface of glue is exposed to the refrigerated air, and as a result most of the heat has to be conducted to the air through the medium of the metal pans; that if the coolers or pans are made of galvanized iron they rust badly and have to be replaced; that they frequently leak, with consequent loss of product; that one has "tops" and "bottoms" which prevent uniformity of product or make it necessary to put these parts into a lower grade or into some other commercial form; and that the product has to be kept so long in the coolers that in warm weather, particularly humid weather in summer, the quality of the glue is so affected by liquefying organisms that the glue maker has serious difficulty both in the cutting and drying of the glue; and finally, the labor in filling these pans and emptying them, cutting by the methods outlined, and finally spreading the product by hand on nets, is not only laborious but costly.

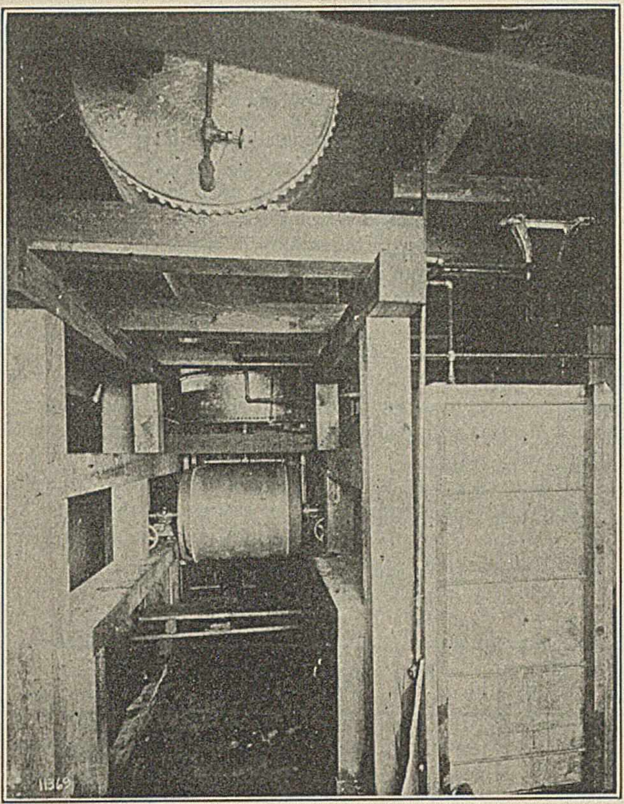

Fig. I—Feed Tank and Distributing Pipe Feeding the Glue Solution onto the Belt
(The large tank at the top is not part of the machine)

Because of these facts experiments have been carried on for years in the effort to secure mechanical or automatic devices of a continuous nature which would simplify the procedure and thus avoid so much loss and handling of the product. Various types of chilling rolls have been tried from time to time without success. The Cooper factory employed a chilling wheel years ago for this purpose, in which the wheel, chilled from within, picked up the liquid and chilled it; but somehow or other the process did not turn out to be practical. The writer has been informed within the last few years that one of the large glue companies has perfected a similar process, or at least is employing it commercially, in which a large wheel is employed. It is his understanding that this wheel may be 14, 16 or 18 ft. in diameter, with cored and flanged rim, using brine circulation in the rim which is supplied and circulated through stuffing boxes in the ends of the shaft. It is his understanding that this wheel spreads a sheet 30 in. wide. The writer wrote to the President of the company employing this machine, and had hoped to be able to include a cut and a more detailed description of it in this paper. So far as he knows it is used only by this one company.

Some years ago when the Bureau of Chemistry of the United States Department of Agriculture started to investigate the gelatine industry with a view to decreasing the bacterial count of commercial gelatines and to prevent metallic contamination; some manufacturers found it necessary to adopt different methods of manufacture from the very beginning, in the selection of their raw materials and particularly in their method of handling the product from its inception until it reached the final stages. Inasmuch as gelatine is a particularly good culture medium for bacteria, it was found desirable to concentrate efforts on methods which would reduce the period of time after the gelatine left the evaporator until it was converted into sheets or other finished form. The object sought was to obtain a continuous method of chilling, cutting and spreading the product without having it come in contact with agencies carrying bacteria, such as employees' hands, etc. A method of this kind was worked out and later patented by Maurice Kind under United States Patent No. 1,046,307, issued in 1912. His method consisted in running the gelatine from the evaporators into a head tank located above a continuous belt, as shown in Fig. I. A general idea of the principles involved in connection with this machine can best be gathered, perhaps, by quoting some of the objects of this invention directly from the patent, and from photographs shown herewith. A more detailed description can be readily obtained by reference to the patent itself.

"An object of the invention is to provide an apparatus wherein gelatin or other products where heat is necessary for extraction, may be converted from a liquid state, into a semi-solid state, by means of treatment with chilled air, and thereafter cut into the desired shapes for marketing purposes.

"A further object of the invention is to provide an apparatus of the above character with means for directing chilled air onto the upper surface of the semi-solid sheet, as it is formed and passed through a cooler on a conveyer.

"A further object of the invention is to provide a device of the above character with cutters for cutting the semi-solid sheets into strips.

"A further object of the invention is to provide an apparatus of the above character with a cutting means for cutting the strips into sections, together with a conveyor for receiving said sections which conveyor is so timed in its movements as to space the sections in trays carried by the conveyor."

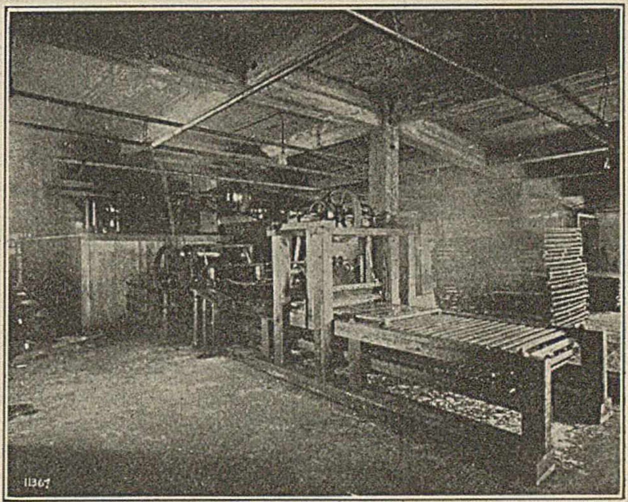

Fig. II—Chilling Box and Spreading and Cutting Devices of Kind Machine

To sum up: this machine consists of a device for chilling the product in a continuous sheet of the required thickness, spreading on an endless belt, which passes though a refrigerating tunnel, and automatically cutting the gelatine into sheets of the desired size and spreading it automatically upon the usual screens employed for receiving it preparatory to drying.

This machine was perfected and was found to accomplish the desired purposes in the manufacture of gelatine. A number of glue makers learned of the use of this machine for gelatine, and about five years ago the first of these machines was installed for glue. It has been found well suited for this purpose, and capable of chilling, cutting and spreading any kind of glue which could be handled by the older methods previously outlined. As a result, a large number of both large and small glue manufacturers have adopted this machine. The manufacturers of this machine advise that it requires a floor space of about 85 ft. in length and 10 ft. in width for the installation of a single machine; that the power required to operate fan and belts is about 10 horse-power; that it requires about 10 to 12 tons of refrigeration per machine, and that the capacity of each machine is about 4300 lbs. dry glue in a period of 20 hours, based on spreading the glue $^1/_4$ in. thick, and on a basis of glue fed to the machine containing 16 per cent solids. It is found in practice that the glue is spread on nets ready for drying, in not to exceed 15 minutes from the time the glue leaves the evaporator. Their claims for the machine are that it eliminates all of the disadvantages ascribed previously in this paper to the old methods of handling.

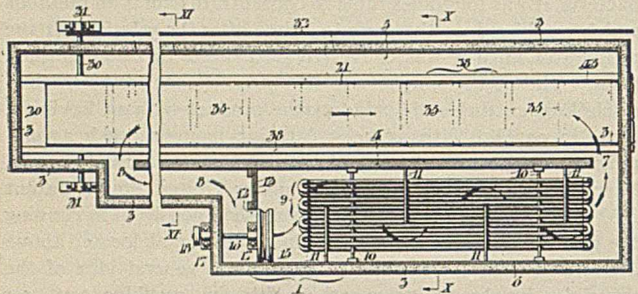

Fig. III—Plan of Cooling Compartment showing Relative Position of Belt and Coils, and Direction of Travel of the Glue Spread on the Belt and of the Refrigerated Air

DRYING OF GLUE

Glue has been and is still ordinarily dried in straight tunnels with longitudinal circulation of warm air. There is a great difference of opinion among different operators as to the best length of glue tunnels, the size and kind of fan, the method of temperature regulation to be employed, whether a suction system or positive pressure system should be used, etc., etc., but it is not the purpose of the writer to enter into a discussion of these points.

A number of other methods of drying glue have been attempted and some are being employed. Vacuum driers of one type or another have frequently been tried, but in most instances without meeting with commercial success. One company builds a drier with rotary air circulation, passing alternately over the coils and glue nets, which they recommend for glue drying.

In conclusion, the writer wishes to express his thanks to Mr. F. S. Williams; also to Mr. L. A. Kind for information relative to the Kind machine.

First National Bank Building
Chicago, Ill.

CURRENT INDUSTRIAL NEWS

RUSSIAN METAL TRADE

Statistics recently published by the Russian authorities, says *Mining Journal*, 116 (1917), 149, shows that larger imports than ever of copper were necessitated by war demand. The supplies were got chiefly from the United States which contributed 11,728 tons and from Japan which supplied 8,517 tons. The figures for home production are not yet published.

Russian Imports in Metric Tons

	1914	1915	1916
Aluminum	863	2,316	149
Antimony	1,343	2,325	3,636
Copper	4,576	10,778	23,548
Iron and Steel	2,236,345	1,787,041	1,752,660
Lead	36,691	25,059	23,128
Nickel	1,793	1,146	1,541
Tin	3,570	4,906	2,424
Zinc	14,328	14,137	11,840

Aluminum was only available in comparatively small amounts. Large supplies of antimony were available from Japan, and this metal shows a steady increase. As regards iron and steel, the imports are naturally small, Russia depending largely on her own domestic supplies.—A. MacMillan.

PLUMBAGO IN MYSORE

According to a Press message from Madras, an important discovery of plumbago is stated to have been recently made in Mysore by an expert prospector who is well known in the state. Graphite has been found in Bangalore before now but only in such small quantities as not to be paying. The present discovery appears to be a fairly rich deposit with the additional advantage that it is within three miles of the railway. Plumbago has been found in Travancore and Mysore previously, but the quality was not up to the standard of the Ceylon and Madagascar product, which is what the market requires. Whether the present kind is of better quality is not yet known.—M.

BLUE ASBESTOS

The annual report (1915) of the mining engineer for the South African Government, states that the only mines on which there are considerable reserves of blue asbestos actually developed and in sight, are those of the Cape Asbestos Company at Koegas and Westerberg. These mines have been developed underground on normal lines as also are the workings at Haauwpoort and Elandsfontein in the Hay district. At other places the asbestos is obtained from surface quarrying, but the seams that have been discovered and worked at the surface to more or less profit indicate supplies that will generally prove to be available for profitable extraction by underground methods later. The following analyses show the difference between blue asbestos (crocidolite) and chrysotile or white asbestos:

Percentages	Blue Asbestos	White Asbestos
Silica	51.1	39.3
Oxide of Iron	35.8	2.8
Magnesia	2.3	41.0
Alumina	....	3.6
Water	3.9	14.5

The blue variety contains also traces of lime and manganese oxide and a little soda. The presence of the large quantity of iron and the low content of water must account for whatever virtues and also faults the blue variety contains. There does not seem to be much question of the properties of white asbestos as a heat-resisting material, some varieties having been known to withstand a temperature of 5,000° F. without being affected. In addition, there can be no doubt as to its superior softness which enables it to be easily milled and reduced, and makes it specially useful for gland packing. On the other hand, blue asbestos has certain qualities peculiarly its own. The fiber, in addition to being lighter, is longer, stronger and more elastic, and its superior efficiency as an insulating material as regards heat, appears to be well known.—M.

KLEENSURFACE—A COATING FOR TOOLS BEFORE HARDENING

We have recently received, says the *Engineer*, 123 (1917), 298, from the Brooke Tool Manufacturing Company, Birmingham, England, some particulars of a compound to which the name "Kleensurface" has been given. This substance is for coating tools before hardening, so as to eliminate the waste of time and energy consumed in sand-blasting and to overcome the difficulties and risks due to oxidation of steel requiring a high temperature for hardening which may cause pitted and blistered surfaces on parts that cannot afterwards be ground. It is said to have no action whatever on the metal, being a protective agent only, and we gather that it preserves the smooth and bright finish which the cutter or tool has before hardening, thus preventing loss of size due to scaling whether the hardening be carried out in up-to-date appliances or in the open fire, while at the same time the need for sand-blasting is done away with. The method of using the substance is simple. The tool to be treated is first of all heated to visible red, and is then held in the compound for about ten seconds, withdrawn and then again plunged into the compound. It is then dried in the air. All that is now necessary is to heat the tool to the required hardening temperature and to quench it in the usual way. During quenching or air hardening, the protective film will, for the most part, peel off, and what remains can be easily removed, leaving, it is claimed, a clean white surface. The compound is also said to be very effective for annealing high-speed steel.—M.

GERMANY'S PRODUCTION OF IRON

At a recent meeting of the Union of German Iron and Steel Industries, some interesting information was given on the German production of iron during the war. The production of pig-iron in Germany during 1916 was about 13,000,000 tons as against 11,790,000 tons in 1915 and 14,380,000 tons in 1914. As regards this latter year, it should be borne in mind that, while the production for the first seven months was exceptionally high, it was the reverse for the last five months of the year, and the figure for 1914 does not afford any reliable basis for comparison. The following table shows Germany's production of pig-iron for the last ten years from which it will be seen that the industry has receded considerably from the preceding peace figures, in spite of strenuous efforts.

Year	Tons	Year	Tons
1907	13,040,000	1912	17,870,000
1908	11,810,000	1913	19,290,000
1909	12,920,000	1914	14,380,000
1910	14,790,000	1915	11,790,000
1911	15,530,000	1916	13,000,000

—M.

ZEPPELIN ENGINE

A six-cylinder, 160 horse-power Benz engine used for enemy aircraft purposes has cylinders 130 mm. diameter and 180 mm. stroke. The cylinders are all cast separately and the weight of the engine complete comes out at 3.70 lbs. per brake horse power at the normal speed of 1550 r. p. m. These particulars have been obtained by the British Naval and Military authorities from an engine taken from a captured Zeppelin.—M.

FUEL FROM PEAT

A Christiania paper reports the formation of a company in Norway for making fuel from peat by the Rosendahl method. The raw material for the new industry will be chiefly peat from the extensive Norwegian moors, but any other material may be used which is sufficiently abundant in the neighborhood of the factory, *e. g.*, wood waste. The product is said greatly to resemble English coal. Preliminary experiments have been conducted not only in the laboratory, but also under factory conditions on a small scale, and the product is stated to have been satisfactorily tested in Christiania households.—M.

GAS ANALYSIS BY ALPHA-RAYS

It is known that the highest conductivity in gases can be produced by exposing them to α-rays which ionize the gas. These rays, says *Engineering*, 103 (1917), 401, are absorbed by the gas, and if the absorption be complete, the ionization and the resulting saturation current are little affected by the nature of the gas. When the tube containing the gas is so long, however, that saturation is just secured by a heavy gas, the current would not be saturated if the gas were replaced by another less dense gas.

On this peculiarity, Professor F. Krüger, of Danzig, has based a new method of determining the proportion of two gases in a mixture, often a troublesome problem. The method is a current measurement, and, as the currents are very weak, of the order 10^{-9} ampere, very high resistances are required. At the winter meeting of the Bunsen Gesellschaft, Krüger explained how he produced high resistances for the purpose. He volatilizes platinum cathodes by the electric discharge and condenses the platinum vapor on little rods of amber. In this way, he has prepared a series of film resistances, ranging from 5×10 up to 3×10^{13} ohm. The analytical method is said to be expeditious and reliable within 0.1 per cent or less.—M.

QUALITIES OF STEEL

According to a paper published in the *Bulletin des usines de guerre*, the change in volume produced by hardening (quenching) steel is small if the hardening temperature is kept below a certain limit. Hardening in oil gives less variation in volume than hardening in water. Special metals, such as nickel-steel, show less diminution in volume than the carbon steels. Eutectic steels "crack" more frequently than carbon-steels, which latter undergo considerable changes in volume. Finally, from experiments carried out, in flat pieces the tension is distributed uniformly in every direction, while in cylindrically shaped pieces the ends contract and become hollow, the piece bellying out.—M.

BRITISH SUGAR BEET GROWING

An enterprise, estimated to cost $2,500,000, for the production of home-grown sugar, has now been initiated. A grant of $625,000 has been made by the Treasury by way of loan from the Development Fund towards the purchase of an estate of 5,600 acres at Kelham, England, where it is proposed to grow the sugar-beet and to erect a factory for its manufacture into sugar.

The undertaking is to be carried out by the British Sugar Beet Growers' Society, Ltd., of which Captain Beville Stainer is Chairman. The property has already been acquired and Mr. Alfred Wood, who is in charge of the home-grown flax, hemp and tobacco undertaking in England is the Secretary.—M.

OIL SHORTAGE IN DENMARK

According to the *Extrabladet*, the oil mill at Aarhus, which supplies all the great margarine factories in Denmark with oil, is threatened with having to close unless supplies of copra arrive in the near future, as the factories have only very small stocks in hand. It is feared that margarine will soon be unobtainable in Denmark. The *National Tidende* anticipates that the entry of the United States into the war will cause further difficulties in connection with Denmark's already extremely limited supplies of oil. The journal even regards a complete stoppage of supplies as not at all unlikely and expects that the controlling authorities will enforce considerable restrictions on consumptions. All electric power stations using oil are expected to close down and the use of petroleum for lighting purposes will probably be prohibited.—M.

A NEW SOURCE OF PLATINUM

According to a Bulletin of the Siberian Engineers' Society on the platinum fields of the Nizhni-Tagilsk Mining Circuit, the mining engineer, V. N. Tchorzhevsky, has begun the first experiments in the world on the extraction of platinum from dunite. The experiment promises to be extremely interesting. The platiniferous nature of dunite has long ago been observed and the presence of the metal is apparently connected with the existence of chrome iron ore in the rock, on the abundance of which the greater or lesser content of platinum in the whole dunite mass depends. All this was known before, but was rather of scientific interest and it is only now that the investigation of the dunites for platinum on a wide scale is being undertaken, in order to prepare a plan for utilizing the immense reserves of dunitic rocks which in the Nizhni-Tagil district alone occupy an area of 11.7 sq. mi. The method of extraction adopted is the simple grinding under runners of the rock and the collection of the chromite slack, and then a fresh grinding of the latter in order to leach the pure metal finally from it. The chromite slack remaining after washing, the platinum sands being scrupulously cleared of all visible platinum, yielded with an experimental grinding by runners in the month of March, when it was impossible to deliver dunites to the factory, over 200 oz. of metal out of 9,720 lbs. The gray slack, which consists chiefly of undecomposed dunite obtained from the dredges when washing platinum, yielded 171 grains (Troy) of metal from 3,600 lbs.—M.

INDUSTRY IN CANADA

Last year a postal census was taken in Canada of all manufacturing concerns and constructive operations. The results of this investigation, classified under certain large groups of industries, are shown in the following table. The returns cover the year 1915:

Groups of Industries	Establishments	Capital	Cost of Material	Value
1 Food	6,470	$198,246,942	$291,997,953	$377,811,758
2 Textiles	2,670	26,488,339	81,427,279	144,691,235
3 Iron	849	194,278,446	58,924,280	119,636,755
4 Timber	3,181	263,407,682	59,1'0,149	123,250,986
5 Leather	523	60,081,498	45,175,517	0,975,644
6 Paper	1,306	38,544,786	29,324,906	74,038,498
7 Liquors	341	52,283,857	10,129,252	34,859,927
8 Chemicals	255	52,148,588	24,930,308	45,410,486
9 Clay	771	96,371,573	10,962,041	27,228,413
10 Metals	1,173	174,621,994	45,931,080	90,943,278
11 Tobacco	166	23,066,898	16,017,707	28,987,250
12 Vehicles	464	125,965,499	40,547,113	73,878,212
13 Vessels	103	12,331,341	3,035,857	8,419,648
14 Miscellaneous	1,440	441,118,405	56,323,786	134,255,029
15 Handtrades	1,579	26,135,559	17,627,192	38,129,834
TOTAL	21,291	$1,984,991,427	$791,524,420	$1,392,516,953
Per cent increase over 1905	34.8	134.5	....	93.8

The total salary and wage lists, respectively, in the 15 groups of industries shown amounted to $60,144,000 and $227,509,000 as compared with $30,724,000 and $134,376,000 in 1905. The only industries which have not shared in the substantial growth are sawmills, planing mills, brickyards, etc., and fruit and vegetable canneries.—M.

PURIFICATION OF ASBESTOS

A writer in a German paper says that commercial asbestos contaminated with iron compounds may be purified by treatment with a 2 per cent aqueous solution of oxalic acid for 48 hours, followed by washing with water. A band of asbestos 20 mm. wide showed at fourteen different places an electrical resistance of 600 to 700 ohms; after treatment as described, the resistance increased to 150,000 ohms. An alternative method consists in treating the asbestos for 20 to 24 hours in a current of hydrogen or carbon monoxide at 390 to 400° C. and then washing with very dilute hydrochloric or sulfuric acid and afterwards with water.—M.

FRENCH EXPORT PROHIBITIONS

A French Ministerial Decree dated March 19 abrogates the provisions of various earlier decrees by virtue of which the following articles were allowed to be exported or re-exported from France without special authorization when consigned to the United Kingdom, British Dominions, colonies and protectorates, Belgium (territory not in enemy occupation), Japan, Russia and the countries of America:

Acetone
Cadmium in all forms
Carbide of calcium
Cement
Cinchona bark
Cobalt in all forms
Copper, ore or metal, pure or alloyed, in all forms
Dextrine and soluble starches
Fatty acids of all kinds
Fats, animal (tallow, lard, margarine, oleomargarine and similar substances)
Fats, fish, vegetable, alimentary
Lead: metal, pure or alloyed; pipes and other wares of all kinds
Manures of all kinds (including chemical manures)
Mica in sheets and plates
Mica and micanite, worked
Monazite (ore of cerium, lanthanum, thorium)
Nickel, metal, pure or alloyed, in all forms
Ores of manganese, molybdenum, titanium, vanadium
Radium and its salts
Saccharine and similar products
Salts of chromium, copper, tin, mercury and molybdenum
Silica bricks
Silicon
Sodium
Starch
Stearic acid
Tin, ore or metal, pure or alloyed, in all forms
Tungsten metal in all forms
Whale oil

—M.

BRITISH BOARD OF TRADE

During the month of April the British Board of Trade received inquiries from firms in the United Kingdom and abroad regarding sources of supply for the following articles. Firms which may be able to supply information regarding these things are requested to communicate with the Director of the Commercial Intelligence Branch, Board of Trade, 73 Basinghall St., London, E. C.:

CHEMICALS: Ammon'm sulfocyanide
    Dinitrophenol
    Dichlornitrobenzol
    Potassium permanganate
    Silicate of sodium
    Sodium permanganate
MACHINERY:
    for combining thin sheets of tortoise shell to form thick sheets
    for cutting out and sewing fabric gloves
    for filling quilts by air pressure
    for making drawing pins
    for cementing or jointing tortoise shell
    for making paper spills
    for crushing and refining oilseeds
    for electrolytic production of oxygen and hydrogen
Flint glazing machines for pasteboards similar to "Grahl & Hoehl" machine
Wire-stitching machines for box corners
Bread grating machines or nut mills
Hand-branding machines fitted with petrol reservoir
Pebble grinding mills
Anglite frames for ladies' handbags
Brushes: tooth, hair, clothes, for Egypt
Buttons, all kinds
Cast-iron lavatories
Dog-collars, metal
Fatty acids, cotton and corn oil
Fittings for manicure cases, in bone and ebony (cheap)
Folding market bags, American cloth
Log-wood, black lake
Marine chronometers (2-day) chains and escape wheels, etc.
Micrometers with 3 verniers
Moorsom's measuring apparatus for ships
Poker-work needles, platinum points
Shaving-soap, containing less than 1% of glycerine
Split rings, steel or iron
Swivel hooks, iron
Thimbles
Varnish, black, for coating beer vats internally
Zinc oxide (40 tons)

—M.

PHOSPHOR BRONZE

The characteristics of phosphor bronze in different forms are described in a publication by the Phosphor Bronze Company. Among other points, attention is drawn to the resistance it offers to corrosion and acid waters, to the small effect that rise of temperature has upon its mechanical properties, and to the fact that it does not yield a spark when struck. On this last account, tools and implements used in gunpowder mills, magazines and mines are advantageously made of it. In addition to being cast, it can be forged, drawn into rods, wire and tubes, and rolled into sheets, strips, tape and bars. When cold rolled or drawn, since its elasticity is absolute practically up to breaking stress, the metal can be exposed to strains only a few tons below the breaking weight without permanent set or deformation. The pamphlet also gives particulars of various other alloys—such as phosphor tin and copper, anti-friction metals of various kinds, and printing and stereotype alloys.—M.

THE MANUFACTURE OF IODINE

Reports from Quimper (France), says the *Oil and Color Trade Journal*, 51 (1917), 1469, speak of a new process for the manufacture of iodine and its derivatives. Iodine, of which the Department of Finistère is a great producer, was hitherto extracted from the soda produced by the incineration of certain kinds of marine algae. This method of operation, which necessitated the algae being first of all transformed, rendered the yield very poor and lacking in uniformity, as the incineration employed was very rudimentary. Mons. Vincent, Director of the Laboratory of Finistère, who has been studying the question for some time, has now discovered a process enabling iodine to be extracted by a direct treatment of such algae or seaweed. This process has been patented and is in use in the works at St. Pierre-Penmark and has given excellent results. A joint stock company has been formed for working the patent and utilizing the by-products.—M.

WOOD IN GAS-MAKING

In reference to the use of resinous wood for the production of gas, which has been adopted on a more or less extensive scale in several continental countries, a correspondent of the *Journal des Usines à Gaz* records his experience in the distillation of fir and oak in the Romorantin Gasworks. The wood, he writes, was distilled, unmixed with coal, in retorts of dimensions approximately 10 ft. × 25 in. × 14 in. in quantity to yield from 10 to 20 per cent of the make of gas from coal. Each charge was about 100 kilos of fir or 120 kilos of oak and it yielded about 25 cu. m. (900 cu. ft.) of gas. In working a bench of retorts, it was found necessary to adopt alternate days for the distillation of the wood. Continuous use of the same retorts for wood gave rise to stoppages in the ascension-pipes in the shape of a viscous grayish deposit, very troublesome to remove. The following figures were obtained for the cost of using the two woods: *Fir,* price per ton, 40 frcs.; labor, 4 frcs.; furnace coke (200 kilos), 17.50 frcs.; total, 61.50 frcs.; deducting 50 frcs. for sale of charcoal, the net cost is 11.50 frcs. *Oak,* price per ton, 58.50 frcs.; labor, 4 frcs.; coke, 17.50 frcs.; allowing for sale of charcoal at 70 frcs., the net cost is 10 frcs. The charcoal sells readily, the weight per hectolitre being 15 kg. in case of fir and 18 kg. for oak.—M.

TREATMENT OF TIMBER

Excellent results have been obtained with saponified creosote by simply soaking estate timber in an open tank, and the method seems to deserve a trial if the greater expense of creosoting pit timber under pressure cannot be faced, says the *Iron and Coal Trade Review*. The idea was first suggested by Mr. S. H. Collins, of Newcastle, England, in July 1914. According to him, the addition of a small percentage, say 0.25 per cent or less, of caustic soda to pure creosote improves penetration, even in the case of timbers like spruce, which take the oil with difficulty even when comparatively well seasoned. Moreover, saponification makes it possible to dilute the creosote with water and thus cheapens the impregnating process.—M.

SCARCITY OF SYNTHETIC PERFUMES

A number of synthetic perfumes are scarcely obtainable at the present moment. Among these is phenyl-ethyl alcohol, which is an absolutely necessary ingredient for artificial otto of roses. It is true, says the *Oil and Color Trade Journal*, that a certain amount is being offered, but a good deal of this is of indifferent quality, really fine grades being very difficult to obtain and then only at much enhanced prices. Amberpene is hardly to be found, the few makers complaining of lack of raw material. Benzaldehyde, free from chlorine, is exceedingly difficult to find, but the ordinary quality containing chlorine is offered fairly freely, although the price is very firm.—M.

OBITUARIES

JULIUS O. SCHLOTTERBECK

Once again the roll is called, and as the name of Julius Otto Schlotterbeck is reached, there comes the mournful yet triumphant response: "Gone forward."

Professor Schlotterbeck was born in Ann Arbor, Michigan, in 1865, the son of Hermann and Rosina Schlotterbeck. After attending the primary and high schools of Ann Arbor, he entered the pharmacy course at the University of Michigan in the fall of 1885, graduating from that institution as pharmaceutical chemist in June 1887. He continued his studies at the University, at the same time performing the duties of assistant in pharmacy and pharmacognosy, and in June, 1891, he was granted the baccalaureate degree in science.

His brilliant career in college won for him, as soon as he graduated, a position on the faculty of the University. In 1891 he was made instructor in pharmacognosy and botany, which position he retained until 1895, when he became a student of Tschirch at the University of Berne, where two years later he was awarded the degree of doctor of philosophy (*summa cum laude*). Returning to America, he was made assistant professor of pharmacognosy and botany; in 1904 he was junior professor and in 1907 he was promoted to the full professorial position. On the death of Professor Prescott, in 1905, he was chosen Dean of the School of Pharmacy, and he retained that position until his death.

Professor Schlotterbeck was a tireless worker. In the publications of the American Pharmaceutical Association we find 18 papers from his pen; while he contributed three papers to the *Journal* of our own association. Of these, the most brilliant are his reports on his researches on the unusual alkaloids of the Poppy family, particularly noteworthy being his painstaking investigation of protopine and his discovery in *Stylophorum diphyllum* of a new papaveraceous alkaloid, stylopine, $C_{19}H_{19}NO_5$.

It is needless to say that such a man was in demand in association work. In 1905 he was president of the State Pharmaceutical Association; in 1902 he was chairman of the Scientific Section of the American Pharmaceutical Association, while for two terms, 1910 to 1912, he was president of the American Conference of Pharmaceutical Faculties, after serving that organization for several terms as its secretary. In our own association, he was an active supporter of the division on pharmaceutical chemistry. He was a Fellow of the American Association for the Advancement of Science, and a member of the Committee on Revision of the United States Pharmacopoeia.

In his home life, Dr. Schlotterbeck was singularly happy. As one of his friends said recently about him: "He was a home man—the passion of science never built a barrier between him and his fireside." Deep, therefore, is the loss that has come to his widow and his three children, Prescott, a freshman at the University of Michigan, Miriam, a high school student, and Carl, a boy of eleven years. To these, our deepest sympathies go forth.

The writer will never forget his first meeting with Schlotterbeck. It was a delightful August evening in 1895, in the Schloss-Garten at Heidelberg, where we two, who had frequently heard of each other in America, met as comparatively old friends on foreign soil. He was then on his way to Berne, full of quiet enthusiasm for the work he was about to begin and which he so brilliantly completed two years later. Since that time, our meetings have been frequent, as our work has been along similar lines, and each meeting has brought a deeper appreciation of the many fine traits that Schlotterbeck possessed. Quiet and unassuming, yet conscious of his own powers and of the responsibility they brought to him, a deep student and yet a good comrade, Schlotterbeck was a man that American Pharmacy and American Chemistry can ill afford to lose.

College of Pharmacy, Columbia University
New York City
H. V. Arny

ALOIS VON ISAKOVICS

It was a terrible shock to all when we learned that our dear friend and colleague, Alois Von Isakovics, had passed away in the prime of his life on June 5 at his residence in Monticello, N. Y., after a comparatively short illness.

Alois Von Isakovics was born in Prag, Bohemia, July 20, 1870, the son of a distinguished military family. His father, an officer of high rank in the Austrian army, had mapped out for his only son a military career, and was greatly disappointed when the young son showed by his independent character that he did not believe army life would appeal to him. When a very small boy he started a little business of his own, collecting stamps and selling them, working at this after school and often late into the night, and before he left Europe this business, built up entirely by himself, had grown to such a size that he found it necessary to employ several of his school friends to help him with his correspondence and filling of orders. His aim already in early life was to have an international business and this he enjoyed even when a boy, as he received orders for his stamps from all over the world.

After finishing his general education, which comprised the regular curriculum of a young man of good European family, he came in the Spring of 1886 to America, the land of freedom and unhampered development. At first the battle was hard and the little money he brought with him soon gave out, but possessed with a grim determination to win and a never ceasing ambition, he accepted some very menial positions until he had mastered the English language and thus was started at the foot of the ladder, the top of which he so gloriously had reached at the time of his death.

In October 1888, he met Miss Marie Upshur, the daughter of a historic Southern family, which seemed to have been a real case of "love at first sight." They became engaged in July 1889, and after he was naturalized in 1892, in New York City, they were married in July 1895, at the Church of the Transfiguration, just twenty-five years after her parents were married there by the same minister, the Rev. Dr. Houghton. Their love remained ever young and devoted after twenty-two years of an unbroken union of happiness and bliss. They worked up together what was the beginning of the Synfleur Scientific Laboratories and their lives were united in thought, purpose and ambition—the one was an inspiration to the other.

Von Isakovics was a genius in the particular field of chemistry to which he devoted his talents. He combined a high character, a lovable nature, with thorough scientific knowledge and exceptional commercial and executive abilities. It will be readily understood that it was uphill work to build up such a business monument as he left, in the face of severe competition which was backed by unlimited capital, but he always said it *could* be done and he would succeed.

The secret of his success has been his never failing business policy, to give his customers exactly what he said he would. There was never in his mind anything "good enough;" only the "best" that science could produce would he offer his clients. He has thrown away many a pound of valuable materials because they did not comply with his idea of quality. He had often said he did not care how much the loss might be in dollars and cents so long as his conscience was clear and he gave his clients the very best possible value.

It was his cherished wish that should he ever be taken away his wife should go ahead in the same way as they had done together for the past 28 years and finally he hoped that his only son, Alois Von Isakovics, Jr., would take up the work. Mrs. Von Isakovics has been connected with the business from the day it was started by her late husband and it is her intention to take up the work where he has left off and to carry out his ideas in every detail.

Von Isakovics was endowed with those qualifications which go to make up an ideal man. His intelligence, honesty and fairness combined with his superior ability placed him in a position to be known all over the country and in many foreign lands. At the time of his death he was a member in the following Scientific and Social Societies: American Chemical Society, American Electrochemical Society (charter member), American Pharmaceutical Association, Manufacturing Perfumers' Association, Chemists' Club, Franklin Institute, New York Academy of Science (Fellow), American Association for the Advancement of Science (Fellow), Society of Chemical Industry, and Verein Deutscher Chemiker.

His great professional triumphs are recorded on the pages of scientific and practical literature such as: "Synfleur Heralds," Synopsis of Columbia University Lectures on "Perfumes and Flavoring Materials," and "Essential Oils, Synthetic Perfumes and Flavoring Materials," Chapter XXIX, in Rogers and Aubert's "Industrial Chemistry."

Von Isakovics was a devoted husband, a kind father and a sincere friend.

New York City
William Dreyfus

NOTES AND CORRESPONDENCE

CALENDAR OF MEETINGS

American Pharmaceutical Association: Indianapolis, Indiana, August 27 to September 13, 1917.

American Chemical Society: Annual Meeting, Boston, Mass., September 10 to 16, 1917.

National Exposition of Chemical Industries (Third): Grand Central Palace, New York City, September 24 to 29, 1917.

American Electrochemical Society: Autumn Meeting, Pittsburgh, October 3 to 6, 1917.

National Paint, Oil and Varnish Association: Annual Convention, Chicago, October 8 to 10, 1917.

American Institute of Mining Engineers: Annual Meeting, St. Louis, Mo., October 8 to 13, 1917.

THE TEACHING OF ANALYTICAL CHEMISTRY

Editor of the Journal of Industrial and Engineering Chemistry:

To no one engaged in analytical chemistry, whether as practitioner, teacher, or original investigator, can the recent address by Dr. Hillebrand on "Our Analytical Chemistry and Its Future,"[1] fail to be stimulating and full of suggestion. It is not to be expected that the universities can turn out experienced analysts, but the chemical world has a right to expect our institutions to turn out men who have a capacity for becoming reliable analysts after reasonable experience. Dr. Hillebrand suggests that in this the universities have, in a large number of instances, failed; and those who have had opportunity of in-

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[1] This Journal, 9 (1917), 170.

vestigating the conditions in the analytical laboratories of many of our industries will endorse that suggestion. In searching for a cause for this state of affairs one need not look very far, for a glance over the catalogues of a few universities will quickly convince one that other subjects in the curriculum are making rapid inroads on the time formerly devoted to chemical analysis. In view of the increasing number of topics which now find place in a chemical education this is not surprising, for not only must the claims of other chemical and related subjects be considered, but also the undeniable swinging back to a broader educational basis, which is becoming increasingly evident in many of our institutions, and which brings with it a less specialized curriculum.

Before taking up the discussion as to the best method of employing our reduced time in teaching analytical chemistry, it would be well to consider the true place of this branch in a chemical education. If training in this subject is restricted to the mere teaching of a number of procedures which can be more or less mechanically carried through, it is certain that it does not deserve much consideration; but there is no reason why the work should not be made a really useful end in itself—which it is not, if carried out in the manner just mentioned, and at the same time an educational factor of vital importance. There has been a decided tendency to raise the standard of qualitative analysis in the latter respect, as is evidenced by the tone and character of many of the recent books on the subject; but in quantitative analysis we are not yet quite so far advanced, and the few really modern books which have appeared have to make their way against much conservatism and prejudice. There is no branch better adapted to the presentation of elementary physicochemical ideas than analytical chemistry, and in following this system of presentation there is the great advantage of keeping the student in vital contact with the indispensable modern ideas through the whole of his course, instead of allowing him, as is now too frequently done, to forget most of the real chemistry he has learned in advanced general chemistry and qualitative analysis, by plodding through a year in which his only chemical subjects may be old-style courses in quantitative analysis and organic chemistry. Surely the department of physical chemistry would be willing to let the analytical department encroach a little on its territory if, by so doing, students could be handed on for work in physical chemistry with a knowledge and enthusiasm which would materially lighten the burden of instructors in that department. With quantitative analysis taught on this basis, we whose hobby this subject is need not apologize for our interest.

There are two main points to be considered: *First*, students must be trained in exact methods of work, so that reliable results can be obtained; and *second*, the dignity of analytical chemistry must be maintained as a sound educational factor. A greater proportion of lecture work, even at the expense of some laboratory hours, seems to hold the greatest promise for the accomplishment of both ends. It is perfectly true that the student is more deeply impressed by what he learns in the laboratory than by the statements of a lecturer, and if unlimited time were at our disposal formal lectures might well be dispensed with altogether, and the whole instruction, even in the more abstract and theoretical phases, could be imparted by informal talks and discussions at the laboratory bench. Such a course, however, involves so great an expenditure of time, and necessitates so large a teaching force as to make it impossible under existing circumstances. The best thing we can do, then, is to give a far greater share of instruction in the lecture room than is now usually done, and thus free more of the laboratory time for the essentials that cannot be gained except by experience. Discrimination is a point frequently neglected, and it is common experience to find a student wasting time by weighing out a steel sample for the determination of phosphorus with the same accuracy that he would employ in weighing copper foil for standardization. By more carefully planned lecture work, and by greater coöperation on the part of the laboratory assistants it should not be difficult to accomplish a third more in the average analytical course than is now done.

Dr. Alexander Smith[1] has called attention to the evils of overlapping courses, and my observation is that this is particularly true in analytical chemistry, both as regards lecture work and the analysis of samples in the laboratory. In the majority of institutions the departments of qualitative and quantitative analysis are entirely separate; text-books by different authors are used, the lectures are given by different instructors, and the instructor in one course is but little acquainted with the exact method of presentation used in the other course. In the qualitative course the student acquires, after much hard work, a faint glimmering of an understanding of the fundamental principles underlying the subject of analytical chemistry. The next year the study of quantitative analysis is begun, and the book of another author is used. The same ionic hypothesis is presented, the same mass law, in short, the same fundamental principles, for they are common alike to both qualitative and quantitative analysis; but in the work of this new author the student looks in vain for the familiar expressions, mathematical formulae, and symbolism which he has laboriously learned the year before; for the author of this new work has started again from the beginning, and, in his own way, and with his own peculiar terminology, he has presented the whole of the material which the student has learned before, with just a little in addition which applies exclusively to quantitative analysis. The result is that the student has to spend a good part of his second year in learning over what he is supposed already to know, simply because it is presented in a different way, with little thought of correlation with what has gone before.

This condition would be remedied by the adoption of a text-book, in two volumes, on analytical chemistry from the modern view-point by one author; or by having the lectures in both branches given by one instructor, any necessary changes in the terminology of the two books being made with a view to obtaining a unified system of presentation. If lack of suitable texts makes the first, and program difficulties make the second alternative impossible, it is still feasible to have both qualitative and quantitative analysis under the direction of the department of analytical chemistry, and to let the head of that department see to it that a unified system of instruction is established. In this way the quantitative course would take up the subject where the qualitative work left it, that is, without repetition of first principles, but with constant reference to those portions of the first course which deal with the knowledge prerequisite to the particular discussion in hand. The theoretical part of the second course would thus be really a continuation of the first, rather than a more or less confusing repetition of it, in which the seeming contradictions of the different writers tend to cast a haze of indefiniteness over minds not yet sufficiently advanced to sift for themselves the chaff from the wheat. By this method of coördination much valuable time could be saved, and this could be devoted to extra drilling in the methods of securing exactness of results by added emphasis on those minor details which are so frequently hurried over for lack of time.

The curtailment of laboratory time makes imperative the optimum utilization of these hours, and a great saving can be made by avoiding undue repetition in advanced courses. The working through of the determination of phosphorus in iron ore, in steel, in coke, in several types of fertilizers, and again in a slag, is doubtless splendid practice, but it is not economy. An extreme case has been cited, but it will serve to illustrate what, in a lesser degree, is a real condition in much analytical instruction. Phosphorus should be determined in one class of

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[1] This Journal, 8 (1916), 527.

material gravimetrically, in another volumetrically; and in the lecture room the student should be taught the application of these methods to the most varied kinds of industrial products. There is no finer practice than the complete analysis of a rock, but for a student it consumes an immense amount of time. Even if there is not time, however, for the complete analysis, the fundamentals of rock analysis can still be taught, for the student will already have made a partial analysis of limestone, probably a silica by fusion, and a determination of sulfur in some form. In a one-hour lecture this work can be gathered into an organized whole, and correlated with the subject of a complete rock analysis. The student can then be required to determine ferrous iron, alkalies, titanium, and the other constituents which his previous experience has not covered. Thus by the organization of the laboratory work through the correlating influence of carefully planned lectures and theoretical study, a much broader foundation can be laid in the allotted time than is now usually done.

In summarizing, analytical chemistry should be taught as one subject, with the various branches closely correlated in a unified system. An unnecessary burden is placed upon students by using different methods in presenting the fundamental principles of qualitative and quantitative analysis. Much laboratory time can be saved by more lecture work, and by the avoidance of undue repetition in analytical exercises. This time should be spent in extra drill in the details of accuracy.

University of Arizona
Tucson, February 14, 1917
Paul H. M.-P. Brinton

A CHEMICAL LETTER BY DR. ANDREW URE

Editor of the Journal of Industrial and Engineering Chemistry:

The following letter by Dr. Andrew Ure—the well-known author of Ure's Dictionary—has recently come into my possession and as it was written exactly 100 years ago and contains considerable matter of historical interest, its publication in the July issue of the Journal may not be out of place. The letter, except for a slight tear due to breaking of the wax seal, is in perfect preservation. It bears the address, Dr. Granville, Hotel de Saxe, No. 12 Rue de Colombier, Faubourg St. Germain, Paris, and runs as follows:

Glasgow, July 5th, 1817

My dear Sir:

I avail myself with great pleasure of the opportunity offered by the visit of my ingenious friend, Dr. N. Hill, to Paris, to assure you of the grateful recollections which I shall ever entertain of your kindness, regretting only that the arthritic affection of my ankles prevented me from profiting so much as I would otherwise have done of your acquaintance with the French *Savans*. My journey homeward was tedious and uncomfortable; but soon after breathing my native Caledonian air my health returned to its former soundness, and the anomalous affections, connected, I believe, with the French wines, entirely disappeared.

Though far distant from you, I have followed with undiminished interest your useful labors and very interesting communications in the Institution Journals. Your tribute to Vauquelin is elegantly expressed, and very justly merited. It has found an echo in every man's heart who has, like me, had the good fortune to meet with this illustrious and benevolent philosopher. I hope soon to have a public opportunity of expressing my sentiments on the same grateful subject.

My winter occupations consist more in teaching pupils the general truths of science than in original investigations. Since the session ended, I have, however, been incessantly occupied in some researches which will make their appearance in monthly succession in our scientific journals—chiefly the *Annals of Philosophy*. In the *Medical and Surgical Journal of London* for this month you will find a paper of mine containing a description and analysis of a morbid intestinal concretion sent to me for examination by a physician in the vicinity of Perth. It differs entirely from any of which I have seen an account, resembling in chemical and physical properties pure ambergris, and containing no earthy phosphates or indeed any other saline matter.

By the analysis of Lagrange ambergris contains benzoic acid. The substance in question yields none to any attempts at extraction which I have been able to make. And on examining with care two different specimens of ambergris, both reputed genuine, I have found the one to contain benzoic acid, but the other, and that the most characteristic, none. The paper itself will shew you that I have bestowed some pains on the subject, though I have by no means completed my investigations, being very much pressed for the account for this month's magazine. Some phenomena led me to fancy that the acid of ambergris was not benzoic but succinic acid; and I accordingly tried to discover a simple and certain criterion between them. Succinate of Ammonia sublimes without decomposition. Benzoate of Ammonia is decomposed in a gentle subliming heat; the Ammonia escaping partly in gas and partly combined with the water of crystallization. This fact, if you please, you may mention to M. Vauquelin; but very likely that excellent chemist may be already acquainted with it.

My first paper for the *Annals*, is on Ammonia, Muriatic Acid, Sal Ammoniac, the other Ammoniacal Salts, and the chlorides in general. It contains I believe several new facts, which I hope you will see next month. I should wish exceedingly to know the opinion concerning it of your distinguished friends at Paris. Will you write me? The whole deductions are from my own experiments. I point out some inaccuracies in Dr. Wollaston's Scale as well as in Dr. Thomson's Weight of the Atoms. I endeavor to show that Sal Ammoniac is not a chloride of ammonium, as Dr. T. has called it.

The bearer of this letter is author of a very ingenious paper on Laryngitis, and very deserving of being assisted in his views of seeing a little of Parisian Practice. As there is no person who is so thoroughly capable of promoting his views, may I beg you to give him a general system of directions for making the most of his time at the French Capital?

Present my respectful complements to your lady and believe me to be always, Dear Sir,

Your faithful and obliged servant,
Andrew Ure

Dr. Augustus Bozzi Granville, to whom the above letter is addressed, had one of the most adventurous careers which ever befell a man of science. He was the son of an Italian named Bozzi, a relative of Napoleon, but afterwards adopted the family name of his English mother. He studied under Volta at Pavia, from which university he graduated as a physician in 1802. Granville was an enthusiastic devotee of the new science of chemistry. At Paris he became acquianted with Countess Rumford, the widow of Lavoisier, who encouraged him in his chemical studies; Gay-Lussac, Vauquelin, and other well-known chemists were among his teachers. In 1814 and 1815 Granville taught chemistry at a medical school in London. His experiences, however, as a teacher of chemistry were unfortunate; an accident with chlorine gas completely destroyed his sense of smell and, the treasurer of the school absconding, the institution failed and Granville was never paid his salary. After this he returned to France and was studying in Paris at the time of Ure's letter.

Granville's extensive travels, together with his linguistic attainments, gave him a wider acquaintance with noted scientists than was the fortune of most other men of his day. He rendered no small service by helping to bring together English and Continental scientists who had been separated from one another by the Napoleonic wars for nearly 20 years. Granville[1] died in 1872 at the age of 88 and his long life forms a connecting link between the chemists of Lavoisier's time and those of the present day.

Although the imperfections of Ure's analytical methods throw little light upon the nature of his "morbid intestinal concretion," it seems probable that he was dealing with cholesterine or coprosterine, substances of which chemists are still striving to determine the exact constitution.

The allusion which Ure makes to his researches upon the composition of sal ammoniac recalls the famous "chloridic controversy" which occupied the minds of chemists a century ago. Ure's paper was published in Thomson's *Annals of Philosophy*

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[1] Granville was well known as an authority upon mineral waters and sewage disposal. He also made important contributions to the study of the internal use of hydrocyanic acid in medicine. His two-volume autobiography published in 1874 has all the fascinations of an exciting novel.

for Sept. 1917 (Vol 10, page 203), and in it he contends that sal-ammoniac is not a chloride of ammonium but a muriate of ammonia. According to the old view muriatic acid and ammonia both contained oxygen while hydrochloric acid and ammonium were oxygen-free. The muriates upon heating were supposed to be converted into chlorides by the expulsion of water.

Ure sublimed dry sal ammoniac over hot metals and obtaining water concluded that the latter was due to a combination of the hydrogen and oxygen in the sal ammoniac molecule. Sal ammoniac was therefore a muriate and not a chloride. The fallacy of this conclusion was pointed out by Thomson (in Vol. 12 of his *Annals*, p. 381) who by a natural intuition picked the winning side in the chloridic argument, as he did in the atomic controversy, years before most of his contemporaries.

Although Ure in after years realized the correctness of Thomson's view, he had the satisfaction of knowing that he went astray in good company. Berzelius believed up to 1820 in a hypothetical element *muriaticum*, which, upon combining with two atoms of oxygen, produced the anhydride of muriatic acid; this anhydride, upon further oxidation, as by means of manganese peroxide, yielded oxy-muriatic acid gas or chlorine. Berzelius also believed in another hypothetical element *nitricum*, the oxide of which was nitrogen and which oxide in combination with hydrogen gave ammonia. Relics of these old views still survive in chemical nomenclature.

The contribution of Ure, who was assisted in his experiments by Gmelin, a pupil of Berzelius, will always be worth reading, for it illustrates the difficulties with which early experimenters had to contend. As Kopp remarks in his account of the chloridic controversy, "it is interesting to note how correct observations led to incorrect conclusions."

The tributes which Granville and Ure both pay to Vauquelin only confirm what others have written about one of the best loved and most honored chemists of France. The readiness with which English scientists, after the bitter Napoleonic wars, could give expression to such feelings of admiration shows the strength of the bonds which unite the great international brotherhood of science, and at the time of the present crisis should fill us with hope for the future.

80 South Street, New York City C. A. Browne
May 16, 1917

TWO LETTERS ON THE INCOMPLETE HYDROGENATION OF COTTONSEED OIL

Editor of the Journal of Industrial and Engineering Chemistry:

In a very interesting article entitled "Incomplete Hydrogenation of Cottonseed Oil," by Hugh K. Moore, *et al.*, published in the May 1917 number of This Journal, the following statement occurs on page 461 under the caption "Response to Halphen Test: The amount of hydrogenation which is required to render the oil just incapable of responding to the test has not to our knowledge been investigated." A very limited amount of experimental data is given and a conclusion is drawn on page 462: "The degree of hydrogenation necessary to destroy the response of Cottonseed Oil to the Halphen test has been shown to be a drop of about four units in the iodine number." There are so many variable factors which would have an effect on this conclusion that it seems a rather broad statement to make on the limited evidence submitted.

It is rather interesting to the writer that the statement is made in the article that "the amount of hydrogenation which is required to render the oil just incapable of responding to the test has not to our knowledge been investigated," in view of United States Patent 1,187,999, application for which was filed by the writer on August 31, 1915, and issued on June 20, 1916, in which the following statement appears in the specification: "In carrying out my new process for the manufacture of the product, a fatty oil, for instance, choice or prime yellow cottonseed oil, is placed in a closed vessel and caused to be chemically combined with hydrogen in the presence of a catalyzer. Any of the known processes of hydrogenation, or any active catalyzer may be employed, which does not leave any residual catalytic impurities in the product after careful filtration. A temperature of 150 to 200° C. has been satisfactorily employed, and the time required to produce the desired result after attaining this temperature, is from five to thirty minutes, depending upon the activity and proportion of the catalyzer employed. In practice the time or degree of hydrogenation desired are determined by preliminary experiment on the oil and catalyzer used in an experimental apparatus. In carrying on such preliminary test the hydrogenation process is continued until a sample of the oil fails to respond to the Halphen reaction and the desired degree of crystallization takes place when the oil is chilled.

"Depending upon the particular oil treated by the process, the iodine value of the finished product varies from about 90 to 102. Its titre (as determined by the Wolfbauer method) has been slightly increased during the process to the extent of from about 0.1 to 0.5° C. over that of the original oil treated. The color of the treated product is usually somewhat lighter than the original oil. On cooling the product it in part readily crystallizes, thereby making separation of the stearin from the oil much easier and more effective for 'winter pressing' for salad oil than is the case with ordinary cottonseed oil. The new product responds negatively to the Milliau test for cottonseed oil."

Other parts of the specification and also the claims of this patent treat further on this subject.

Inasmuch as a copy of this patent was sent to the Berlin Mills Company and was investigated by their patent attorney, it is somewhat surprising to the writer to find at this time an article published by the research laboratory of this company over the name of the company, in which the above quoted statement occurs.

Chicago, June 6, 1917 Arthur Lowenstein

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Editor of the Journal of Industrial and Engineering Chemistry:

In reply to Dr. Arthur Lowenstein's criticism of a section in our article on "The Incomplete Hydrogenation of Cottonseed Oil," we wish to state that U. S. Patent 1,187,999 was familiar to us at the time the section in question was written; neither at that time nor at the present time, however, could we regard the disclosures of the patent as constituting anticipation of our work.

The fundamental statement of the patent, as quoted above by Dr. Lowenstein, is as follows: "..... the hydrogenation process is continued until a sample of the oil fails to respond to the Halphen reaction and the desired degree of crystallization takes place when the oil is chilled." There is no warrant for assuming from the language of the patent that when the Halphen test is just destroyed the proper amount of crystallizable material has just been produced; in fact it would appear that a considerable degree of choice may be exercised in the production of this stearine after the Halphen test response is gone.

The iodine number of the product of the patent is not stated to be that of a product in which the response to Halphen test has just been destroyed, but is that of a product in which both conditions have been met. The breadth of the range given, 90–102, indicates that "the desired degree of crystallization" upon chilling, is subject to considerable variation, according to the object in view.

The other distinguishing mark given in the patent, namely, a range of increase in titre, likewise fails to disclose any definite knowledge of the degree of hydrogenation necessary to destroy the response to the test; its indication is ambiguous, like that of the iodine number. We have not experimented with the Wolfbauer method, since its use is uncommon in this country, but it is certain that the range of 0.1 to 0.5° C. represents a very large range in actual hydrogenation, as measured by change in iodine number. It is noteworthy that our experiments invariably showed a decrease in titre, as measured by the A. O. A. C. method, before any increase began, so that to increase the titer 0.1 to 0.5° C. above that of the original oil required a drop of iodine number to about 70.

We wish to point out that if, as Dr. Lowenstein asserts, there are "many variable factors which would have an effect on this conclusion," there exists no published evidence to that effect. It seems probable to us that temperature is the only factor which would have such an effect, and the temperature 150 to 160° C. was specified in the experiment in question.

We are therefore unable to agree with Dr. Lowenstein's implication that U. S. Patent 1,187,999 anticipates our disclosure. It is quite possible that other investigators have carried out the same work at an earlier date, but we believe ourselves to have been the first to publish the results of such work.

BERLIN
NEW HAMPSHIRE
June 12, 1917

H. K. MOORE
G. A. RICHTER
W. B. VANARSDEL

AN EXPLOSION OF AN ANILINE STRIPPER

Recently a stripper employed on aniline waters exploded and as the cause has not been ascertained, it is thought that a description of same may be of interest to manufacturers of aniline and similar compounds.

DESCRIPTION OF STRIPPER

The stripper is a $^3/_8$-in. steel tank 7 ft. in diameter and 8 ft. $^3/_8$ in. deep, flat bottom and plate cover on top, all $^3/_8$-in. steel. To stiffen the cover, two 6-in. I-beams ($12^1/_4$ lbs.) 16 in. between centers were riveted on the cover. The cover was bolted to the flange with about forty $^3/_4$ in. × $1^1/_2$ in. bolts. The bolt holes are spaced about 6 in. apart on three-quarters of the circumference and 12 in. on centers on the remaining quarter. The bottom has a $2^1/_2$-in. outlet with a plug cock which runs to the sewer. The top has a $2^1/_2$-in. inlet with a cross. The cross has a 2-in. inlet with a valve and a $1^1/_2$-in. inlet with a valve. On the top of the cross was a $^3/_4$-in. level safety valve and a gauge.

The stripper has a closed coil of 2-in. pipe, for the purpose of heating, 8 turns, welded, connected in through the side with cast-iron elbows and nipples to the coil.

There is a $1^1/_2$-in. valve and line feeding the top of the coil with steam and the bottom drains through a $^3/_4$-in. steam trap.

On the cover was a manhole and a 6-in. vapor line outlet running up vertically for 6 ft. to a $2^1/_2$-in. coil in a 4 ft. × 6 ft. wooden tank. The vapor line, coil and coil-outlet have no valve. The coil discharges into a steel separator, 5 ft. × 6 ft. The aniline is drawn off the separator.

OPERATION JUST PRIOR TO THE EXPLOSION

The stripper was filled with aniline waters up to just 30 in. from the top of the stripper, by means of a steam siphon from the wooden tank in the yard which is used as a reservoir for aniline waters. At 4:30 P.M., April 21, 1917, the cover was placed on the manhole of the stripper and the steam turned on the coil between 4:45 and 5:15 P.M. by a workman. The stripper is operated by simply distilling the aniline waters, condensing the aniline and water in a coil and running same into a separator. About 5:45 P.M. the stripper exploded. A workman was 10 to 20 ft. from the stripper when it went up and was splashed with water, undoubtedly from the stripper: the water was warm, not hot, and he was not burned.

RESULTS OF THE EXPLOSION

The cover of the stripper was blown off with considerable force, breaking all the bolts which held it on by tension. The cover was bent and the flange of the stripper bent. The cover landed on the edge of the floor beside the stripper.

The entire contents of the stripper (1600 gallons) were thrown out, leaving a layer of $1^1/_2$ in. of iron sludge in the bottom of the stripper. A hole 20 ft. × 25 ft. was torn through the roof and an 8-ft. I-beam bent 18 in. out of line. The wire glass windows which were near were broken. The stripper was not damaged very much. The same cover was replaced and except for a few fittings was satisfactory for service again.

After the explosion the inlet valve to the coil was found wide open $5^3/_4$ turns. The condenser was clear. The two valves on inlets to the cross on the cover were closed.

COMMENTS

The aniline waters were analyzed with the following results:

SAMPLE:	Feed Water as put into Stripper	Liquid from Bottom of Stripper after Explosion
Aniline	3.13 per cent	3.07 per cent
Acidity (as H_2SO_4)	0.005 per cent	0.09 per cent
Nitro Compounds	None	None

The explosion behaved as though a layer of explosive had been placed on the bottom of the stripper. It is almost inconceivable that the explosion could have been caused by steam because the $1^1/_2$ in. steam inlet is the only supply. If this were led into the stripper through a break in the coil, the contents of the stripper would probably have been heated to boiling before exploding. Even then, it is difficult to see how the steam at 115 lbs. would create such a sudden and violent explosion, entering as it did, and with the exit condenser coil wide open.

We would be pleased to receive opinions as to the probable causes of this explosion, which we are at present unable to explain.

NEWARK, NEW JERSEY
April 30, 1917

MARDEN, ORTH & HASTINGS CO., INC.,
per RICHARD S. BICKNELL

BUREAU OF STANDARDS' ANALYZED SAMPLES

The Bureau of Standards, Washington, D. C., now has ready for distribution its High Phosphorus Standard Analyzed Iron E No. 7, which is typical of the irons from the Alabama area. The analysis is: carbon, 2.17; graphite, 1.82; combined carbon, 0.38; silicon, 2.21; titanium, 0.095; phosphorus, 0.862; sulfur, 0.051; manganese, 0.444; copper, 0.021; chromium, 0.014; nickel, 0.016; and vanadium, 0.073. The renewal No. 12-*b*, of the Basic Open Hearth Steel approximately 0.4 Carbon, is also ready. Until printed certificates can be secured, the above samples will be issued with provisional certificates without details of analysis, or description of methods. A new sample of Bessemer steel with approximately 0.1 per cent carbon to replace No. 8-*a* is now in process of analysis.

DECENNIAL INDEX OF CHEMICAL ABSTRACTS

The intention of offering the Decennial Index of Chemical Abstracts in bound form has been reconsidered. There has been so little demand, and members who are binding their volumes have so many different bindings, that it was considered unwise, and, in fact, almost impossible to offer a binding which would suit the members of the Society.

June 8, 1917

CHAS. L. PARSONS

ALCOHOL AND WATER IN ETHER—CORRECTION

In the article under the above title, THIS JOURNAL, 9 (1917), 521, in the table on page 522, the first "0.25 per cent Water" in the last group of figures should read "0.025".

R. L. PERKINS

NITROGEN INDUSTRIES LITERATURE—CORRECTION

In printing the "Literature of the Nitrogen Industries, 1912 to 1916," in the April issue of THIS JOURNAL, pages 424 to 438, we omitted to state that this material was reprinted from the January, February and March, 1917, issues of the *General Electric Review*.—[EDITOR]

WASHINGTON LETTER

By PAUL WOOTON, Metropolitan Bank Building, Washington, D. C.

That the United States is fully alive to the important part chemistry plays in modern warfare is indicated by the vast amount of chemical work which is being done by government agencies or under the direct supervision of the government. Practically every one of the many chemical laboratories in the city is devoting a considerable portion of its time to war work.

Much of the chemical work which is in progress in Washington, or is being directed and controlled from the capital, is of a nature which precludes any public discussion. This applies particularly to the work being done under the direction of the Committee on Chemicals of the Council of National Defense, of which Dr. Wm. H. Nichols, of New York, is chairman. It also applies to the very extensive experimentation by the Bureau of Mines with poison gases. It has not been deemed good judgment to disclose many facts with regard to the work being done by the Carnegie Geophysical Laboratory and the Bureau of Standards on optical glass. Some of the problems being worked upon at the Bureau of Chemistry are of such a nature as to preclude even the mention of the class of work being conducted.

It is agreed that splendid judgment was shown by Van. H. Manning, director of the United States Bureau of Mines, by Dr. Chas. L. Parsons, the chief chemist of that bureau, by George E. Hale, chairman of the National Research Council, and by Prof. Marston T. Bogert, chairman of the Committee on Chemistry of the same organization, in undertaking several months ago a census of all chemists in the United States. As a result of the foresight shown, more than 10,000 names have been classified. This long list, which is thought to include a large proportion of the chemists of the United States, has been card indexed under the personal direction of Albert H. Fay, statistician for the Bureau of Mines. The chemists have been classified under no less than forty heads, so that ample sources of information on any subject are available to any one working in the government interest. It is also anticipated that it will be necessary to draw many men from this list for Federal Service, as Congress comes to realize the need for more chemical aid and appropriates for this work.

Speaking generally, however, Dr. Nichols' committee is canvassing the requirements of the country for chemical supplies and is matching this information against available supplies. Its efforts will be directed largely toward keeping the requirements and the production on a parity. Diligent work is under way to make available adequate supplies of such chemical materials as may show a deficiency. The importance of the work is more clearly understood when it is said that many of these materials are essential to our national life. The Nichols committee will give preferential attention to general industrial and munitions chemistry. A full understanding has been had with all government and many private agencies, so as to coordinate the work and to eradicate duplication.

Means by which poison gas attacks may be combatted form one of the principal problems being considered by the Chemistry Committee of the National Research Council, of which Marston T. Bogert, professor of organic chemistry at Columbia University, is chairman. It may be stated that definite results have been accomplished and that the assistance which the Committee is rendering is being increasingly recognized by the government.

Research, looking to betterments in non-corroding alloys also has been given preferential attention by Prof. Bogert's committee. The importance of these alloys has been increased tremendously during this war by the necessity of providing more lasting linings to lengthen the life of big guns, by the demand for guns to be mounted on submarines and by the need for non-corroding alloys in submarine and torpedo construction. Fixation of atmospheric nitrogen, problems involved in treating balloon envelopes and the means of detecting hydrogen escaping from a gas bag give an idea of the varied problems which are under active investigation by the Chemistry Committee.

The development of industries, totally new to the United States, and the working out of certain standards for munition manufacturers and for those directing other businesses, give an indication of the tremendous scope of the work in hand. In fact, Prof. Bogert's committee is the clearing house for the chemical research work of the country. The organization is comprised of the main committee and some thirty sub-committees. Each of the sub-committees in turn functions as a clearing house. The whole chemical field has been subdivided and each division placed in charge of a sub-committee. The returns of the census of the chemists taken by the National Research Council, including replies from more than 10,000 chemists, have been classified carefully. Each sub-committee will be supplied with a list of the experts handling the class of work to which the sub-committee is assigned.

The Chemistry Committee is mainly coördinating and supplementing work being done by the various government bureaus. No work is undertaken until it is certain that efforts can be combined to advantage and care is taken to see that there is no duplication of effort. As a result of the stress of the existing war situation, investigations being conducted by the government, by universities and by privately conducted enterprises, are being forced into a much closer coördination. The old barriers of secrecy are being broken down. What had been impossible of attainment in times of peace is being accomplished quickly now, as a result of a great increase in efficiency. It is expected that this entente will be maintained after the close of the war.

Recently a ship carrying a cargo worth $10,000,000 was sunk by a submarine. Prof. Bogert points out that a fraction of this sum would be sufficient to mobilize all the scientific brains of the country, and he is strongly of the opinion that more financial assistance should be given the scientific agencies which are at work on problems of the utmost importance to the welfare of the nation. As it is, much of the scientific work is being carried on by volunteers and their immediate friends at very heavy expense to themselves.

Due to the strain being placed upon the transportation facilities of the country, Dr. Carl L. Alsberg, chief of the Bureau of Chemistry of the Department of Agriculture, is making every effort to reduce to a practical basis the drying of fruits and vegetables, thereby eliminating ninety per cent of their weight and facilitating their transportation and preservation. Another great advantage of the drying process is the important difference in the expense between this and other methods of preservation.

High prices being demanded for copper sulfate have set the Bureau of Chemistry to a thorough checking up of the Pickering method of preparing Bordeaux mixture. The noted English chemist maintains that the amount of copper sulfate in Bordeaux mixture can be reduced materially without impairing its efficacy. In addition to laboratory work in this connection, actual field experiments are being conducted on an extensive scale.

Due to the fact that the chemical properties of lead arsenates never have been studied exhaustively, the Bureau of Chemistry is conducting important work with these compounds. It has been found that the common lead arsenates in many cases were not compounds, but mixtures instead. Since tri-lead arsenate is not formed by the ordinary processes of manufacture, work on this chemical is receiving special attention. Study is being made of the action of water upon the lead arsenates. Natural waters have been found with such chemical content as to break up a lead arsenate. Since arsenic in a soluble form is highly injurious to foliage, this problem is a very important one. It also has been found that some other spray materials, when combined with lead arsenates, also break up the compound. Calcium arsenates are being studied in the hope of providing a cheaper substitute for lead arsenates.

Rapid progress has been made by the congressional committees on the Trading with the Enemy Bill. The House Committee on Interstate and Foreign Commerce has ordered the bill reported favorably. Representative Montague, of New Jersey, was authorized to write the report and is now engaged in this work. A sub-committee of the Senate Committee on Commerce, consisting of Senators Ransdell (*chairman*), Vardaman and Fernald, is now engaged in the study of the bill. It probably will be reported to the full committee before the end of the present week. The sub-committee has found no objection to that portion of the bill which provides for the manufacture within the United States of such products as may be protected by a patent owned by an enemy of the nation. The bill authorizes the Federal Trade Commission to license the manufacture of such products if it shall be for the public welfare. The bill provides that the person undertaking the production of an article covered by such a patent shall file with the Federal Trade Commission a full statement of the extent of the use and enjoyment of the license that he has made. Five per cent of the gross sums received by the licensee from the sale of these inventions are to be deposited with the government for the protection of the owner of the patent.

June 19, 1917

PERSONAL NOTES

The Franklin Institute made the annual presentation of its Franklin Medal on May 16, 1917. The medal was presented to Admiral David Watson Taylor, Chief Constructor, Chief of Bureau of Construction and Repair, United States Navy, in recognition of his "fundamental contributions to the theory of ship resistance and screw propulsion, and of his signal success in the application of correct theory to the practical design of varied types of war vessels in the United States Navy," and to Prof. Hendrik Antoon Lorentz, President Royal Academy of Sciences, Amsterdam, Professor of Mathematical Physics, University of Leiden, in recognition of his "researches which have so largely contributed to laying on a new foundation our knowledge of the nature of light and in developing our ideas concerning the ultimate constitution of matter." Chevalier W. L. F. C. van Rappard, on behalf of the Royal Netherlands Government, received the Franklin Medal for Prof. Lorentz, and addressed the Institute. Admiral Taylor addressed the Institute on the subject of "The Science of Naval Architecture."

Memorial services were held in Lawrence, Kansas, June 7, in honor of the late George E. Patrick, who, at the time of his death, was Chief of the Dairy Laboratory of the Bureau of Chemistry, U. S. Department of Agriculture. Following the service the ashes of Professor Patrick and of his wife were deposited in the cemetery at Lawrence. Professor Patrick was from 1874 to 1883 head of the Chemistry Department of the University of Kansas. In connection with the memorial services addresses were made on different phases of his life and work by Dr. Erasmus Haworth, Dr. E. H. S. Bailey, Hon. J. D. Bowersock, Dean L. E. Sayre and Chancellor Frank Strong. Professor Patrick left to the University a fund of something over $7,000 in memory of his wife. The interest of this fund is to be used for a series of prize essays by students on "The Application of the Teachings of Jesus to the Practical Affairs and Relations of Life."

Dr. C. G. Storm has resigned his position as directing chemist of the Aetna Explosives Co., Inc., New York City, to accept a position as consulting explosives chemist with the Ordnance Department of the War Department, at Washington, D. C.

Dr. Wm. L. Gomory has discontinued practice in New York City as a consulting chemical engineer and is now associated with the Wabash Refining Company as general manager at their refinery in Robinson, Illinois.

At the May meeting of the Rhode Island Section of the A. C. S., a Chemical Section of the Providence Engineering Society was formed, which will have its meetings in conjunction with the Local Section of the A. C. S. It is expected that this affiliation will awaken greater interest in chemistry in that locality and be of benefit to both the chemists and the engineers.

The National Academy of Sciences gave a reception at the Smithsonian Institution, Washington, D. C., in honor of the members of the French Scientific Mission to the United States, on Thursday evening, June 14, 1917.

The Industrial Sites Association of America has been recently organized and incorporated, with offices at 115 Broadway, New York City. The purpose of the I. S. A. A. is to serve as a clearing house for data concerning the properties, sites, buildings, railroad and water facilities, labor conditions, population, etc., of all towns and cities where manufacturing plants could be advantageously established. This information will be given free.

William C. Carnell, chemical director for Harrison Brothers Co., Philadelphia, has resigned to become associated with Charles Lennig & Co., manufacturers of chemicals, Philadelphia.

Dr. T. R. Ball, of the University of Illinois, has been appointed assistant professor in chemistry at Washington University, Saint Louis, Mo.

Mr. Edward L. Pierce, vice-president of the Semet-Solvay Company, has been elected president of the Solvay Process Company to succeed the late Mr. Frederick R. Hazard.

Beta Rho, a local chemical fraternity of Washington University, Saint Louis, was installed on June 9, as Alpha Epsilon Chapter of Alpha Chi Sigma, the national chemical fraternity. The installation was conducted by Dr. L. I. Shaw, of Northwestern University, and Dr. L. F. Nickell, of Washington University, assisted by members of the Saint Louis Alumni Chapter. The members of the active chapter are Messrs. L. F. Nickell, E. E. Fickett, F. B. Langreck, I. C. Walker, E. J. Ulbricht, A. E. Goldstein, J. S. Logan, W. C. Adams, P. G. Marsh, J. F. Stickley, H. M. Van Horn, G. F. Dreimeyer, A. W. Roth, M. E. Schwarz, J. S. Boulden, C. W. Studt.

A Committee on Research to coöperate with the National Research Council has been appointed at Washington University, St. Louis, consisting of B. M. Duggar (Chairman), J. Erlanger, E. Flad, W. W. Horner, A. S. Langsdorf, E. Mallinckrodt, R. McCulloch, L. McMaster, G. T. Moore, E. L. Opie, L. Pyle, P. A. Shaffer and J. L. Van Ornum.

Dr. E. C. H. Davies, of the University of Chicago, has been appointed instructor in chemistry at Washington University.

Mr. F. A. Lidbury, manager of the Oldbury Electrochemical Company, Niagara Falls, N. Y., has been elected president of the Engineering Society of Buffalo.

Mr. B. A. Foley has terminated his connections as assistant manager of the Palo Co. and is now associated with the Lenz Apparatus Co., Inc., 9–11 East 16th Street, New York City.

Mr. Clifton Taylor, until recently general sales agent of the Electric Reduction Company, has been elected assistant treasurer. Mr. Taylor is located at the Washington plant office.

Drs. J. R. Bailey, H. W. Harper and E. P. Schoch, of the University of Texas, have recently taken over the solution of all chemical problems in connection with the largest army camp in this country, situated at San Antonio, Texas.

A complimentary dinner was given to Mr. Thomas J. Parker by some of his friends, at the Chemists' Club, New York City, on the evening of May 19th. The speakers were Dr. Milton C. Whitaker, Prof. Chas. F. Chandler, Dr. Charles H. Herty and Dr. Hugo Schweitzer.

Prof. C. E. Davis has resigned as professor of chemistry at the Utah Agricultural College at Logan, and accepted a position as research chemist for the National Biscuit Co., with headquarters in the Havemeyer Laboratory, Columbia University.

Dr. R. P. Rose, until recently with the Mellon Institute and the General Coal Products Company, is now in Saint Louis in connection with work on a phenol plant.

Dr. William R. Cathcart has been appointed technical director of the mill and paper division of the Corn Products Refining Company, succeeding the late George M. MacNider.

James Mason Crafts, formerly president of the Massachusetts Institute of Technology (1898–1900), died at his summer home in Ridgefield, Conn., on June 20, aged 78 years.

The U. S. Civil Service Commission announces the following open competitive examinations: *Organic Chemist* (male), for filling two vacancies in the Bureau of Science, Manila, P. I., at entrance salaries from $1800 to $2250 a year; *Laboratory Aid and Junior Chemist* (male), at entrance salaries of $3.28, $3.84, $4.48, and $5.04 per diem.

Mr. Edward R. Taylor, charter member of the American Electrochemical Society, and for several years on the Board of Directors as manager and vice-president, died at his home in Penn Yan, N. Y., on May 28th. He was best known for his electrical carbon bisulfide furnace.

Platinum ware, consisting of two dishes, eight crucibles, and covers, and ten feet of wire, was stolen from the chemistry department of Miami University, Oxford, O., about May 26th.

Prof. Lloyd Van Doren, of Earlham College, Richmond, Ind., has been coöperating with The McIntosh Stereopticon Co., Chicago, in the compilation of a series of lantern slides suitable for illustrating topics in general chemistry and in industrial chemistry.

The Technical Section of the Canadian Pulp and Paper Association held its Summer Meeting, June 14–16th, in the course of a visit to the plants of the Belgo-Canadian Pulp and Paper Co., The St. Maurice Paper Co., and Laurentide Co., Ltd., all situated in the province of Quebec. The Technical Association of the Pulp and Paper Industry sent delegates headed by President H. P. Carruth.

Dr. Allerton S. Cushman, president of the Institute of Industrial Research, with headquarters at Washington, D. C., has been commissioned a major in the Officers' Reserve Corps, and will do special research work under the ordnance section on the chemistry of high explosives.

The Blaw Steel Construction Company, Pittsburgh, Pa., announce the appointment of Mr. G. E. Land as advertising manager. Mr. Land was recently connected with the advertising department of the National Tube Company.

Miss Helen S. French, instructor of chemistry in Wellesley College, has been advanced to an assistant professorship.

Mr. James F. Couch has been elected president of the Des Moines Chemical Society.

Prof. G. H. Clevenger, of Leland Stanford University, has been appointed research professor in metallurgy and will relinquish his elementary and routine teaching.

Dr. E. C. Worden is in Texas directing the development of a new oil and sulfur property near Houston.

Mr. John C. Summers has recently been appointed as head of the Baking Department of the Dunwoody Institute at Minneapolis. He will sever his connections with the Operative Miller and Baker School and Laboratories July 1st and take up his new duties at that time in Minneapolis. Mr. Summers has previously been connected with the experiment stations in the Louisiana State University, Purdue University, Colorado Agricultural College, and Kansas Agricultural College, and has also filled the position of chief chemist with the Holley Sugar Company, Denver, Colorado.

The Fourteenth Annual Meeting of the American Leather Chemists' Association, held in Atlantic City, N. J., June 7-9, 1917, was the most successful ever held, both in point of attendance and the character of the papers presented. One hundred and thirty-five of the less than four hundred members of the association were present, Westerners predominating.

The following members of the Philadelphia Section A. C. S. are chairmen of subcommittees of the Chemistry Committee of the National Research Council, of which Dr. M. T. Bogert is chairman: Mr. Arthur H. Thomas, president Arthur H. Thomas Company, Philadelphia; Dr. A. E. Taylor, Rush professor of physiological chemistry, University of Pennsylvania; Dr. Arthur M. Comey, director of the Eastern Research Laboratories, E. I. du Pont de Nemours & Company.

Mr. James J. Bajda, formerly chief dye chemist and chemical engineer for B. Heller & Company, will have charge of the dye plants, now under construction, of the Block Chemical Laboratories.

W. E. Tottingham, assistant professor of agricultural chemistry, College of Agriculture, Madison, Wis., is on leave of absence and is working at Johns Hopkins University with Prof. Livingston, on special problems in plant chemistry and physiology.

Mr. C. D. Geidel, chemist and bacteriologist in the state food laboratory, Madison, Wis., has accepted a position in the miscellaneous laboratory, Bureau of Chemistry, Washington, D. C., and assumed his new duties on June 15.

FOREST PRODUCTS LABORATORY

Mr. C. P. Winslow has been appointed director of the Forest Products Laboratory to succeed Mr. H. F. Weiss, now in charge of the Division of Forest Products of the C. F. Burgess Laboratories.

Dr. A. W. Schorger, who for seven years has been connected with the Forest Products Laboratory, has resigned to take charge of organic chemistry with the C. F. Burgess Laboratories. The Burgess Laboratories are actively engaged at present upon problems of national preparedness and defense and are represented on both national and state committees. Dr. Schorger's immediate duties will be in connection with some of these problems, especially those relating to foodstuffs.

Mr. R. C. Palmer resigned as chemist in charge of wood distillation to become chief chemist of the Newport Resin & Turpentine Co., with headquarters at Pensacola, Fla. Dr. L. F. Hawley has succeeded him.

Dr. S. F. Acree severed his connection as chief chemist at the laboratory on April 1st. He is now with the National Wood Chemical Association, with headquarters at Syracuse University.

Dr. F. W. Kressman is now manager of the Standard Lesse Co. plant at Fullerton, La.

Mr. Sidney D. Wells has left the paper and pulp division to become superintendent of the Chesapeake Pulp & Paper Co. plant at West Point, Va.

INDUSTRIAL NOTES

The Marden, Orth & Hastings Company has recently opened a new branch office in the Hoge Building, Seattle. This is the fifth American branch of the firm, which has its main office at 61 Broadway, New York City.

The Bayer Company is suing the United Drug Company for alleged infringement of the trade mark "Aspirin."

A fire in the Barrett Manufacturing Co.'s chemical plant at Philadelphia, destroyed the naphthalene building and damaged several others, loss $40,000.

A new company has recently been organized at Stockholm, Sweden, for the manufacture of nitric acid and other chemicals. The works will be erected at Trollhattan and will be supplied with electric energy by the "Royal Waterfalls Committee." The company intends to use the Birkeland-Eyde process and will produce about 7000 tons annually of concentrated nitric acid and a large quantity of nitrates as a by-product. It is planned to commence operations this year.

Experimental laboratories of the Aetna Explosives Company, at 1387 Sedgwick Avenue, Bronx, New York City, were partially wrecked by explosion on Tuesday night, May 29, 1917.

Harrisons, Inc., who recently became affiliated with the du Pont Chemical Works, Wilmington, have purchased the plants of Cawley, Clark & Company, large paint and color manufacturers, Newark, N. J., and the lithopone plants of the Beckton Chemical Company in Newark and Philadelphia. The deal is said to involve over $2,000,000.

Walter Birge, president of the Air Reduction Company, has confirmed previous reports that negotiations were in progress looking to a merger of his Company with the Union Carbide Company. He stated that should any basis of exchange of stock be agreed upon he would offer only the oxy-acetylene business of the Air Reduction Company. The Company has been devoting much time to the development of the nitrogen end of its business and, Mr. Birge reported, expected to be working its nitrogen plants on a commercial basis within a few days.

The American Association of Pharmaceutical Chemists at their annual convention in Atlantic City, N. J., adopted, on June 12, resolutions urging Congress to suspend the patent rights of alien enemies of the United States during the war.

The Synthetic Manufacturing Co., of North Tonawanda, N. Y., of which Mr. A. E. Summey is general manager, has recently engaged as production manager one of the production engineers of the Scoville Manufacturing Co. This was necessitated by the large demand on the Synthetic Co. for their products ortho and para nitrophenol and salicylic acid.

The American branch of The Treibacher Chemical Works of Treibach, Austria, contemplates the erection of an American plant. One of their chemists, Mr. Goldfogle, has recently returned from Austria where he spent several months familiarizing himself with the German process for the manufacture of rare earth metals. It is understood the Central Empires are using rare earth alloys in place of tungsten steel.

Contracts have been awarded by the Powers-Weightman-Rosengarten Co. for the erection of a shed at their factory, Ridge Ave. and Calumet St., Philadelphia, and for repairs to the factory. The shed will cost $5,500 and the repairs $9,000. The repairs are to replace the damage done in a recent fire at the plant.

The National Aniline & Chemical Company, located for more than twenty years at 100 William Street, have leased three floors in the new Heckscher Building at 244 Madison Avenue, New York City, for executive offices.

Through a coöperative agreement with Cornell University, representatives of the Bureau of Mines have been stationed at Morse Hall, where the electric furnace equipment of the department of chemistry has been utilized in some metallurgical work of the Bureau. Experiments on the electric melting of brass have indicated that a suitable electric furnace might materially reduce the metal losses from volatilization and avoid the use of costly crucibles. The Bureau is now testing a commercial-size furnace with special attention to its suitability for use on brasses for cartridges and shrapnel cases. Another electric furnace problem studied by the Bureau has been the production of ferro-uranium from the uranium oxide obtained as a by-product in the extraction of radium from its ores. Ferro-uranium is used in making uranium steel, which is said to be used by Germany for the liners of big guns which will stand up at a rate of fire so rapid that other steels fail. It is undecided whether the work on gun steel will be done at Cornell or some other university.

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

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.

BUREAU OF STANDARDS

Rules and Regulations for the Enforcement of the Lime-Barrel Act. Anonymous. Circular No. 64, 5 pp. Issued April 20. Paper, 5 cents.

Structure of the Coating on Tinned Sheet Copper in Relation to a Specific Case of Corrosion. Paul D. Merica. Technologic Paper No. 90, 17 pp. Paper, 5 cents.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

Annual Report. This report includes the following five supplements which contain the principal technical findings as developed by the Board during its two years' work: General specifications covering requirements of aeronautic instruments; nomenclature for aeronautics; mufflers for aeronautic engines; gasoline carbureter design; experimental researches on the resistance of air.

GEOLOGICAL SURVEY

Zinc in 1915. Production and Resources. C. E. Siebenthal. From Mineral Resources of the United States, 1915, Part I, pp. 851–981. Published April 30.

Spelter Produced and Consumed in the United States in 1915

Production of primary spelter (a)	(Short tons)
From domestic ore	458,135
From foreign ore	31,384
	489,519
Production of secondary spelter (a)	
Redistilled	29,764
Remelted	23,136
	542,419
Apparent consumption of primary spelter	364,494

(a) "Primary spelter," which is produced directly from ore, is here distinguished from "secondary spelter," which is obtained by refining zinc ashes, skimmings, drosses, and old metals. The statistics of secondary spelter are given on page 856.

Fuel Briquetting in 1916. C. E. Lesher. From Mineral Resources of the United States, 1916, Part II, pp. 1–4. Published May 4. "The production of fuel briquets in 1916 was 295,155 net tons, valued at $1,445,662, an increase, compared with 1915, of 73,618 tons, or 33 per cent, in quantity and $409,946, or 40 per cent, in value. The production in 1916 was the greatest recorded and exceeded that of 1914, the previous high record, by 44,520 tons."

Gypsum. R. W. Stone. Bulletin 666–E. 3 pp. "The three years 1913–1915 saw no marked fluctuation in the gypsum industry. For some time the annual output has been near 2,500,000 tons of raw material.

"This particular industry could not suffer from restraint of ocean traffic, because the imports, which come wholly from New Brunswick and Nova Scotia, are normally only about one-fifteenth as much as the domestic production, and gypsum is so abundant and widespread in the United States that the nation is easily industrially independent in this respect.

"In 1915 there were 77 active mines or quarries which supplied 69 gypsum plants. A number of plants are standing idle. In case of greatly increased demand for gypsum products the idle plants could quickly be put into commission, and the active plants that are working only one or two shifts could be put on a 24-hour schedule, thus making a large increase in the output. The production of gypsum boards probably could not be so quickly increased as that of other products, because they are made on machines which are not on the market.

"As the deposits of high-grade gypsum in the United States are widespread, practically inexhaustible, and in many places close to present lines of transportation, and as the milling part of the industry can easily be made to increase its output, the outlook for this popular structural material is fair even in times of world-wide unrest.

"The principal uses of gypsum are as structural material and as ingredient in Portland cement. Gypsum wall plaster is in common use, and gypsum boards, blocks, and tile are fast making a market because of their light weight, convenience, and fire-resistant qualities. Because of the rapidity with which the plaster sets, permitting carpenters to follow the plasterers within a few hours, and because of the size and shape of the gypsum block, tile, and board units, which favor quick construction, these materials are especially adapted to the hurried emergency building operations occasioned by great industrial activity."

Grinding and Polishing Materials. F. J. Katz. Bulletin 666–K. 3 pp. "The American industries requiring millstones, grindstones, pulpstones, oilstones, whetstones, scythestones, corundum, garnet, silica, feldspar, diatomaceous earth, and tripoli, have long been independent of foreign supplies, and the developed domestic sources of supply are capable of greatly increased production. The imports of these materials have been small in comparison with domestic production and have very probably been fostered only by a natural preference and conservatism in favor of articles that had long been used before the American supplies came into the market.

"American emery seems to be inferior to and unable to supplant the emery from Naxos, Greece, imports of which have been very largely shut out. Artificial carbide and aluminum oxide abrasives can be substituted, but some manufacturers, particularly lens grinders, seem to be reluctant to make a change, probably because it would involve changes in technique. Necessity must overcome such reluctance.

"Corundum for a number of years has been supplanted by the artificial abrasives. Very recently, however, there has been a small revival in corundum mining.

"No domestic source of satisfactory lump pumice has been exploited commercially.

"The country remains dependent on foreign sources for diamond dust and bort, imports of which in the last three years have been about 25 per cent less than the average during the previous three years.

"The pottery industry, however, is in need of siliceous pebbles for grinding quartz and feldspar in tube mills. Substitutes that contain even small quantities of iron cannot be used.

"Metallurgic plants and cement mills have used a far larger quantity of flint pebbles than the pottery industry. The pure silica pebble is not required for them, the only essentials being toughness and hardness. For these purposes there are large quantities of suitable granite and porphyry pebbles in many localities along the New England coast which have not yet been drawn upon.

"Dimension blocks cut from quartzites in Florida, Tennessee, and Iowa, have appeared on the market during the last two years and seem to be satisfactorily supplanting foreign flint lining."

Potash. Hoyt S. Gale. Bulletin 666-N. 4 pp. "The output of potash salts and potash products in the United States during 1916 has been reported to the amount of 35,739 short tons, having a mean potash content of about 27 per cent K_2O and a total potash content of 9,720 short tons of K_2O. This is almost exactly 10 times the production reported for 1915, although it is still perhaps less than 5 per cent of the normal potash consumption. In 1913 the only potash known to have been produced within this country was made from wood ashes.

"The almost entire stoppage of supplies from abroad and the meager stocks on hand with which to meet the requirements have at times carried the price of potash from a normal figure of 50 to 75 cents to $5 or $6 a unit (1 per cent of potash per ton of material).

"The forms in which potash has been produced and marketed are so diverse that it is difficult to make a summation of actual tonnage that will have any real significance. Therefore the tonnage reports of all forms have been reduced to terms of available or water-soluble potash (K_2O) contained in the product, which is the standard commercial unit by which the potash value of these materials is usually expressed.

Summary of Potash Production in 1916

Source	Available potash (K_2O) (short tons)	Value of point of shipment
Natural salts or brines	3,994	$1,937,600
Alunite and silicate rocks, including recoveries through furnace dust	1,850	715,000
Kelp	1,556	781,100
Wood ashes (potashes, pearl ash)	412	270,000
Distillery waste (molasses)	1,845	500,900
Miscellaneous organic sources	63	38,130
	9,720	$4,242,730

"The foregoing list does not include many fertilizer materials previously on the market, such as cottonseed meal and tobacco stems, some of which are largely or chiefly valued for their potash content and whose price has accordingly risen in the present market. These materials, being by-products of other industries, are not produced primarily because of their content of potash. The total given therefore represents the marketed production of potash salts and products manufactured especially or chiefly for their potash value.

"The present situation of this country concerning potash, with a view to possible emergency requirements, though not ominous, requires most careful consideration. It may be assumed that the stocks of high-grade salts of German origin remaining in the United States and, indeed, throughout the world except in the central allied countries are now practically exhausted. The actual domestic production of high-grade salts, moreover, is still very small and is limited to a very few sources, and the difficulties in the way of refining the large bulk of low-grade potash materials would probably be great."

Bauxite and Aluminum. James M. Hill. Bulletin 666-O. "The consumption of bauxite in the United States has increased steadily because of increase both in the consumption of aluminum and in the output of other products made from bauxite. It is particularly gratifying to know that although the consumption of bauxite in the United States in 1916 amounted to 425,130 long tons, an increase of 41 per cent over the consumption in 1915 and of 74 per cent over the consumption in 1914, practically all domestic requirements were met by the American producers. This bears out the forecast made by the Geological Survey in 1914, that the domestic deposits would be more actively developed to supply the demand formerly met by French bauxite.

"Deposits of bauxite in Pulaski and Saline Counties, Ark., have yielded the larger part of the domestic output. The deposits in the bauxite field of northern Georgia and Alabama have contributed a considerable quantity, and in recent years the fields in central Georgia and Tennessee have made additions to the output.

"The growth of the American aluminum industry has been steady heretofore, but it is probable that the production in 1917 will show a pronounced increase, owing to the operation of the new plant at Badin, N. C., which is practically completed and which made a small output in 1916. This project, started by French capital, was taken over by American interests in 1915 and pushed to completion.

"The uses of aluminum are myriad, but as some are more essential than others, it is likely that the minor articles formerly made from aluminum will for the present be made in smaller quantity, because the available supply of aluminum will probably be diverted to more urgent uses.

"In statistics for years prior to 1916 published by the United States Geological Survey, the output of aluminum abrasives has been included with that of other artificial abrasives and cannot now be separated, but the domestic production in 1916 amounted to 30,708 short tons, having a value of $2,139,230."

PUBLIC HEALTH SERVICE

Vaccine Virus. Anonymous. Public Health Reports, 32, 687-9 (May 11). Virus of various manufacturers purchased at drug stores has been found, though within the stamped expiration date, to give less than 50 per cent of "takes;" but when obtained direct from the manufacturer, "takes" were nearly 100 per cent. Vaccine virus at pharmacies is often kept in the cellar or in the soda fountain cooler, and the temperature of these places, both winter and summer, has been found to be in the neighborhood of 15° C. (59° F.) or higher. This is by no means satisfactory. Ice-box temperature is not freezing temperature, but usually several degrees above freezing. Vaccine virus should be kept in a metal container in constant contact with the ice itself. If it can be kept at or below the freezing point, so much the better. There is no danger of keeping it too cold.

Conference of Health Authorities. United States Public Health Service in Annual Conference with State and Territorial Health Authorities, Washington, April 30 and May 1, 1917. Public Health Service, 32, 689-91 (May 11). This is a summary of the proceedings.

Drinking Fountains. Investigation of Fountains at the University of Minnesota. H. A. Whittaker. Public Health Reports, 32, 691 (May 11). "This investigation included the 77 drinking fountains in use at the University of Minnesota. These fountains represented 15 different types, all of which were found to be improperly constructed to prevent them from contamination by the consumer. The bacteriological examinations conducted on these fountains showed that 80 per cent were infected with streptococci, and that the water from 11 per cent of these fountains contained organisms of this type when they were not found present in the water supplied to the fountains. These results indicate that drinking fountains may be a factor in the transmission of communicable diseases, a condition which should be remedied.

"Experiments were conducted with various fountain nozzles to supplant those in use, and a type was designed which is economical to construct and safe from a sanitary point of view."

Public Health Administration in South Bend, Indiana. Carroll Fox. Public Health Reports, 32, 776-834 (May 25). Of interest to municipal and state health officials.

The Public Health Service in Time of War. Executive Order Making the United States Public Health Service a Part of the Military Forces of the United States. Public Health Reports, 32, 773 (May 25). "Under the authority of the Act of Congress approved July 1, 1902, and subject to the limitations therein expressed, it is ordered that hereafter in times of threatened or actual war the Public Health Service shall constitute a part of the military forces of the United States, and in times of threatened or actual war the Secretary of the Treasury may, upon request of the Secretary of War or the Secretary of the Navy, detail officers or employees of said service for duty either with the Army or the Navy. All the stations of the Public Health Service are hereby made available for the reception of sick and wounded officers and men, or for such other purposes as shall promote the public interest in connection with military operations.

(Signed) Woodrow Wilson

The White House, 3 April, 1917."

Maintenance of Health in Industries. Its Relation to the Adequate Production of War Materials. J. W. Schereschewsky. Public Health Reports, 32, 835–839 (June 1).

COMMERCE REPORTS—MAY, 1917

Owing to the cutting off of the Austrian supply, exports of **magnesite** from Greece to the United States have greatly increased. Details of its mining, calcimining and uses are given. (Pp. 411–415.)

Several plants in Switzerland are preparing to manufacture **synthetic alcohol and acetic acid,** starting with **calcium carbide.** The proposed annual output is 7,500 to 10,000 tons of alcohol. (P. 426.)

Tests made at the Bureau of Standards upon "palau" as a **substitute for platinum** in crucibles, have shown that it compared favorably with platinum. It is, however, much more attacked by fused pyrosulfate than is platinum. (P. 427.)

The output of **porcelain** from Bohemia in 1916 was about half the normal amount. Fears are expressed as to future trade in the United States owing to American and Japanese competition. (P. 480.)

The Norwegian production of **whale oil** is about 58 per cent of the world's production. The oil obtained by boiling the flesh and bones is of inferior grade, containing as much as 50 per cent of free fatty acids. **Fertilizer** and cattle food are obtained as by-products. (P. 454.)

Investigation of **platinum** deposits in Spain has shown that platinum is present in the sands of 12 or more rivers, in amounts up to 2 or 3 g. per cubic meter. The investigation is to be continued and will also include study of associated iron chromium and nickel deposits. (P. 476.)

Export of **argols** from Argentine is decreasing on account of increased production and consumption of **tartaric acid** in Argentine. (P. 484.)

Production of **rubber** in the Dutch East Indies shows a large increase. (P. 497.)

A factory for the manufacture of **"kraft"** paper has been established in British Columbia. (P. 498.)

Great efforts are being made to increase the production of **camphor** in Formosa. (P. 500.)

Details of the cultivation of coconuts and production of **copra** in East Africa are described. (P. 502.)

Japan is now suffering from an over-supply of **potassium chlorate,** the price of which has greatly declined. (P. 553.)

Imports of **copra** and **coconut oil** into the United States for 1917 are nearly twice those of 1916. The three principal sources are the Philippines, Australia and the Dutch East Indies. (P. 556.)

Plans are being made in Russia to increase the production of **cement** to four or five times the present annual production (25,000,000 barrels). (P. 574.)

Hull, England, is now the world's greatest center for the **vegetable-oil industry,** based on the quantity of oil-yielding materials handled. Marseilles is first in yield of oil. The principal materials used are linseed, rape-seed, cottonseed, castor seed, soya beans, illipe, mowra, poppy seed, sesame seed, palm kernels, peanuts, and copra. The oils are in demand for margarine, and as a source of glycerine; and the "cake" for cattle food. (Pp. 580–588.)

A list of **dyestuff manufacturers,** prepared by the Bureau of Foreign and Domestic Commerce, contains the names of 158 manufacturers. (P. 590.)

Lignite is to be used as fuel in Australian power plants. (P. 603.)

Statistics are given for the Japanese production and export of **antimony, molybdenum, tin,** and **tungsten.** (P. 647.)

Production of **platinum** in Russia in 1916 was 86,800 troy ounces, about 75 per cent of the 1915 production. (P. 647.)

Export of **nitrate** from Chili has again decreased, owing to the shortage of vessels and to strikes. (P. 678.)

A company has been formed in Norway for developing the extensive deposits of **titanium iron ore.** (P. 709.)

The use of **coal gas** for firing furnaces for the **heat treatment** of **metals** is increasing greatly in England. (P. 715.)

Exports of **copper** from Chile in 1916 are higher than ever before, being 20,000 tons greater than in 1915. (P. 725.)

Production of **mica** in India is over 50 per cent greater than usual. (P. 734.)

Plans are being made in British Guiana to manufacture **alcohol** instead of rum (import of which into the United States has been forbidden). An annual production of 4 or 5 million gallons of alcohol is anticipated. (P. 751.)

New deposits of **copper** and **gold** are reported from Central Asia. (P. 769.)

Large deposits of **chrome iron ore** and **molybdenite** are reported from Australia. (P. 794.)

Any appreciable export of **soya beans** from Manchuria to the United States is unlikely, owing to the local demand and to the lack of shipping. Details of the production and handling of the beans are described. (P. 796.)

Large **iron works** are to be erected at Ekaterinburg, in the Urals. (P. 799.)

Russia furnishes practically the world's whole supply of **licorice** which is used in medicines, candy and tobacco. The industry is described in some detail. (P. 806.)

The mineral output of British Columbia in 1916 was over 40 per cent greater than in 1915. It includes **gold, silver, lead, copper, zinc, coal,** and **coke.** Some **manganese** was obtained as a by-product of zinc smelting; about 40 ounces of **platinum** were recovered in placer mining; and small amounts of **antimony** and **molybdenum** ores were also produced. (Sup. 23*b*.)

Special Supplements Issued During the Month

Denmark—4*a*
Sweden—16*a*
Canada—23*b* and *c*
Dominican Republic—26*a*
Haiti—30*a*
Aden—49*a*

Statistics of Exports to the United States

London—642
Rubber
Tin
Hides
Indigo

Nottingham—686
Leather
Paints
Hides
Stoneware

Vera Cruz—702
Chicle
Vanilla
Hides
Rubber
Lead
Mica
Mercury
Silver

Dominican Republic—Sup. 26*a*
Hides
Molasses
Copper ore
Rosin
Sugar
Wax
Fustic
Logwood

Denmark—Sup. 4*a*
Chalk
Chemicals
Diamonds
Flint pebbles
Fusel oil
Hides
Ink
Leather
Paper
Porcelain
Rags
Rennet

Sweden—Sup. 16*a*
China
Glassware
Enameled ware
Hides
Iron and steel
Iron ore
Matches
Fusel oil
Creosote oil
Paper
Potash
Soda
Wood pulp

Winnipeg—Sup. 23*c*
Hides
Paper
Senega root
Wood pulp

British Columbia—Sup. 23*b*
Bullion
Cascara
Coal
Explosives
Fertilizer
Firebrick
Hides
Lime
Copper ore
Gold ore
Rubber
Tin

Nova Scotia—Sup. 23*b*
Cod oil
Fertilizer
Grindstones
Gypsum
Hides
Lime juice
Manganese ore
Paper stock

Haiti—Sup. 30*a*
Beeswax
Castor beans
Coconuts
Fustic
Guano
Hides
Logwood

NEW PUBLICATIONS

By Irene DeMatty, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Agricultural Geology. R. H. Rastall. 8vo. 331 pp. Price, $3.25. G. P. Putnam's Sons, New York.

Agriculture: Productive Agriculture. J. H. Gehrs. 12mo. 436 pp. Price, $1.00. The Macmillan Company, New York.

Analysis: A Brief Outline of Qualitative Analysis. J. O. Frank. 8vo. 22 pp. Price, $0.50. Castle-Pierce Press, Oshkosh, Wis.

Applied Mechanics: Cours élémentaire de mécanique industrielle. E. Gouard and G. Herniaux. 2 Vol. 8vo. 549 pp. Price, 7 fr. H. Dunod et E. Pinat, Paris.

Cement Industry: A Practical Treatise on the Building, Equipping and Running of a Portland Cement Plant. W. A. Brown. 8vo. 158 pp. Price, $3.00. D. Van Nostrand Company, New York.

Chemical Tests for Minerals. A. J. Burdick. 12mo. 93 pp. Price, $1.25. Gateway Publishing Company, Beaumont, Cal.

Chemistry: Experimental General Chemistry. J. H. Ransom. 2nd Ed. 12mo. 191 pp. Price, $1.00. McGraw-Hill Book Company, New York.

Chemistry: Historical Introduction to Chemistry. T. M. Lowry. 12mo. 581 pp. Price, $2.50. The Macmillan Company, New York.

Chemistry: Les Sciences physiques du brevet élémentaire. Notions de physique et de chimie. A. Brémant. 16mo. 374 pp. Price, 8 fr. E. Arrault et Cie, Paris.

Chemistry of Farm Practice. T. E. Keitt. 12mo. 265 pp. Price, $1.25. John Wiley & Sons, New York.

Compressed Air for the Metal Worker. C. A. Hirschberg. 8vo. 321 pp. Price, $3.00. Clark Book Company, New York.

Engineers' Manual. R. G. Hudson and Others. 12mo. 310 pp. Price, $2.00. John Wiley & Sons, New York.

Food Analysis: A Course in Food Analysis. A. L. Winton. 8vo. 252 pp. Price, $1.50. John Wiley & Sons, New York.

Gasworks: Modern Gasworks Practice. Alwyne Meade. 4to. 529 pp. Price, $7.50. D. Van Nostrand Company, New York.

Hydrodynamics. Horace Lamb. 4th Ed. 8vo. 708 pp. Price, $6.25. G. P. Putnam's Sons, New York.

Hydroelectric Practice: American Hydroelectric Practice. W. T. Taylor. 8vo. 439 pp. Price, $5.00. McGraw-Hill Book Company, New York.

Inorganic Chemistry: Experimental Inorganic Chemistry. Alexander Smith. 5th Ed. 12mo. 171 pp. Price, $1.00. The Century Company, New York.

Marine Engineering. W. F. Durand. 8vo. 982 pp. Price, $6.00. Marine Engineering, New York.

Materials: Résistance des matériaux appliqués aux constructions. E. Aragon. 8vo. 662 pp. H. Dunod et E. Pinat, Paris.

Mechanical Movements, Powers and Devices. G. D. Hiscox. 15th Ed. 8vo. 409 pp. Price, $3.00. Norman W. Henley Publishing Company, New York.

Scientific Works: Bibliographie des travaux scientifiques. J. Deniker. 4to. 206 pp. Price, 5 fr. Ernest Leroux, Paris.

Sewage: The Activated Sludge Process of Sewage Treatment. A Bibliography of the Subject with Abstracts. J. E. Porter. 8vo. 40 pp. Price, $0.25. General Filtration Company, Rochester, N. Y.

Solution: The Nature of Solution. H. C. Jones. 8vo. 380 pp. Price, $3.50. D. Van Nostrand Company, New York.

Storage Batteries Simplified; Operating Principles, Care and Industrial Applications. V. W. Page. 12mo. 208 pp. Price, $1.50. Norman W. Henley Publishing Company, New York.

Sulfuric Acid: The Manufacture of Sulfuric Acid and Alkali; a Theoretical and Practical Treatise. Supplement to Vol. 1. Georg Lunge. 4th Ed. 8vo. 347 pp. Price, $5.00. D. Van Nostrand Company, New York.

Tube Milling. A. Del Mar. 8vo. 159 pp. Price, $2.00. McGraw-Hill Book Company, New York.

White Coal (Tasmanite): La Houille blanche. A. Bergès. 8vo. 24 pp. Price, 3 fr. Joseph Baratier, Grenoble.

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Acetylene: Cutting Steel Risers with Oxy-Acetylene. A. Krebs. *The Acetylene Journal*, Vol. 18 (1917), No. 12, pp. 664–666.

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Coal-Tar Dyestuff Industry. I. F. Stone. *The Chemical Engineer*, Vol. 25 (1917), No. 3, pp. 110–112.

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Compressed Air. C. L. Hubbard. *Industrial Management*, Vol. 53 (1917), No. 2, pp. 225–246.

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Flax Straw as a Material for Papermaking. E. B. Biggar. *Paper*, Vol. 20 (1917), No. 9, pp. 13–14.

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Flow of Water over Triangular Weirs. H. E. Broughton. *Technology Monthly*, Vol. 4 (1917), No. 2, pp. 21–25.

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Lead Mining in Derbyshire. L. C. Stuckey. *The Mining Magazine*, Vol. 16 (1917), No. 4, pp. 193–200.

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Milk: The Composition of Milk. P. S. Arup and Others. *The Analyst*, Vol. 42 (1917), No. 493, pp. 118–124.

Nitrogen: Relation of the Transformation and Distribution of Soil Nitrogen to the Nutrition of Citrus Plants. I. G. McBeth. *Journal of Agricultural Research*, Vol. 9 (1917), No. 7, pp. 183–252.

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Ore Treatment at the Perseverance Mine, West Australia. W. R. Cloutman. *The Mining Magazine*, Vol. 16 (1917), No. 4, pp. 202–208.

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Silica as a Component of Furnace Slags. W. G. Imhoff. *Blast Furnace and Steel Plant*, Vol. 5 (1917), No. 4, pp. 155–159.

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Steam *vs.* Oil Engines for Small Light Plant. L. H. Morrison. *Power*, Vol. 45 (1917), No. 20, pp. 657–659.

Steam Distillation: Studies in Steam Distillation. H. D. Richmond. *The Analyst*, Vol. 42 (1917), No. 493, pp. 125–139.

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MARKET REPORT—JUNE, 1917

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON JUNE 20

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	4.50	@	4.55
Alum, lump ammonia	100 Lbs.	4.00	@	4.25
Aluminum Sulfate, high-grade	Ton	70.00	@	80.00
Ammonium Carbonate, domestic	Lb.	11½	@	12
Ammonium Chloride, white	Lb.	15	@	15½
Aqua Ammonia, 26°, drums	Lb	6½	@	7
Arsenic, white	Lb.	18	@	19
Barium Chloride	Ton	80.00	@	90.00
Barium Nitrate	Lb.	11	@	11½
Barytes, prime white, foreign	Ton	30.00	@	40.00
Bleaching Powder, 35 per cent	100 Lbs.	1.75	@	2.00
Blue Vitriol	Lb.	9½	@	10
Borax, crystals, in bags	Lb.	7¾	@	8½
Boric Acid, powdered crystals	Lb.	13	@	13½
Brimstone, crude, domestic	Long Ton	45.00		
Bromine, technical, bulk	Lb.	55	@	60
Calcium Chloride, lump, 70 to 75% fused	Ton	30.00	@	32.00
Caustic Soda, 76 per cent	Lb.	6.75	@	6.85
Chalk, light precipitated	Lb.	4½	@	4¾
China Clay, imported	Ton	18.00	@	30.00
Feldspar	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered	Ton	35.00		
Glauber's Salt, in bbls	100 Lbs.	70	@	75
Green Vitriol, bulk	100 Lbs.	1.00	@	1.05
Hydrochloric Acid, commercial, 18°	Lb.	1⅜	@	1½
Hydrochloric Acid, C. P., conc., 22°	Lb.	1¾	@	2
Iodine, resublimed	Lb.	3.50	@	3.55
Lead Acetate, white crystals	Lb.	15	@	15¼
Lead Nitrate	Lb.	15½	@	16
Litharge, American	Lb	11	@	11½
Lithium Carbonate	Lb.	1.25		
Magnesium Carbonate, U. S. P.	Lb	20	@	22
Magnesite, "Calcined"	Ton	60.00	@	65.00
Nitric Acid, 36°	Lb.	6½	@	6¾
Nitric Acid 42°	Lb.	7½	@	8½
Phosphoric Acid, sp. gr. 1.710	Lb.	33	@	37
Phosphorus yellow	Lb.	1.45	@	1.50
Plaster of Paris	Bbl.	1.50	@	1.70
Potassium Bichromate, casks	Lb.	36	@	37
Potassium Bromide (granular)	100 Lbs	1.00	@	1.10
Potassium Carbonate, calcined, 80 @ 85%	Lb.	65	@	75
Potassium Chlorate, crystals, spot	Lb.	54	@	56
Potassium Cyanide, bulk, 98–99 per cent	Mixture	2.30	@	2.40
Potassium Hydroxide, 88 @ 92%	Lb.	82	@	83
Potassium Iodide, bulk	Lb.	2.90		
Potassium Nitrate	Lb.	30	@	32
Potassium Permanganate, bulk	Lb	4.00	@	4.25
Quicksilver, flask	75 lbs	85.00		
Red Lead, American, dry	Lb.	11½	@	13
Salt Cake, glass makers'	Ton	19.00	@	20.00
Silver Nitrate	Oz.	47¾		
Soapstone in bags	Ton	10.00	@	12.50
Soda Ash, 58%, in bags	100 Lbs.	2.70	@	2.80
Sodium Acetate	Lb.	9	@	10
Sodium Bicarbonate, domestic	100 Lbs.	2.10	@	2.25
Sodium Bichromate	Lb.	15¾	@	16½
Sodium Chlorate	Lb.	23½	@	24½
Sodium Fluoride, commercial	Lb.	12½	@	13½
Sodium Hyposulfite	100 Lbs.	1.75	@	1.85
Sodium Nitrate, 95 per cent, spot	100 Lbs.	4.05	@	4.15
Sodium Silicate, liquid, 40° Bé	100 Lbs.	1.60	@	1.70
Sodium Sulfide, 60%, crystals, in bbls	Lb.	2¾	@	3
Sodium Bisulfite, powdered	Lb.	.05	@	.05¼
Strontium Nitrate	Lb.	28	@	30
Sulfur, flowers, sublimed	100 Lbs.	3.05	@	3.45
Sulfur, roll	100 Lbs.	2.85	@	3.25
Sulfuric Acid, chamber, 66° Bé	Ton	29.00	@	30.00
Sulfuric Acid, oleum (fuming)	Ton	40.00	@	42.00
Talc, American white	Ton	10.00	@	12.00
Terra Alba, American, No. 1	100 Lbs.	85	@	90
Tin Bichloride, 50°	100 Lbs.	19.75		
Tin Oxide	Lb.	66	@	68
White Lead, American, dry	Lb.	11½	@	12
Zinc Carbonate	Lb.	23	@	25
Zinc Chloride, commercial	Lb.	16	@	17
Zinc Oxide, American process XX	Lb.	15	@	15½

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	47	@	48
Acetic Acid, 56 per cent, in bbls	Lb.	10	@	10½
Acetic Acid, glacial, 99½%, in carboys	Lb.	37	@	42
Acetone, drums	Lb.	27	@	29
Alcohol, denatured, 180 proof	Gal.	1.00	@	1.01
Alcohol, grain, 188 proof	Gal.	3.24	@	3.30
Alcohol, wood, 95 per cent, refined	Gal.	1.00	@	1.02
Amyl Acetate	Gal.	4.25	@	4.50
Aniline Oil	Lb.	29	@	30
Benzoic Acid, ex-toluol	Lb.	5.00	@	5.50
Benzol, 90 per cent	Gal.	55	@	58
Camphor, refined in bulk, bbls	Lb.	89	@	90
Carbolic Acid, U. S. P., crystals, drums	Lb.	40	@	42
Carbon Bisulfide	Lb.	6	@	6½
Carbon Tetrachloride, drums, 100 gals	Lb.	16	@	17
Chloroform	Lb.	60	@	61
Citric Acid, domestic, crystals	Lb.	74	@	75
Creosote, beechwood	Lb.	1.90	@	2.00
Cresol, U. S. P.	Gal.	1.25	@	1.30
Dextrine, corn (carloads, bags)	100 Lbs.	6.35	@	6.40
Dextrine, imported potato	Lb.	15	@	16
Ether, U. S. P., 1900	Lb.	23	@	30
Formaldehyde, 40 per cent	Lb.	18	@	18½
Glycerine, dynamite, drums included	Lb.	58½	@	59
Oxalic Acid, in casks	Lb.	46	@	47
Pyrogallic Acid, resublimed bulk	Lb.	3.25		
Salicylic Acid	Lb.	1.35	@	1.40
Starch, cassava	Lb.		—	
Starch, corn (carloads, bags) pearl	100 Lbs.	5.05	@	5.10
Starch, potato	Lb.	12½	@	13
Starch, rice	Lb.	10	@	12
Flour, sago	Lb.	6	@	6½
Starch, wheat	Lb.	5¾	@	6½
Tannic Acid, commercial	Lb.	45	@	50
Tartaric Acid, crystals	Lb.	80	@	81

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	60	@	65
Black Mineral Oil, 29 gravity	Gal.	13½	@	14
Castor Oil, No. 3	Lb.	25	@	26
Ceresin, yellow	Lb.	14	@	18
Corn Oil, crude	100 Lbs.	15	@	16
Cottonseed Oil, crude, f. o. b. mill	Gal.	1.10	@	1.11
Cottonseed Oil, p. s. y.	Lb.	16¼	@	16½
Menhaden Oil, crude (southern)	Gal.	—	@	—
Neat's-foot Oil, 20°	Gal.	1.70		
Paraffine, crude, 118 to 120 m. p.	Lb.	7½	@	7¾
Paraffine Oil, high viscosity	Gal.	29½	@	30
Rosin, "F" Grade, 280 lbs.	Bbl.	6.40		
Rosin Oil, first run	Gal.	37		
Shellac, T. N.	Lb.	60		
Spermaceti, cake	Lb.	24		
Sperm Oil, bleached winter, 38°	Gal.	nominal		
Spindle Oil, No. 200	Gal.	24	@	25
Stearic Acid, double-pressed	Lb.	24	@	25
Tallow, acidless	Gal.	1.50	@	1.60
Tar Oil, distilled	Gal.	31½		
Turpentine, spirits of	Gal.	43		

METALS

Aluminum, No. 1, ingots	Lb.	59	@	61
Antimony, ordinary	Lb.	19½	@	20
Bismuth, N. Y.	Lb.	3.00	@	3.10
Copper, electrolytic	Lb.	33		
Copper, lake	Lb.	31		
Lead, N. Y.	100 Lbs.	11¾	@	12
Nickel, electrolytic	Lb.	55	@	56
Platinum, refined, soft	Oz.	105.00		
Silver	Oz.	77⅞		
Tin, Straits	Lb.	64	@	64½
Tungsten (WO_3)	Per Unit	20.00		
Zinc, N. Y.	100 Lbs.	9⅜	@	9½

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	5.85	@	6.00
Blood, dried, f. o. b. Chicago	Unit	5.50	@	5.60
Bone, 4 and 50, ground raw	Ton	35.00		
Calcium Cyanamid	Unit of Ammonia	4.00		
Calcium Nitrate, Norwegian	100 Lbs.	—		
Castor Meal	Unit	—		
Fish Scrap, domestic, dried, f. o. b. works	Unit	nominal		
Phosphate, acid, 16 per cent	Ton	14	@	15
Phosphate rock, f. o. b. mine:				
Florida land pebble, 68 per cent	Ton	1.75	@	2.00
Tennessee, 78–80 per cent	Ton	4 75	@	5.00
Potassium "muriate," basis 80 per cent	Ton	350.00	@	365.00
Pyrites, furnace size, imported	Unit	nominal		
Tankage, high-grade, f. o. b. Chicago	Unit	5.10	&	10

CLASSIFIED LIST OF CHEMICAL EQUIPMENT

Absorption Towers
Badger & Sons Co., E. B., Boston, Mass.
Duriron Castings Co., N. Y. C.
General Ceramics Co., N. Y. C.
Knight, Maurice A., East Akron, Ohio.
Lummus Co., The Walter E., Boston, Mass.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.
Thermal Syndicate, Ltd., The, N. Y. C.
U. S. Stoneware Co., The, Akron, O.

Acid and Alkali Resistant Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Duriron Castings Co., N. Y. C.
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
Jacoby, Henry E., N. Y. C.
Pfaudler Co., Rochester, N. Y., Chicago, Ill., & N. Y. C.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.

Acid Condenser Tubes—Glass
Corning Glass Works, Corning, N. Y.

Acid Distillation Apparatus
Thermal Syndicate, Ltd., The, N. Y. C.

Acid Eggs
Bethlehem Fd'y & Mach. Co., So. Beth., Pa.
Buffalo Fdy & Mach. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Jacoby, Henry E., N. Y. C.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Schutte & Koerting Co., Philadelphia, Pa.
U. S. Stoneware Co., The, Akron, O.

Acid Pitchers
Bausch & Lomb Optical Co., Rochester, N. Y.
Guernsey Earthenware Co., Cambridge, O.
Knight, Maurice A., East Akron, O.
Palo Co., N. Y. C.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.
U. S. Stoneware Co., The, Akron, O.

Acid Plants (Complete or in Part)
Knight, M. A., East Akron, O.

Acid Proof Brick
General Ceramics Co., N. Y. C.
Knight, M. A., East Akron, Ohio.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.
U. S. Stoneware Co., The, Akron, O.

Acids
Eimer & Amend, N. Y. C.
Merck & Co., N. Y. C.
Palo Company, N. Y. C.

Acid Valves
Chadwick-Boston Lead Co., Boston, Mass.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Duriron Castings Co., N. Y. C.
General Ceramics Co., N. Y. C.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Schutte & Koerting Co., Philadelphia, Pa.
York Manufacturing Co., York, Pa.

Acid Ware
General Ceramics Co., N. Y. C.

Acid Ware (Vitrified Clay)
Guernsey Earthenware Co., Cambridge, O.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.
U. S. Stoneware Co., The, Akron, O.

Agitators or Mixers
Cleveland Brass Mfg. Co., The, Cleveland, O.
Devine Co., J. P., Buffalo, N. Y.
Dorr Co., The, Denver, Col., & N. Y. C.
Duriron Castings Co., N. Y. C.
Elyria Enameled Products Co., Elyria, O.
General Filtration Co., Inc., Rochester, N. Y.
Jacoby, Henry E., N. Y. C.
Pfaudler Co., Rochester, N. Y., Chicago, & N. Y. C.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Stevens Brothers, N. Y. C.
Werner & Pfleiderer Co., Saginaw, Mich.

Air Compressors
Abbé Engineering Co., N. Y. C.
Crowell Engineering Co., Brooklyn, N. Y.
General Electric Co., Schenectady, N. Y.
Hubbard's Sons, Norman, Brooklyn, N. Y.
Schutte & Koerting Co., Philadelphia, Pa.

Air-Diffusing Plates
General Filtration Co., Inc., Rochester, N. Y.

Air Washers
Carrier Engineering Corp., N. Y. C.

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Norton Co., Worcester, Mass.
Scientific Materials Co., Pittsburgh, Pa.

Ammeters
Brown Instrument Co., Philadelphia, Pa.
General Electric Co., Schenectady, N. Y.

Ammonia
Mallinckrodt Chemical Wks., St. Louis, Mo.
Unger, John S., Chicago, Ill.

Ammonia Fittings and Supplies
York Manufacturing Co., York, Pa.

Ammonia—Salts of
Merck & Co., N. Y. C.

Ammonia Stills
Badger & Sons Co., E. B., Boston, Mass.

Analysis—Gas
Sarco Co., Inc., N. Y. C.

Analysis—Gas Apparatus
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eberbach & Son Co., Ann Arbor, Mich.
Eimer & Amend, N. Y. C.
Emil Greiner Co., The, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Sarco Co., Inc., N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Analytical Apparatus
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eberbach & Son Co., Ann Arbor, Mich.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
Laboratory Supply Co., Columbus, O
Mine & Smelter Supply Co., N Y. C.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Analytical Laboratories
Columbus Laboratories, Chicago, Ill.
Dearborn Chemical Co., Chicago, Ill.
Sadtler & Son, Samuel P., Philadelphia, Pa.

Aniline Oil—Salts of
Merck & Co., N. Y. C.

Antimony—Salts of
Merck & Co., N. Y. C.

Arsenic—Metallic & Salts
Merck & Co., N. Y. C.

Arsenic Plants (Acid Proof Stoneware)
Knight, M. A., East Akron, O.

Asphalt & Tar Testing Apparatus
Eimer & Amend, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

Autoclaves
Eimer & Amend, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Autoclaves (Glass Enameled Steel)
Pfaudler Co., Rochester, N. Y., Chicago, Ill., & N. Y. C.

Autoclaves (High and Low Pressure)
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Automatic Pressure Regulators
Taylor Instrument Cos., Rochester, N. Y.

Automatic Temperature Regulators
Taylor Instrument Cos., Rochester, N. Y.

Bakelite
General Bakelite Co., N. Y. C.

Balances and Weights
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eberbach & Son Co., Ann Arbor, Mich.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
Laboratory Supply Co., Columbus, O.
Mine & Smelter Supply Co., Denver, Salt Lake City, El Paso, & N. Y. C.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Whitall Tatum Co., Philadelphia, Pa.

Barium—Salts of
Merck & Co., N. Y. C.

Barometers
Taylor Instrument Cos., Rochester, N. Y.

Barometer Tubing Glass
Corning Glass Works, Corning, N. Y.

Beakers
Bausch & Lomb Optical Co., Rochester, N. Y
Braun-Knecht-Heimann Corp., San Francisco, Cal.
Corning Glass Works, Corning, N. Y.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Guernsey Earthenware Co., Cambridge, O.
Herold China & Pottery Co., Golden, Col.
Macbeth-Evans Glass Co., Pittsburgh, Pa.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Whitall Tatum Co., Philadelphia, Pa.

Belt Cement
Schieren Co., Chas. A., N. Y. C.

Belt Dressing
Dixon Crucible Co., Joseph, Jersey City, N. J.
Schieren Co., Chas. A., N. Y. C.

Benzol
Merck & Co., N. Y. C.

Betanaphthol
Merck & Co., N. Y. C.

Betanaphthol Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Bismuth—Metallic & Salts
Merck & Co., N. Y. C.

Blowers
Abbé Engineering Co., N. Y. C.
Crowell Mfg. Co., Brooklyn, N. Y.
Duriron Castings Co., N. Y. C.
Eimer & Amend, N. Y. C.
Palo Company, N. Y. C
Pratt Eng. & Mach. Co., Atlanta, Ga., & N.Y.C.
Schutte & Koerting Co., Philadelphia, Pa.
Scientific Materials Co., Pittsburgh, Pa.

Boiler Insulation
Brunt & Co., H. H., Chicago, Ill.

Boiler Water Treatment
Dearborn Chemical Co., Chicago, Ill.
Dixon Crucible Co., Joseph, Jersey City, N. J
Merck & Co., N. Y. C.

Bolting Cloth
Abbé Engineering Co., N. Y. C.

Bone Black
Booth Apparatus Co., Syracuse, N. Y.
Toch Bros., N. Y. C.

Books
Chemical Publishing Co., The, Easton, Pa.
Longmans, Green & Co., N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Van Nostrand Co., D., N. Y. C.
Wiley & Sons, Inc., John, N. Y. C.

Bottles (Glass)
Eimer & Amend, N. Y. C.
Whitall Tatum Co., Philadelphia, Pa.

Brick (Heat Insulating)
Brunt & Co., H. H., Chicago, Ill.
Dixon Crucible Co., Joseph, Jersey City, N. J.

Brinell Machines
Eimer & Amend, N. Y. C.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

Burner Guards
Knight, M. A., East Akron, O.

Burners—Gas and Oil
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eberbach & Son Co., Ann Arbor, Mich.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Laboratory Supply Co., Columbus, O.
Mine & Smelter Supply Co., N. Y. C.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Schutte & Koerting Co., Philadelphia, Pa.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Burners—Pyrites
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.

Burners—Sulphur
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Schutte & Koerting Co., Philadelphia, Pa.

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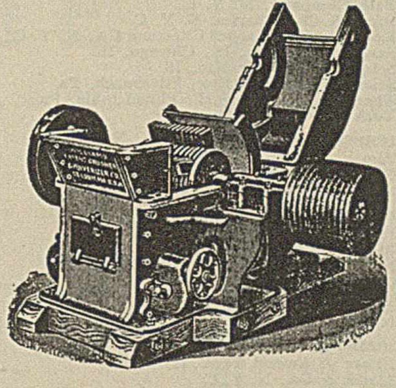

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Scientific Materials Co., Pittsburgh, Pa.
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Corning Glass Works, Corning, N. Y.

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Bausch & Lomb Optical Co., Rochester, N. Y
Braun-Knecht-Heimann Co., San Francisco, Cal.
Eimer & Amend, N. Y. C.
Norton Co., Worcester, Mass.
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Thermal Syndicate, Ltd., The, N. Y. C.

Carbon Bisulfide
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Carbon Tetrachloride
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Carboys
Whitall Tatum Co., Philadelphia, Pa.

Carboy Inclinators
Eimer & Amend, N. Y. C.

Carboy Stoppers
Whitall Tatum Co., Philadelphia, Pa.

Carboy Stoppers (Acid Proof)
Knight, M. A., East Akron, O.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.

Casseroles
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Corning Glass Works, Corning, N. Y.
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Eimer & Amend, N. Y. C.
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Herold China & Pottery Co., Golden, Colo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.

Castings (Acid and Heat Resisting)
Bethlehem Fd'y & Mach. Co., So. Beth., Pa.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Devine Co., J. P., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.
Jacoby, Henry E., N. Y. C.
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Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.

Castings—Caustic
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Castings (Chemical)
Bethlehem Fd'y & Mach. Co., So. Beth., Pa.
Buffalo Fdy. & Mach. Co., Buffalo, N. Y.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Devine Co., J. P., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.
Jacoby, Henry E., N. Y. C.
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Sowers Mfg. Co., Buffalo, N. Y.
Werner & Pfleiderer Co., Saginaw, Mich.

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Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

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Merck & Co., N. Y. C.

Caustic Pots
Bethlehem Fd'y & Mach. Co., So. Beth., Pa.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.

Caustic Soda
General Chem. Co., N. Y. C.
Mallinckrodt Chemical Wks., St. Louis, Mo.
Merck & Co., N. Y. C.

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Toch Bros, N. Y. C.

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Daigger & Co., A., Chicago, Ill.
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Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

Centrifugals
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Cal.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
International Equipment Co., Boston, Mass.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Schaum & Uhlinger, Inc., Philadelphia, Pa.
Scientific Materials Co., Pittsburgh, Pa.
Sharples Specialty Co., The, West Chester, Pa.
Tolhurst Machine Works, Troy, N. Y.

Centrifuges
Chicago Surgical & Electrical Co., Chicago, Ill.

Centrifugal Engineers
Sharples Specialty Co., The, West Chester, Pa.
Tolhurst Machine Works, Troy, N. Y.

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Merck & Co., N. Y. C.

Charcoal
Booth Apparatus Co., Syracuse, N. Y.

Chemical and Process Patents
Foster, A. B., Washington, D. C.

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Scientific Materials Co., Pittsburgh, Pa.

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Corning Glass Works, Corning, N. Y.
Eimer & Amend, N. Y. C

Chemicals
Badische Company, N. Y. C.
Baker & Adamson Chemical Co., Easton, Pa.
Baker Chemical Co., J. T., Phillipsburg, N. J.
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Brunt & Co., H. H., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Dearborn Chemical Co., Chicago, Ill.
Eberbach & Son Co., Ann Arbor, Mich.
Eimer & Amend, N. Y. C.
General Chemical Co., N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Mallinckrodt Chem. Co., St. Louis, Mo.
Merck & Co., N. Y. C.
Mine & Smelter Supply Co., N. Y. C.
National Aniline & Chemical Co., N. Y. C.
Newport Chemical Works, Inc., N. Y. C.
Palo Company, N. Y. C.
Pfizer & Co., Charles, N. Y. C.
Roessler & Hasslacher Chemical Co., N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Toch Bros.. N. Y. C.

Chemicals—C. P.
Eimer & Amend, N. Y C.
Merck & Co., N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

Chemicals—Laboratory
Eimer & Amend, N. Y. C.
Merck & Co., N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

Chemicals—Medicinal
Eimer & Amend, N. Y. C.
Merck & Co., N. Y. C.

Chemicals—Photographic
Eimer & Amend, N. Y. C.
Merck & Co., N. Y. C.

Chemicals—Technical
Eimer & Amend, N. Y. C.
Merck & Co., N. Y. C.

Chemical Glassware
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Corning Glass Works, Corning, N. Y.
Daigger & Co., A., Chicago, Ill.
Eberbach & Son Co., Ann Arbor, Mich.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Laboratory Supply Co., Columbus, O.
Mine & Smelter Supply Co., N. Y. C.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Whitall Tatum Co., Philadelphia, Pa.

Chemical Mfrs.
Merck & Co., N. Y. C.

Chemical Plants (Complete Installation)
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Knight, M. A., East Akron, O.
Lummus Co., The Walter E., Boston, Mass.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Swenson Evaporator Co., Chicago, Ill.

Chemical Plants (Erected and Supervised)
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
McNamara, M., Everett, Mass.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Swenson Evaporator Co., Chicago, Ill.

Chemical Reagents
Baker Chem. Co., J. T., Phillipsburg, N. J.
Bausch & Lomb Optical Co., Rochester, N. Y.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
General Chemical Co., Baker & Adamson Works, Easton, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Mallinckrodt Chem. Co., St. Louis, Mo.
Merck & Co., N. Y. C.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

Chemical Specialties
Merck & Co., N. Y. C.

Chemists' and Assayers' Supplies
Eimer & Amend, N. Y. C.
Merck & Co., N. Y. C.

Chlorine Generators—Acid Proof
Knight, M. A., East Akron, O.

Chlorine—Liquid
Electro Bleaching Gas Co., N. Y. C.

Chromel Metal
Hoskins Mfg. Co., Detroit, Mich.

Chromium (Metal & Salts)
Merck & Co., N. Y. C.

Circuit Breakers and Switches
General Electric Co., Schenectady, N. Y.

Clarifiers
Sharples Specialty Co., The, West Chester, Pa.

Classifiers
Dorr Co., The, Denver, Colo., & N. Y. C.

Classifiers or Washers
Dorr Co., The, Denver, Colo., & N. Y. C.

Coal-Tar Products
Badische Company, N. Y. C.
Barrett Co., The, N. Y. C.
Merck & Co., N. Y. C.
National Aniline & Chemical Co., N. Y. C.
Newport Chemical Works, Inc., N. Y. C.

Coal-Tar Products (Plants for)
Devine Co., J. P., Buffalo, N Y.

Coal Testing Apparatus
Eimer & Amend, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

Cobalt—Metal & Salts
Merck & Co., N. Y. C.

Cocks—Plug (Acid Proof)
Chadwick-Boston Lead Co., Boston, Mass.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Duriron Castings Co., N. Y. C.
Knight, M. A., East Akron, O.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.
U. S. Stoneware Co., The, Akron, O.

Coils or Worms (Acid Proof Stoneware)
Knight, M. A., East Akron, Ohio.

Colorimeters
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Calif.
Daigger & Co., A., Chicago, Ill.
Eberbach & Son Co., Ann Arbor, Mich.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

Colors—Aniline
Merck & Co., N. Y. C.

Colors—Aniline and Alizarine
Badische Co., N. Y. C.
Metz, H. A., N. Y. C.
National Aniline and Chemical Co., N. Y. C.

Combustion Tubes and Boats
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
German-American Stoneware Wks., N. Y. C.
Guernsey Earthenware Co., Cambridge, O.
Heil Chemical Co., Henry, St. Louis, Mo.
Laboratory Supply Co., Columbus, O.
Norton Co., Worcester, Mass.

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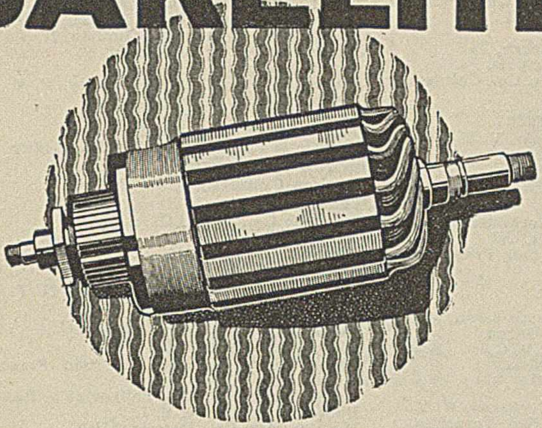

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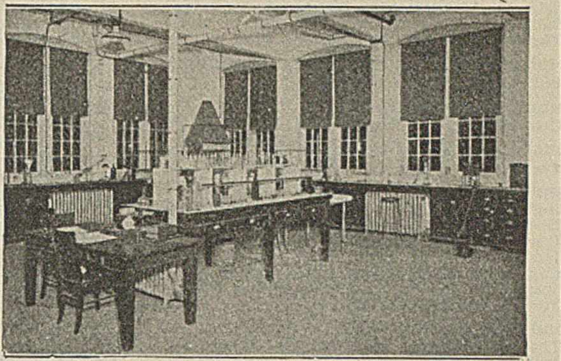

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CLASSIFIED LIST OF CHEMICAL EQUIPMENT—(*Continued*)

Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Sidio Company of America, Inc., The, N. Y. C.
Thermal Syndicate, Ltd., The, N. Y. C.

Combustion Tubes and Boats (Platinum)
Baker & Co., Inc., Newark, N. J.

Compressors, Rotary
Crowell Mfg. Co., Brooklyn, N. Y.

Concentrators—Sulphuric Acid
Thermal Syndicate, Ltd., The, N. Y. C.

Condensers (Barometric and Surface)
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.
Jacoby, Henry E., N. Y. C.
Lummus Co., The Walter E., Boston, Mass.
Schutte & Koerting Co., Philadelphia, Pa.
Stevens Brothers, N. Y. C.

Condensers—Nitric Acid
Thermal Syndicate, Ltd., The, N. Y. C.

Conductivity Measuring Apparatus
Leeds & Northrup Co., The, Philadelphia, Pa.

Consulting Chemists and Chemical Engineers
Abbott, W. G., Jr., Wilton, N. H.
Booth Apparatus Co., Syracuse, N. Y.
Brickenstein, John H., Washington, D. C.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Burrell, G. A., Pittsburgh, Pa.
Columbus Laboratories, Chicago, Ill.
Dannerth, Frederic, Newark, N. J.
Foster, A. B., Washington, D. C.
Hersey Co., Ltd., Milton, New York, Montreal, Winnipeg.
Institute of Industrial Research, Washington, D. C.
Levin, Isaac H., Newark, N. J.
Little, Arthur D., Inc., Boston. Mass.
McNamara, M., Everett, Mass.
Mantius, Otto, 233 Broadway, N. Y. C.
Marsh, C. W., N. Y. C.
Parker, C. L., Washington, D. C.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Sadtler & Son, Samuel P., Philadelphia, Pa.
Stillwell Laboratories, N. Y. C.
Sutton, Frank, N. Y. C.
Swenson Evaporator Co., Chicago, Ill.
Townsend, Clinton P., Washington, D. C.
Unger, John S., Chicago, Ill.
Will Corporation, The, Rochester, N. Y.

Contracting Engineers
Swenson Evaporator Co., Chicago, Ill.

Controlling Instruments
Taylor Instrument Cos., Rochester, N. Y.

Converters—Rotary
General Electric Co., Schenectady, N. Y.

Copper—Salts of
Merck & Co., N. Y. C.

Cores
Norton Co., Worcester, Mass.

Corn Oil (Extracted)
Woolner & Co., Peoria, Ill.

Counters—Revolution
Brown Instrument Co., Philadelphia, Pa.

Coverings for Pipes and Boilers
Brunt & Co., H. H., Chicago, Ill.

Critical Point Determination Apparatus
Brown Instrument Co., Philadelphia, Pa.
Eimer & Amend, N. Y. C.
Hoskins Mfg. Co., Detroit, Mich.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Thwing Instrument Co., Philadelphia, Pa.

Crucibles
Bausch & Lomb Optical Co., Rochester, N. Y
Braun Corporation, Los Angeles, Cal.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Dixon Crucible Co., Joseph, Jersey City, N. J.
Duriron Castings Co., N. Y. C. (Acid-proof.)
Eimer & Amend, N. Y. C.
Guernsey Earthenware Co., Cambridge, O.
Heil Chemical Co., Henry, St. Louis, Mo.
Herold China & Pottery Co., Golden, Col.
Laboratory Supply Co., Columbus, O.
Mine & Smelter Supply Co., N. Y. C.
Norton Co., Worcester, Mass. (Alundum.)
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Sidio Company of America, Inc., The, N. Y. C.
Thermal Syndicate, Ltd., The, N. Y. C. (Vitreosil.)

Crucibles, Platinum
American Platinum Works, Newark, N. J.
Baker & Co., Inc., Newark, N. J.
Bishop & Co., J. Malvern, Pa.
Eimer & Amend, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

Crushers and Grinders (Industrial and Laboratory)
Abbé Engineering Co., N. Y. C.
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Calif.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Mine & Smelter Supply Co., N. Y. C.
Palo Company, N. Y. C.
Raymond Bros. Impact Pulv. Co., Chicago, Ill.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Williams Patent Crusher & Pulv. Co., Chicago, Ill.

Crystallizers—Ammonia Nitrate
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Crystallizing Pans (Acid Proof)
Knight, M. A., East Akron, Ohio.

Cupels
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Cal.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chemical Company, Henry, St. Louis, Mo.
Hoskins Mfg. Co., Detroit, Michigan.
Mine & Smelter Supply Co., N. Y. C.
Norton Company, Worcester, Mass.

Cylinders (Glass)
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Corning Glass Works, Corning, N. Y.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Whitall Tatum Co., Philadelphia, Pa.

Decanting Pots—Acid Proof
Knight, M. A., East Akron, O.

Denitrating Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Diaphragms—Acid Proof
General Filtration Co., Inc., Rochester, N. Y.
Herold China & Pottery Co., Golden, Colo.

Diffusion Apparatus
General Filtration Co., Inc., Rochester, N. Y.
Lummus Co., The Walter E., Boston, Mass.
Swenson Evaporator Co., Chicago, Ill.

Dipping Baskets & Jars—(Acid Proof)
Knight, M. A., East Akron, Ohio.

Dishes (Platinum)
Bishop & Co., J., Malvern, Pa.
Eimer & Amend, N. Y. C.

Dissolving Tanks—Automatic
Badger & Sons Co., E. B., Boston, Mass.
Lummus Co., The Walter E., Boston, Mass.
Werner & Pfleiderer Co., Saginaw, Mich.

Distilling Machinery and Apparatus
Badger & Sons Co., E. B., Boston, Mass.
Bausch & Lomb Optical Co., Rochester, N. Y.
Booth Apparatus Co., Syracuse, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Calif.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Daigger & Co., A., Chicago, Ill.
Devine Company, J. P., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.
Eimer & Amend, N. Y. C.
Electric Heating Apparatus Co., N. Y. C.
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
German-American Stoneware Works, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
Jacoby, Henry E., N. Y. C.
Laboratory Supply Co., Columbus, O.
Lummus Co., The Walter E., Boston, Mass.
Palo Company, N. Y. C.
Pfaudler Co., Rochester, N. Y., Chicago, Ill., & N. Y. C.
Roos' Son, August, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Sidio Company of America, Inc., The, N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Stokes Machine Company, F. J., Phila., Pa.
Swenson Evaporator Co., Chicago, Ill.
Thomas Co., Arthur H., Philadelphia, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.
Unger, John S., Chicago, Ill.
Werner & Pfleiderer Co., Saginaw, Mich.
Zaremba Company, Buffalo, N. Y.

Draft Gauges
Braun-Knecht-Heimann Co., San Francisco, Cal.
Brown Instrument Co., Philadelphia, Pa.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

Drum Dryers—Vacuum and Atmospheric
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Dry Blast Plants
Carrier Engineering Corp., N. Y. C.

Dryers—Atmospheric
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Dryers—Vacuum
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Company, J. P., Buffalo, N. Y.
Jacoby, Henry E., N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Stokes Machine Co., F. J., Philadelphia, Pa.
Werner & Pfleiderer Co., Saginaw, Mich.

Drying Apparatus and Machinery
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Eimer & Amend, N. Y. C.
General Electric Co., Schenectady, N. Y.
Jacoby, Henry E., N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Palo Company, N. Y. C.
Werner & Pfleiderer Co., Saginaw, Mich.

Duriron—Acid-Proof
Duriron Castings Co., N. Y. C.

Dyestuffs
Badische Co., N. Y. C.
Metz, H. A., N. Y. C.
Merck & Co., N. Y. C.

Dynamos and Motors
General Electric Co., Schenectady, N. Y.

Efficiency Gas Burners
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Efficiency Instruments
Braun-Knecht-Heimann Co., San Francisco, Cal.
Brown Instrument Co., Philadelphia, Pa.
Eimer & Amend, N. Y. C.
Hoskins Mfg. Co., Detroit, Mich.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Thwing Instrument Co., Philadelphia, Pa.

Electric Heating Devices
Chicago Surgical & Electrical Co., Chicago, Ill.

Electrical Instruments
Brown Instrument Co., Philadelphia, Pa.
General Electric Co., Schenectady, N. Y.
Hoskins Mfg. Co., Detroit, Mich.
Palo Company, N. Y. C.
Thwing Instrument Co., Philadelphia, Pa.

Electrical Measuring Instruments
General Electric Co., Schenectady, N. Y.
Brown Instrument Co., Philadelphia, Pa.
Leeds & Northrup Co., Phila., Pa.
Palo Company, N. Y. C.

Electrical Supplies
General Electric Co., Schenectady, N. Y.

Electric Locomotives—Industrial
General Electric Co., Schenectady, N. Y.

Electrodes—Platinum
American Platinum Works, Newark, N. J.
Baker & Co., Inc., Newark, N. J.
Bausch & Lomb Optical Co., Rochester, N. Y.
Bishop & Co., J., Platinum Works, Malvern, Pa.
Braun Corporation, Los Angeles, Cal.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Engelhard, Chas., N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.

Electrolytic Apparatus—Acid Proof
Knight, M. A., East Akron, O.

Enameled Apparatus (Acid Resistant)
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
Jacoby, Henry E., N. Y. C.
Pfaudler Co., Rochester, N. Y., Chicago, & N. Y. C.

Enamel Paint (Impervious to Acid Fumes)
General Bakelite Co., N. Y. C.
Toch Brothers, N. Y. C.

Essential Oils
Merck & Co., N. Y. C.

Evaporating Machinery
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Company, J. P., Buffalo, N. Y.
Electric Heating Apparatus Co., N. Y. C.
Jacoby, Henry E., N. Y. C.
Lummus Co., The Walter E., Boston, Mass.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Sperry & Co., D. R., Batavia, Ill.
Stokes Mach. Co., F. J., Philadelphia, Pa.
Swenson Evaporator Co., Chicago, Ill.
Werner & Pfleiderer Co., Saginaw, Mich.
Zaremba Company, Buffalo, N. Y.

Evaporating Pans and Dishes
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Daigger & Co., A., Chicago, Ill.
Duriron Castings Co., N. Y. C. (Acid Proof.)
Eimer & Amend, N. Y. C.
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
General Ceramics Co., N. Y. C.
Guernsey Earthenware Co., Cambridge, O.
Heil Chemical Co., Henry, St. Louis, Mo.
Herold China & Pottery Co., Golden, Colo.
Knight, Maurice A., East Akron, Ohio.
Laboratory Supply Co., Columbus. O.
Palo Company, N. Y. C.
Pfaudler Co., Rochester, N. Y., Chicago, Ill., & N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.

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The very names of many Coal-Tar Chemicals which are known to every one today were little known and seldom mentioned in this country a few years ago.

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It is with a justified feeling of pride, therefore, that we now find so many purchasing departments specifying *Barrett Standard* when they desire the best in refined Coal-Tar products, because it is an easy way to save words, also money and trouble.

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The Barrett Company

Chemical Department

17 Battery Place TRADE B MARK New York, N. Y.

CLASSIFIED LIST OF CHEMICAL EQUIPMENT—(*Continued*)

Scientific Materials Co., Pittsburgh, Pa.
Sidio Company of America, Inc., The, N. Y. C.
Thermal Syndicate, Ltd., The, N. Y. C.
U. S. Stoneware Co., The, Akron, O.

Evaporators—Crystallizing
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Evaporators—Single and Multiple Effects
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Exhaust and Ventilating Fans
General Electric Co., Schenectady, N. Y.

Exhaust and Ventilating Fans—Acid-Proof
Duriron Castings Co., N. Y. C.

Extracting Apparatus
Badger & Sons Co., E. B., Boston, Mass.
Devine Co., J. P., Buffalo, N. Y.
Eimer & Amend, N. Y. C.
Lummus Co., The Walter E., Boston, Mass.
Scientific Materials Co., Pittsburgh, Pa.
Werner & Pfleiderer Co., Saginaw, Mich.

Extraction Cylinders
Badger & Sons Co., E. B., Boston, Mass.
Lummus Co., The Walter E., Boston, Mass.

Extraction Thimbles
Angel Co., Inc., H. Reeve, N. Y. C.
Eimer & Amend, N. Y. C.
Norton Co., Worcester, Mass.

Extractors—Centrifugal
International Equipment Co., Boston, Mass.

Fabroil Gears & Pinions
General Electric Co., Schenectady, N. Y.

Faucets (Stoneware—Acid Proof)
General Ceramics Co., N. Y. C.
Knight, Maurice A., East Akron, Ohio.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.
U. S. Stoneware Co., The, Akron, O.

Fertilizer Industries Equipment
Schutte & Koerting Co., Philadelphia, Pa.

Filter Cloth (Metallic)
Sweetland Filter Press Co., Brooklyn, N. Y.

Filtering Media
General Filtration Co., Inc., Rochester, N. Y.
Herold China & Pottery Co., Golden, Colo.

Filter Paper
Angel Co., Inc., H. Reeve, N. Y. C.
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Laboratory Supply Co., Columbus, O.
Mallinckrodt Chemical Wks., St. Louis, Mo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Whitall Tatum Co., Philadelphia, Pa.

Filter Paper Clippings
Angel Co., Inc., H. Reeve, N. Y. C.

Filter Paper (Whatman)
Angel Co., H. Reeve, N. Y. C.
Bausch & Lomb Optical Co., Rochester, N. Y.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

Filter Presses (Laboratory & Industrial)
Abbé Engineering Co., N. Y. C.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Eimer & Amend, N. Y. C.
International Filtration Corp., N. Y. C.
Jacoby, Henry E., N. Y. C.
Kelly Filter Press Co., Salt Lake City, Utah.
Lungwitz, E. E., N. Y. C.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill
Shriver & Co., T., Harrison, N. J.
Sperry & Co., D. R., Batavia, Ill.
Sweetland Filter Press Co., Brooklyn, N. Y.
Werner & Pfleiderer Co., Saginaw, Mich.

Filter Pulp
Angel Co., Inc., H. Reeve, N. Y. C.

Filters
General Filtration Co., Inc., Rochester, N. Y.
Norton Co., Worcester, Mass.

Filters—(Acid Proof)
General Filtration Co., Inc., Rochester, N. Y
Knight, Maurice A., East Akron, Ohio.

Filters, Folded
Angel Co., Inc., H. Reeve, N. Y. C.
Eimer & Amend, N. Y. C.

Filters—Vacuum
Devine Co., J. P., Buffalo, N. Y.
General Filtration Co., Inc., Rochester, N. Y.

Filters—Water
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Booth Apparatus Co., Syracuse, N. Y.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
General Ceramics Co., N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Schutte & Koerting Co., Philadelphia, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

Filtros
General Filtration Co., Inc., Rochester, N. Y.

Filtros—Vacuum
Devine Company, J. P., Buffalo, N. Y.

Fire Brick and Clay
Brunt & Co., H. H., Chicago, Ill.
Dixon Crucible Co., Joseph, Jersey City, N. J.
Mine & Smelter Supply Co., N. Y. C.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.

Flasks
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Corning Glass Works, Corning, N. Y.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Whitall Tatum Co., Philadelphia, Pa.

Fuel Gas Plants
Eimer & Amend, N. Y. C.
Tirrill Gas Machine Lighting Co., N. Y. C.

Funnels
Knight, M. A., East Akron, Ohio.
Whitall Tatum Co., Philadelphia, Pa.

Furnace Linings
Brunt & Co., H. H., Chicago, Ill.
Dixon Crucible Co., Joseph, Jersey City, N. J.

Furnaces—Annealing—(Hardening and Enameling)
Abbé Engineering Co., N. Y. C.
Brown Instrument Co., Philadelphia, Pa.
Electric Heating Apparatus Co., N. Y. C.
General Electric Co., Schenectady, N. Y.
Hoskins Mfg. Co., Detroit, Mich.
Palo Company, N. Y. C.

Furnaces (Case Hardening, Rivet and Bolt)
Abbé Engineering Co., N. Y. C.

Furnaces—Electric Laboratory
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Brown Instrument Co., Philadelphia, Pa.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Electric Heating Apparatus Co., N. Y. C.
Engelhard, Chas., N. Y. C.
General Electric Co., Schenectady, N. Y.
Griebel Instrument Co., Carbondale, Pa.
Hanovia Chemical & Mfg. Co., Newark, N. J.
Heil Chemical Co., Detroit, Mich.
Hoskins Mfg. Co., Detroit, Mich.
Mine & Smelter Supply Co., N. Y. C.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia. Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Furnaces—(Forge)
Abbé Engineering Co., N. Y. C.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal
Electric Heating Apparatus Co., N. Y. C.
Hoskins Mfg. Co., Detroit, Mich.

Furnaces (Melting, Oil or Gas)
Abbé Engineering Co., N. Y. C.
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Electric Heating Apparatus Co., N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Mine & Smelter Supply Co., N. Y. C.
Palo Company, N. Y. C.
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Furnaces—Muffle
Abbé Engineering Co., N. Y. C.
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Electric Heating Apparatus Co., N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Hoskins Mfg. Co., Detroit, Mich.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.

Furnaces—Pyrites
Pratt Eng. & Mach. Co., Atlanta, Ga., & N.Y.C.

Furnaces—Sulphur
Pratt Eng. & Mach. Co., Atlanta, Ga., & N.Y.C.
Schutte & Koerting Co., Philadelphia, Pa.

Galvanizing Tanks and Jars—Acid Proof
Knight, M. A., East Akron, O.

Gas Analyzers
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.

Gas Apparatus
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Laboratory Supply Co., Columbus, O.
Palo Company, N. Y. C.
Schaar & Co., Chicago, Ill.
Schutte & Koerting Co., Philadelphia, Pa.
Scientific Materials Co., Pittsburgh, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Gas Burners—Incandescent
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Gas Machines
Braun-Knecht-Heimann Co., San Francisco, Cal.
Eimer & Amend, N. Y. C.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Gas Pipe & Fittings (Chamotte)
Knight, M. A., East Akron, O.

Gauges—Recording, Section & Vacuum
Bausch & Lomb Optical Co., Rochester, N. Y.
Brown Instrument Co., Philadelphia, Pa.

Gauze—Base Metal
Hoskins Mfg. Co., Detroit, Mich.

Generators (Electro-Oxy-Hydrogen)
Shriver & Co., T. Harrison, N. J.

Glass
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Corning Glass Works, Corning, N. Y.
Daigger & Co., A., Chicago, Ill.
Eberbach & Son Co., Ann Arbor, Mich.
Eimer & Amend, N. Y. C.
Laboratory Supply Co., Columbus, O.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Whitall Tatum Co., Philadelphia, Pa.

Glass Blowing
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Greiner Co., Emil, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry. St. Louis, Mo.
Laboratory Supply Co., Columbus, O.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.
Whitall Tatum Co., Philadelphia, Pa.

Glass Enameled Apparatus
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
Pfaudler Co., Rochester, N. Y., Chicago, Ill., & N. Y. C.

Graduates—Glass
Eimer & Amend, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Whitall Tatum Co., Philadelphia, Pa.

Graphite Products
Dixon Crucible Co., Joseph, Jersey City, N. J.

Grinders
Abbé Engineering Co., N. Y. C.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Mine & Smelter Supply Co., N. Y. C.
Raymond Bros. Impact Pulv. Co., Chicago, Ill.
Williams Pat. Crusher & Pulv. Co., Chicago, Ill.

Hardness Testing Apparatus
Braun Corporation, Los Angeles, Cal.
Braun-Knecht-Heimann Co., San Francisco Cal.
Eimer & Amend, N. Y. C.
Palo Company, N. Y. C.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.

Heating Apparatus (Laboratory)
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Cal.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Brown Instrument Co., Philadelphia, Pa.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Electric Heating Apparatus Co., N. Y. C.
General Electric Co., Schenectady, N. Y.
Hoskins Mfg. Co., Detroit, Mich.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Heating Specialties
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Heating Stoves
Chicago Surgical & Electrical Co., Chicago, Ill.

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Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
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Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Hydrochloric Acid Apparatus
Knight, M. A., East Akron, O.

Hydro Extractors
Tolhurst Machine Works, Troy, N. Y.

Hydrometers
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Cal.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Greiner Co., Emil, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Laboratory Supply Co., Columbus, O.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Taylor Instrument Cos., Rochester, N. Y.
Thomas Co., Arthur H., Philadelphia, Pa.

Hygrometers
Taylor Instrument Cos., Rochester, N. Y.

Ice-Making Machinery
General Electric Co., Schenectady, N. Y.
York Manufacturing Co., York, Pa.

Ichthyol
Merck & Co., N. Y. C.

Impregnating and Drying Apparatus—Vacuum
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Incinerators
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Incubating Room
Chicago Surgical & Electrical Co., Chicago, Ill.

Incubators—Surgical
Chicago Surgical & Electrical Co., Chicago, Ill.

Indicating Instruments
Taylor Instrument Cos., Rochester, N. Y.

Indicators—(Speed & Test)
Brown Instrument Co., Philadelphia, Pa.
Scientific Materials Co., Pittsburgh, Pa.

Industrial Burners & Specialties
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Industrial Gas Appliances
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Industrial Motor Control Devices
General Electric Co., Schenectady, N. Y.

Injectors for Acids and Gases
Knight, M. A., East Akron, O.

Instrument—Precision Manufacturers
Scientific Materials Co., Pittsburgh, Pa.

Iodine—Salts of
Merck & Co., N. Y. C.

Iron—Metal and Salts
Merck & Co., N. Y. C.

Iron and Steel Analysis Apparatus—Manufacturers
Eimer & Amend, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

Jars, Museum & Specimen
Eimer & Amend, N Y. C
Whitall Tatum Co., Philadelphia, Pa.

Jars (for Primary & Storage Batteries)
Corning Glass Works, Corning, N. Y.
Daigger & Co., A., Chicago, Ill.
General Ceramics Co., N. Y. C.
Guernsey Earthenware Co., Cambridge, O.
Whitall Tatum Co., Philadelphia, Pa.

Jars and Jugs (Acid Storage)
Bausch & Lomb Optical Co., Rochester, N. Y.
General Ceramics Co., N. Y. C.
Guernsey Earthenware Co., Cambridge, O.
Herold China & Pottery Co., Golden, Col.
Knight, M. A., East Akron, O.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.
U. S. Stoneware Co., The, Akron, O.

Kettles—Caustic Soda
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Kettles (Chemical Castings)
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Devine Co., J. P., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.
Jacoby, Henry E., N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Werner & Pfleiderer Co., Saginaw, Mich.

Kettles (Lined)
Badger & Sons Co., E. B., Boston, Mass.
Elyria Enameled Prod. Co., Elyria, O., N.Y.C.
Pfaudler Co., Rochester, N. Y., Chicago, Ill., & N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Werner & Pfleiderer Co., Saginaw, Mich.

Kettles (Steam Jacketed)
Badger & Sons Co., E. B., Boston, Mass.
Bethlehem Fdy. & Mch. Co., South Bethlehem, Pa.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
Jacoby, Henry E., N. Y C.
Pfaudler Co., Rochester, N. Y., Chicago, Ill., & N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Sperry & Co., D. R., Batavia, Ill.
Stevens Brothers, N. Y. C.
Werner & Pfleiderer Co., Saginaw, Mich.

Kettles (Stoneware)
General Ceramics Co., N. Y. C.
Knight, M. A., East Akron, O.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.
U. S. Stoneware Co., The, Akron, O.

Laboratory Apparatus—Designing & Manufacturing
Eimer & Amend, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.

Laboratory Burners
Eimer & Amend, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Laboratory Chemicals
Eimer & Amend, N. Y. C.
Merck & Co., N. Y. C.

Laboratory Gas Machine
Eimer & Amend, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Laboratory Glassware
Corning Glass Works, Corning, N. Y.
Eimer & Amend, N. Y. C.

Laboratory Supplies
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Corning Glass Works, Corning, N. Y.
Daigger & Co., A., Chicago, Ill.
Duriron Castings Co., N. Y. C.
Eimer & Amend, N. Y. C.
Greiner Co., Emil, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
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Laboratory Supply Co., The, Columbus, O.
Mine & Smelter Supply Co., N. Y. C.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.
Whitall Tatum Co., Philadelphia, Pa.

Laboratory Supplies, Platinum
Baker & Co., Inc., Newark, N. J.
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Lace Leather
Schieren Co., Chas. A., N. Y. C.

Lacquer
General Bakelite Co., N. Y. C.

Lactic Acid
Mallinckrodt Chemical Wks., St. Louis, Mo.
Woolner & Co., Peoria, Ill.

Lamps—Arc and Incandescent
General Electric Co., Schenectady, N. Y.

Leaching Cells
Swenson Evaporator Co., Chicago, Ill.
Zaremba Co., Buffalo, N. Y.

Lead Burning
McNamara, M., Everett, Mass.

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Badger & Sons Co., E. B., Boston, Mass.
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Schieren Co., Chas. A., N. Y. C.

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Lenses Pressed (Glass)
Corning Glass Works, Corning, N. Y.

Lightning Arresters
General Electric Co., Schenectady, N. Y.

Linings, Cupola
Herold China & Pottery Co., Golden, Col.

Lithopone
New Jersey Zinc Co., The, N. Y. C.

Lubricants
Dearborn Chemical Co., Chicago, Ill.
Dixon Crucible Co., Joseph, Jersey City, N. J.

Machinery
Mine & Smelter Supply Co., N. Y. C.

Machinery—Chemical
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Machinery—Electrical
General Electric Co., Schenectady, N. Y.

Machinery—Mining and Metallurgical
Abbé Engineering Co., N. Y. C.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Eimer & Amend, N. Y. C.
General Filtration Co., Inc., Rochester, N. Y.
Mine & Smelter Supply Co., Denver, Salt Lake City, El Paso, & N. Y. C.
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Werner & Pfleiderer Co., Saginaw, Mich.

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Abbé Engineering Co., N. Y. C.
Elyria Enameled Products Co., Elyria, O.
Jacoby, Henry E., N. Y. C.
Pfaudler Co., Rochester, N. Y., Chicago, Ill., & N. Y. C.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Werner & Pfleiderer Co., Saginaw, Mich.

Machinery—Pulverizing
Abbé Engineering Co., N. Y. C.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Eimer & Amend, N. Y. C.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Raymond Bros. Impact Pulv. Co., Chicago, Ill.
Werner & Pfleiderer Co., Saginaw, Mich.
Williams Patent Crusher & Pulv. Co., Chicago, Ill.

Machinery (Special)
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Devine Co., J. P., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.
Jacoby, Henry E., N. Y. C.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Stevens Brothers, N. Y. C.
Werner & Pfleiderer Co., Saginaw, Mich.

Magnesium—Metal and Salts
Merck & Co., N. Y. C.

Mercury—Salts of
Merck & Co., N. Y. C.

Metallographic Apparatus
Bausch & Lomb Optical Co., Rochester, N. Y.
Eimer & Amend, N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.

Metallurgical Laboratory Equipment
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Cal.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Hoskins Mfg. Co., Detroit, Mich.
Palo Company, N. Y. C.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

Meters—Flow Air, Gas, Water
General Electric Co., Schenectady, N. Y.

Microscopes
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry St. Louis, Mo.
Laboratory Supply Co., Columbus, O.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

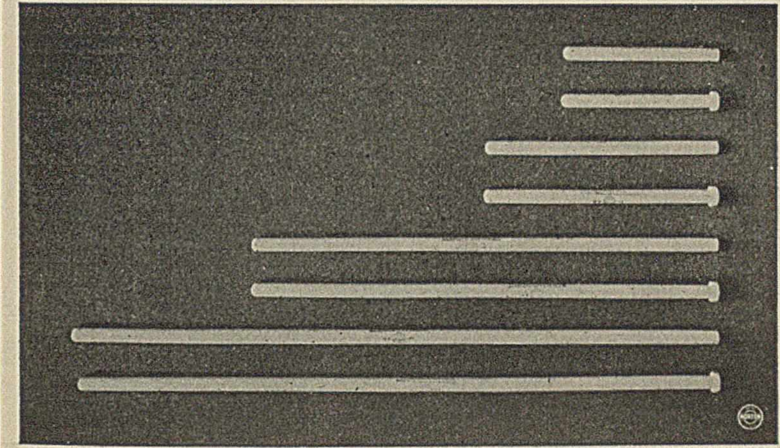
Microtomes
Bausch & Lomb Optical Co., Rochester, N. Y.
Eimer & Amend, N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Thomas Co., Arthur H., Philadelphia, Pa.

Micro Photographic Apparatus . Manufacturers
Eimer & Amend, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

Mills—Ball, Pebble and Tube
Abbé Engineering Co., N. Y. C.
Eimer & Amend, N. Y. C.
Mine & Smelter Supply Co., N. Y. C.
Palo Company, N. Y. C.

Mixers
Elyria Enameled Products Co., Elyria, O.
Pfaudler Co., Rochester, N. Y., Chicago, Ill., & N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Werner & Pfleiderer Co., Saginaw, Mich.

Mixing Tanks
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
Lummus Co., The Walter E., Boston, Mass.
Pfaudler Co., Rochester, N. Y., Chicago, Ill., & N. Y. C.



CLASSIFIED LIST OF CHEMICAL EQUIPMENT—(*Continued*)

Sowers Mfg. Co., Buffalo, N. Y.
Stevens Brothers, N. Y. C.
Werner & Pfleiderer Co., Saginaw, Mich.

Molybdates
Merck & Co., N. Y. C.

Molybdic Acid
Eimer & Amend, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

Montejus—Automatic
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
General Ceramics Co., N. Y. C.
Knight, Maurice A., East Akron, O.
Schutte & Koerting Co., Philadelphia, Pa.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.

Mortars & Pestles
Eimer & Amend, N. Y. C.
Whitall Tatum Co., Philadelphia, Pa.

Muffles
Eimer & Amend, N. Y. C.
Norton Co., Worcester, Mass.

Nickel—Salts of
Merck & Co., N. Y. C.

Nitrating Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Nitrating Pots
Bethlehem Fdy. & Mach. Co., South Bethlehem, Pa.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.
Elyria Enameled Products Co., Elyria, O.
General Ceramics Co., N. Y. C.
Knight, Maurice A., East Akron, O.
Pfaudler Co., Rochester, N. Y., Chicago, & N. Y. C.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Stevens Bros., N. Y. C.
U. S. Stoneware Co., The, Akron, O.
Werner & Pfleiderer Co., Saginaw, Mich.

Nitrators—Sulphonators, Etc.
Bethlehem Fdy. & Mach. Co., South Bethlehem, Pa.
Stevens Bros., N. Y. C.

Nitre Pot Acid Pipes
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Duriron Castings Co., N. Y. C. (Special Alloy.)
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
General Ceramics Co., N. Y. C.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Sidio Company of America, Inc., The, N. Y. C.
Thermal Syndicate, Ltd., N.Y.C. (Silica Ware.)

Nitric Acid Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.

Nitric Acid Plants—Chemical Stoneware
Knight, Maurice A., East Akron, O.

Nitric Acid Retorts
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Nozzles (Acid Proof)
Duriron Castings Co., N. Y. C.
Schutte & Koerting Co., Philadelphia, Pa.

Oil Testing Instruments
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Taylor Instrument Cos., Rochester, N. Y.
Thomas Co., Arthur H., Philadelphia, Pa.

Optical Instruments
Bausch & Lomb Optical Co., Rochester, N. Y.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Palo Company, N. Y. C.
Thwing Instrument Co., Philadelphia, Pa.

Optical Pyrometer
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

Oxygen (Pure)
Levin, Isaac H., Newark, N. J.

Packings (Condensing Tower)
General Ceramics Co., N. Y. C.
Knight, Maurice A., East Akron, O.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.
U. S. Stoneware Co., The, Akron, O.

Paints
Toch Brothers, N. Y. C.

Panels, Rheostats, Motor Generator Sets and Tungar Rectifiers
General Electric Co., Schenectady, N. Y.

Paper, All Kinds
Angel Co., Inc., H. Reeve, N. Y. C.

Paranitraniline
Merck & Co., N. Y. C.

Partition Rings (Chemical Acid Proof)
Knight, Maurice A., East Akron, O.

Patent Attorneys
Brickenstein, John H., Washington, D. C.
Foster, A. B., Washington, D. C.
Parker, C. L., Washington, D. C.
Townsend, Clinton P., Washington, D. C.

Percolators
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
General Ceramics Co., N. Y. C.
Pfaudler Co., Rochester, N. Y., Chicago, & N. Y. C.
Whitall Tatum Co., Philadelphia, Pa.

Perhydrol
Merck & Co., N. Y. C.

Pharmaceutical Dryers
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Pharmaceutical Preparations
Merck & Co., N. Y. C.

Phenol Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Photo-Micrographic Apparatus
Bausch & Lomb Optical Co., Rochester, N. Y.
Eimer & Amend, N. Y. C.
Palo Company, N. Y. C.
Thomas Co., Arthur H., Philadelphia, Pa.

Picric Acid Apparatus
Knight, Maurice A., East Akron, O.

Pipe and Accessories (Glass)
Corning Glass Works, Corning, N. Y.

Pipe and Accessories (Acid Proof)
Bethlehem Fdy. & Mach. Co., South Bethlehem, Pa.
Chadwick-Boston Lead Co., Boston, Mass.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Duriron Castings Co., N. Y. C.
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
General Ceramics Co., N. Y. C.
Herold China & Pottery Co., Golden, Col.
Knight, Maurice A., East Akron, O.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N. Y. C.
Schutte & Koerting Co., Philadelphia, Pa.
Sidio Company of America, Inc., The, N. Y. C.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.
Thermal Syndicate, Ltd., The, N. Y. C. (Fused Silica.)
U. S. Stoneware Co., The, Akron, O.

Pipe Covering
Brunt & Co., H. H., Chicago, Ill.

Pipe and Fittings—Lead or Tin Lined
Chadwick-Boston Lead Co., Boston, Mass.
Schutte & Koerting Co., Philadelphia, Pa.

Pipes—Steam Jacketed
Devine Co., J. P., Buffalo, N. Y.

Pitch for Protective Coatings
The Barrett Co., N. Y. C.

Platinum (Sheet, Wire and Foil)
American Platinum Works, Newark, N. J.
Baker & Co., Inc., Newark, N. J.
Bausch & Lomb Optical Co., Rochester, N. Y.
Bishop & Co., J., Platinum Works, Malvern, Pa.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.

Platinum Ware (Laboratory)
American Platinum Works, Newark, N. J.
Baker & Co., Inc., Newark, N. J.
Bausch & Lomb Optical Co., Rochester, N. Y.
Bishop & Co., J., Platinum Works, Malvern, Pa.
Braun Corporation, Los Angeles, Cal.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Engelhard, Chas., N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
Mine & Smelter Supply Co., N. Y. C.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

Porcelain Ware—Laboratory
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Guernsey Earthenware Co., Cambridge, O.
Heil Chem. Co., Henry, St. Louis, Mo.
Herold China & Pottery Co., Golden, Col.
Laboratory Supply Co., Columbus, O.
Mine & Smelter Supply Co., N. Y. C.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

Portable Ozonators
General Electric Co., Schenectady, N. Y.

Potassium—Salts of
Merck & Co., N. Y. C.

Pots—Acid Proof Stoneware
Knight, Maurice A., East Akron, O.

Precision Instrument Makers
Scientific Materials Co., Pittsburgh, Pa.

Protecting Tubes, Thermocouples
Hoskins Mfg. Co., Detroit, Mich.

Publishers
Chemical Publishing Co., Easton, Pa.
Longmans, Green & Co., N. Y. C.
Van Nostrand Co., D., N. Y. C.
Wiley & Sons, Inc., John, N.Y. C.

Pulverizers—Laboratory
Abbé Engineering Co., N. Y. C.
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Thomas Co., Arthur H., Philadelphia, Pa.
Williams Patent Crusher & Pulv. Co., Chicago.

Pumps
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Pumps—Acid
Bausch & Lomb Optical Co., Rochester, N. Y.
Chadwick-Boston Lead Co., Boston, Mass.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Devine Co., J. P., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.
Eimer & Amend, N. Y. C.
General Ceramics Co., N. Y. C.
Palo Company, N. Y. C.
Schutte & Koerting Co., Philadelphia, Pa.
U. S. Stoneware Co., The, Akron, O.

Pumps (Laboratory Vacuum)
Abbé Engineering Co., N. Y. C.
Bausch & Lomb Optical Co., Rochester, N. Y
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Crowell Mfg. Co., Brooklyn, N. Y.
Daigger & Co., A., Chicago, Ill.
Devine Co., J. P., Buffalo, N. Y.
Eimer & Amend, N. Y. C.
Hubbard's Sons, Norman, Brooklyn, N. Y.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schutte & Koerting Co., Philadelphia, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

Pumps (Vacuum)
Abbé Engineering Co., N. Y. C.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Crowell Mfg. Co., Brooklyn, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Jacoby, Henry E., N. Y. C.
Schutte & Koerting Co., Philadelphia, Pa.

Pump Parts Metal (Acid Proof)
Duriron Castings Co., N. Y. C.
Schutte & Koerting Co., Philadelphia, Pa.

Pyrometer Tubes
Norton Co., Worcester, Mass.

Pyrometers
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Brown Instrument Co., Philadelphia, Pa.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Engelhard, Chas., N. Y. C.
Greiner Co., Emil, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Hanovia Chemical & Mfg. Co., Newark, N. J.
Heil Chem. Co., Henry E., St. Louis, Mo.
Hoskins Mfg. Co., Detroit, Mich.
Leeds & Northrup Co., The, Philadelphia, Pa.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Taylor Instrument Cos., Rochester, N. Y.
Thomas Co., Arthur H., Philadelphia, Pa.
Thwing Instrument Co., Philadelphia, Pa.

Pyrometers—Electrical
Brown Instrument Co., Philadelphia, Pa.
Eimer & Amend, N. Y. C.

Pyrometers (Optical)
Braun-Knecht-Heimann Co., San Francisco Cal.
Brown Instrument Co., Philadelphia, Pa.

Pyrometers (Radiation)
Leeds & Northrup Co., The, Philadelphia, Pa
Taylor Instrument Cos., Rochester, N. Y.
Thwing Instrument Co., Philadelphia, Pa.

Quartz
Booth Apparatus Co., Syracuse, N. Y.

Quartz Glass
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles. Calif.

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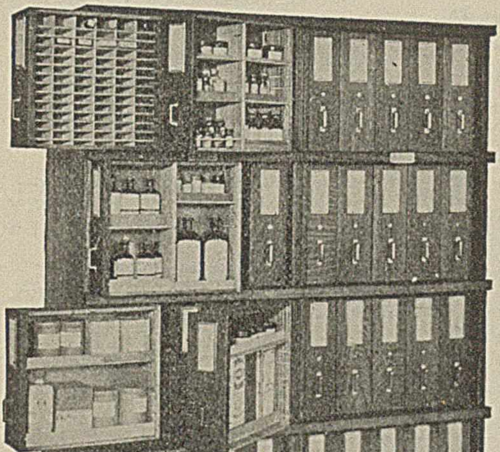

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Barnes Hospital, St. Louis.
Philadelphia College of Pharmacy.
University of Washington, Department of Pharmacy.
Children's Hospital, Philadelphia.

CLASSIFIED LIST OF CHEMICAL EQUIPMENT—(*Continued*)

Braun-Knecht-Heimann Co., San Francisco, Cal.
Brown Instrument Co., Philadelphia, Pa.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Engelhard, Chas., N. Y. C.
Greiner Co., Emil, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Hanovia Chemical & Mfg. Co., Newark, N. J.
Heil Chem. Co., Henry, St. Louis, Mo.
Laboratory Supply Co., Columbus, O.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Sidio Co. of America, The, N. Y. C.
Thermal Syndicate, Ltd., The, N. Y. C.
Thomas Co., Arthur H., Philadelphia, Pa.

Radium
Eimer & Amend, N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.

Reagent Bottles
Eimer & Amend, N. Y. C.
Whitall Tatum Co., Philadelphia, Pa.

Reagents—Chemical
Baker & Adamson Chem. Co., Easton, Pa.
Baker Chem. Co., J. T., Phillipsburg, N. J.
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

Recording Instruments
Braun-Knecht-Heimann Co., San Francisco, Cal.
Brown Instrument Co., Philadelphia, Pa.
Eimer & Amend, N. Y. C.
General Electric Co., Schenectady, N. Y.
Hoskins Mfg. Co., Detroit, Mich.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Taylor Instrument Cos., Rochester, N. Y.
Thwing Instrument Co., Philadelphia, Pa.

Recording Instruments (For Pressure, Temperature, Etc.)
Brown Instrument Co., Philadelphia, Pa.
Scientific Materials Co., Pittsburgh, Pa.
Taylor Instrument Cos., Rochester, N. Y.

Reduction Kettles
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Refineries—(Oil—Sugar Installation)
Lummus Co., The Walter E., Boston, Mass.

Refractories
Brunt & Co., H. H., Chicago, Ill.
Guernsey Earthenware Co., Cambridge, O.
Herold China & Pottery Co., Golden, Colo.
Norton Co., Worcester, Mass.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.

Refrigerating Machinery and Apparatus
General Electric Co., Schenectady, N. Y.
York Manufacturing Co., York, Pa.

Regulators (Automatic Humidity)
Carrier Engineering Corp., N. Y. C.

Relays
General Electric Co., Schenectady, N. Y.

Resistance Ribbon—Base Metal
Hoskins Mfg. Co., Detroit, Mich.

Resistance Wire—Base Metal
Hoskins Mfg. Co., Detroit, Mich.

Resistance Wire—Platinum
American Platinum Works, Newark, N. J.
Baker & Co., Inc., Newark, N. J.
Bishop & Co. Platinum Wks., J., Malvern, Pa.

Retorts
Badger & Sons Co., E. B., Boston, Mass.
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Daigger & Co., A., Chicago, Ill.
Dixon Crucible Co., Joseph, Jersey City, N. J.
Guernsey Earthenware Co., Cambridge, O.
Heil Chemical Co., Henry, St. Louis, Mo.
Laboratory Supply Co., Columbus, O.
Lummus Co., The Walter E., Boston, Mass.
Palo Company, N. Y. C.
Sidio Company of America, Inc., The, N. Y. C.
Thermal Syndicate, Ltd., The, N. Y. C.

Retorts (Cast Iron)
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Sargent & Co., E. H., Chicago, Ill.
Sowers Mfg. Co., Buffalo, N. Y.

Retorts—Acid (Cast Iron)
Bethlehem Fdy. & Mach. Co., So. Beth., Pa.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Griebel Instrument Co., Carbondale, Pa.
Herold China & Pottery Co., Golden, Col.

Rotary Compressors or Blowers
Abbé Engineering Co., N. Y. C.
Crowell Mfg. Co., Brooklyn, N. Y.

Rotary Dryers—Vacuum and Atmospheric
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Rotary Lead Fans
Schutte & Koerting Co., Philadelphia, Pa.

Rubber Tubing, Laboratory
Angel Co., Inc., H. Reeve, N. Y. C.
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Tirrill Gas Mch. Ltg. Co., N. Y. C.
Whitall Tatum Co., Philadelphia, Pa.

Scientific Apparatus
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Cal.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eberbach & Son Co., Ann Arbor, Mich.
Eimer & Amend, N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Hoskins Mfg. Co., Detroit, Mich.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.

Scientific Instrument Makers
Scientific Materials Co., Pittsburgh, Pa.

Screens (Grinding & Pulverizing)
Raymond Bros. Impact Pulv. Co., Chicago, Ill.

Searchlights and Headlights
General Electric Co., Schenectady, N. Y.

Separators—Air
Raymond Bros. Impact. Pulv. Co.. Chicago, Ill.

Separators—Centrifugal
International Equipment Co., Boston, Mass.
Schaum & Uhlinger, Inc., Philadelphia, Pa.
Sharples Specialty Co., The, West Chester, Pa.
Tolhurst Machine Works, Troy, N. Y.

Sheet Metal Apparatus (Special)
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Shelf Dryers—Vacuum
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Shredders
Williams Patent Crusher & Pulv. Co., Chicago, Ill.

Silica—Fused
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Brunt & Co., H. H., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Engelhard, Chas., N. Y. C.
Greiner & Co., Emil, N. Y. C.
Greibel Instrument Co., Carbondale, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
Laboratory Supply Co., Columbus, O.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Sidio Co. of America, The, N. Y. C.
Thermal Syndicate, Ltd., The, N. Y. C.
Thomas Co., Arthur H., Philadelphia, Pa.

Sinks, Laboratory Acid Proof
Duriron Castings Co., N. Y. C.
Knight, Maurice A., East Akron, O.

Slide Warmers
Chicago Surgical & Electrical Co., Chicago, Ill.

Soda Recovery Machinery
Swenson Evaporator Co., Chicago, Ill.

Sodium-Benzol-Sulphonate Dryers
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Sodium—Salts of
Merck & Co., N. Y. C.

Soldering Iron Heaters
Tirrill Gas Mch. Ltg. Co., N. Y. C.

Solenoids
Chicago Surgical & Electrical Co., Chicago, Ill.

Solvent Recovery Apparatus (Vacuum)
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
Lummus Co., The Walter E., Boston, Mass.
Pfaudler Co., Rochester, N. Y., & N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Werner & Pfleiderer Co., Saginaw, Mich.

Spelter
New Jersey Zinc Co., The, N. Y. C.

Spiegeleisen
New Jersey Zinc Co., The, N. Y. C.

Spray Nozzles
Schutte & Koerting Co., Philadelphia, Pa.

Steam Engineering Specialties
Sarco Co., Inc., N. Y. C.

Steam Reducing Valves
Taylor Instrument Cos., Rochester, N. Y.

Steam Traps
Sarco Co., Inc., N. Y. C.

Sterilizers
Chicago Surgical & Electrical Co., Chicago, Ill.

Stills—Aniline, Phenol and Betanaphthol
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Stills—Nitric Acid and Sulfuric Acid
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Stirring Apparatus
Booth Apparatus Co., Syracuse, N. Y.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Devine Co., J. P., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
Jacoby, Henry E., N. Y. C.
Palo Company, N. Y. C.
Pfaudler Co., Rochester, N. Y., Chicago, Ill., & N. Y. C.
Sowers Mfg. Co., Buffalo, N. Y.
Stevens Brothers, N. Y. C.
Werner & Pfleiderer Co., Saginaw, Mich.

Stoneware—Chemical (Laboratory)
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Cal.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
General Ceramics Co., N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
Knight, Maurice A., East Akron, Ohio
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Schutte & Koerting Co., Philadelphia, Pa.
Scientific Materials Co., Pittsburgh, Pa.
Steiger Terra Cotta and Pottery Works, San Francisco, Cal.
Thomas Co., Arthur H., Philadelphia, Pa.
U. S. Stoneware Co., The, Akron, O.

Stoneware (Acid Proof—Industrial Purposes)
General Ceramics Co., N. Y. C.
Knight, M. A., East Akron, O
Schutte & Koerting Co., Philadelphia, Pa.
Stieger Terra Cotta and Pottery Works, San Francisco, Cal.
U. S. Stoneware Co., The, Akron, O.

Stoppers—Rubber
Eimer & Amend, N. Y. C.
Whitall Tatum Co., Philadelphia, Pa.

Storage Battery Recharging Apparatus
General Electric Co., Schenectady, N. Y.

Strontium—Salts of
Merck & Co., N. Y. C.

Succinic Acid
Woolner & Co., Peoria, Ill.

Sugar Mill Machinery
Swenson Evaporator Co., Chicago, Ill.

Sulphonating Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.

Sulphuric Acid
New Jersey Zinc Co., The, N. Y. C.

Sulphuric Acid Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.

Sulphuric Acid Concentrating Pans
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Sulphuric Acid Plants—Chemical Stoneware
Knight, M. A., East Akron, O.

Sulphuric Acid Recovery Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Switchboards
General Electric Co., Schenectady, N. Y.

Synthetic Oils & Chemicals
Merck & Co., N. Y. C.

Syphons
General Ceramics Co., N. Y. C.

Syphons—Steam Jet
Cleveland Brass Mfg. Co., The, Cleveland, O.
Duriron Castings Co., N. Y. C. (Acid Proof.)
Elyria Enameled Prod. Co., Elyria, O., & N. Y. C.
Schutte & Koerting Co., Philadelphia, Pa.

Tachometers
Brown Instrument Co., Philadelphia, Pa.
Palo Company, N. Y. C.
Taylor Instrument Cos., Rochester, N. Y.

Talc
Merck & Co., N. Y. C.

Tanks—(For Acid or Basic Reaction)
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Chadwick-Boston Lead Co., Boston, Mass.
Cleveland Brass Mfg. Co. The, Cleveland, O.