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EDITORIALS

THE CHEMICAL SERVICE SECTION OF THE NATIONAL ARMY

The importance of chemistry in the conduct of the war has received a gratifying endorsement from the War Department in the establishment of a new division attached to the General Staff and designated the Chemical Service Section of the National Army.

The two immediate purposes to be accomplished by the formation of this division are, *first*, the unification and more comprehensive development of the various research activities now being conducted for the War Department, and *second*, the creation of a chemical organization, complete in personnel and equipment, for service with the American Expeditionary Forces in France.

The most significant feature in the formation of this Section is the growing appreciation on the part of the heads of the departments of the Army of the value and necessity of chemistry in modern warfare. General Pershing has urgently requested that a chemical unit be organized and sent to France at the earliest possible moment to care for the emergency problems of vital importance which are constantly arising in the conduct of the war. Both the personnel and laboratory equipment of this force are being prepared upon the basis that the American armies in France have a right to the service of our ablest scientific minds and the most complete and adequate facilities for the work which it is possible for the United States Government to supply.

This chemical unit will serve as adviser to General Pershing on all chemical matters pertaining to the war, and will be attached to his staff through Colonel A. A. Fries, head of the Gas Warfare Division. It will also act as the chemical eyes of the unit in this country, transmitting information relative to chemical problems of the war to the men at work here. Able scientists throughout the country have responded eagerly to this call to national service. The unit will probably have sailed by the time this issue appears. The following have been recommended for commissions:

Lieutenant-Colonel

Raymond F. Bacon

Majors

Gilbert N. Lewis
William A. Hamor

Captains

H. H. Hanson
B. H. Nicolet
J. H. Hildebrand
F. G. Keyes

First Lieutenants

A. R. Norton
L. V. Walker
J. K. Senior
T. D. Stewart
L. H. Cretcher
P. R. Parmelee
W. L. Argo

Second Lieutenants

P. G. Woodward
A. H. Hooker, Jr.
H. W. Nichols, Jr.
L. H. Ashe
G. S. Skinner
D. H. McMurtrie
J. J. Hast
J. W. MacNaugher
E. B. Peck
N. F. Hall
R. B. Hall
Allen Abrams
C. B. Spofford, Jr.
A. R. Olsen

About twenty-five enlisted men, including some of the best of the younger chemists of the country, make up the remaining personnel as at present organized. The names of these enlisted men are not yet available; they will be published in a future issue. As the work develops, more men will be added so that the laboratory will be in position to solve quickly the many problems which the constant changes in the methods and munitions of the war introduce.

In order that the information collected by this force of scientific men may be of the greatest aid to the research work now being conducted in this country, Dr. William H. Walker, of the Massachusetts Institute of Technology, has been commissioned a Lieutenant-Colonel, and will have charge of the unification and coördination of many lines of research now being so ably carried on here. It is not expedient to discuss the activities of these research groups, but it is gratifying to know that real progress is being made in practically every field.

The organization of this Chemical Service Section will provide a means by which men drafted into the service, and having special research ability, may be enabled to serve the country as scientists in a way which will produce results of the very highest value.

A CHEMISTS' CLUB FOR FRANCE

The war has effected in France, as in this country, a remarkable stimulation of the chemical industries. This has reflected itself during the past year in the organization of a French Society of Chemical Industry. The strong bonds of a common endeavor in the struggle against the Teutonic menace has led many of our chemists to join gladly in the formation of an American section of that organization of French industrial chemists.

Another evidence of that same activity has just been received in the announcement of the organization of the Cercle de la Chimie, located at 54 rue de Turbigo, Paris, 3e.

The association is composed, to quote from its constitution, "de membres titulaires recrutés parmi les chimistes de carrière, les industriels, les négociants, les représentants de l'industrie chimique, les constructeurs et toutes les personnes s'intéressant au développement de la Chimie."

The Association has for its object, to quote again, "de permettre à tous ses adhérents de discuter en commun de leurs intérêts matériels et moraux et de

s'intéresser au développement de la science et de l'industrie chimiques françaises."

The *Revue des Produits Chimiques* will be the official organ of the Cercle de la Chimie. The club building will contain a reading room, a writing room, a lounge room, indeed all the conveniences and comforts of a modern club. Provision is made for the holding of scientific meetings, and extensive literature will be available.

To those of our chemists who will soon be in France and to that still larger number who will go as the American Expeditionary Forces increase, the prospect of visiting such a chemistry home will indeed be delightful. Opportunity will there be offered for meeting the distinguished chemists of France and for that fraternization among French and American chemists which so quickly and so naturally develops whenever representatives of the two countries meet. For our own part, we could desire no stronger attraction to such a spot nor need more certain guarantee of the genial atmosphere which will abound than is afforded by the presence of the name of Lieutenant René Engel in the list of the charter members of the Cercle. During the days of his connection with the French Mission in this country Lieutenant Engel won a warm place in the hearts of American chemists.

THE CHEMICAL ALLIANCE

One of the most interesting developments of the past month has been the resuscitation of the Chemical Alliance. This organization, formed at the suggestion of the Department of Commerce, was incorporated during the past summer. Its primary object was to assist in the clearing up of questions connected with the importation of pyrites, a situation so acute at that time. The Alliance, however, was not called upon for this particular service. As originally organized, it consisted of the chairmen of the sub-committees of the Committee on Chemicals, provision being made for associate members of allied groups. The officers were Wm. H. Nichols, *President*, Horace Bowker, *Vice-President*, and J. D. Cameron Bradley, *Secretary*.

With the gradual evolution of the war machine in Washington all of the semi-official committees, such as the Committee on Chemicals, have been discontinued. However, industrial advice is needed by the War Industries Board, so each group has been asked to organize a trade association, without any official government connection, to which that Board can turn for expert advice. To meet this situation the Chemical Alliance has been revived. Dr. Nichols having resigned the presidency of the original organization, a meeting was held recently at which the following officers were elected: Horace Bowker, *President*, Henry Howard, *Vice-President*, and J. D. Cameron Bradley, *Secretary* and *Treasurer*. These officers, together with A. H. Weed, Secretary of the Manufacturing Chemists' Association, are now engaged in drafting a constitution and by-laws for the new organization. For the present, the Board of Directors consists of the original members of the Committee on Chemicals. All manufacturers of chemicals are eligible for membership and it is confidently hoped that all such will become members at once. The members are to be classified in groups, and at a meeting to be held soon each of the groups will elect a director.

Such a representative organization of chemical manufacturers has within itself great potentialities for usefulness. It can act as a clearing house for priority matters, and its recommendations may form the basis of action by the War Industries Board, though accorded no recognition in the form of official approval. Furthermore, this close union in national service suggests the approach of a day of more coördinated effort in a rapidly expanding industry, a coördination which must be effected if the industry is to withstand squarely the shock of the intense competition which will assuredly have to be met in the days to come. Individual effort has been able to accomplish much under the unique conditions of a war period, but thoroughly coördinated and coöperative effort can alone safeguard the future.

PROGRESS IN SELECTIVE SERVICE

In so far as it applies to the wise utilization of chemists, some semblance of order seems to be arising out of the confusion incident to the immediate expansion of the military forces through both voluntary enlistment and the operation of the draft law. Many chemists have been transferred from the line to chemical service. In effecting these transfers splendid service has been rendered by Dr. Charles L. Parsons. In the next draft the new classifications issued by the Provost-Marshall, General Crowder, give assurance that the selective principle originally contemplated in the enactment of the legislation will be substituted for the lottery system which prevailed in the hurried and inexperienced application of the first draft. The regulations recently issued by the same officer remanding drafted engineering students to their universities for completion of their courses partly insures a reserve of better trained chemical engineers. The organization of the Chemical Service Section of the National Army furnishes an official medium for collecting the scattered chemical forces. Finally, we have been informed, though not directly, that the Secretary of War grasps clearly the importance of rôle the chemist must play in the great army we are preparing to send abroad.

The disintegration of the Russian forces along the Eastern front and the Italian reverses in the South have brought clear conviction to this Nation that we must prepare for a long war and on a great scale. With characteristic American pluck our people have accepted this situation, and with grim determination have set themselves to the task of contributing the maximum of men and means of which this country is capable.

If this conviction should prove correct, and no one to-day doubts it, every possible means should be resorted to for preserving the present inadequate supply of chemists and insuring full training of the younger men now preparing for the profession of chemistry.

To meet these two points we wish to urge upon the military authorities careful consideration of the following suggestions:

First—It will be unfortunate if a literal application of the term "chemical engineer" is made in applying the new ruling as to return of engineering students to their universities for completion of the course necessary to graduation. In many institutions the technical "chemical engineering" is not used to describe courses preëminently designed to supply chemists trained for such engineering work as the country needs. Moreover, chemists, just as much as, or even more than, chemical engineers, will be needed in the future for Government war work.

Second—For the training of these young chemists and chemical engineers, competent instruction is a prerequisite. The situation to-day is that many of the ablest professors in our universities have been detached from university work and are now engaged upon special lines of research for the government, while in the operation of the draft law, under the first call, no consideration seems to have been given to the question of exempting such instructors in chemistry departments as are best qualified to carry on the work of training the chemistry reserves.

Third—Many competent chemists are now in the Army, serving as commissioned officers in the line. The chemical ability of such men should be utilized before further inroads are made for Government chemical service upon the chemists now connected with industrial establishments or upon the instruction staffs of educational institutions. For most of these men no record exists in the census of chemists compiled by the Bureau of Mines and the American Chemical Society. The census, however, which is now being compiled in each camp or cantonment by the military authorities will doubtless contain the information which would make such men available.

Fourth—May we not hope that the War Department will issue some general order directing all commanding officers to facilitate the transfer of chemists, now serving in the line, to those branches of the service needing men for chemical work!

If these four steps could be taken immediately the future, in so far as it will be affected by chemists, could be viewed with far greater equanimity than is now the case.

SPRUCE TURPENTINE

From 1,500,000 to 2,000,000 gallons of "spruce turpentine" (sulfite turpentine) are going to waste annually in the mills of the United States and Canada using spruce pine for wood pulp. This oil is formed during the cooking of the chips in the sulfite digesters and escapes with the steam in the blowing-out process. The term "turpentine," as applied to this material, is a misnomer, for it contains only traces of terpenes; the chief constituent, approximating ninety per cent, is cymene. Recovery of the crude product has been carried out in a few mills, but no market was developed sufficient to justify the expense of recovery. This material assumes at the present time a greater importance than hitherto accorded it because of its possibilities as a source of toluol.

Patents have recently been issued to R. H. McKee for a process in which the dried spruce turpentine is heated with aluminum chloride to about the boiling point of the turpentine. The products formed are toluol, propane and a small amount of tar. We are informed that there is a plant in Philadelphia carrying on this process, but so far only turpentine has been obtained to run about one day a week; the sulfite mills have been unwilling to take the trouble to collect and ship the turpentine.

Moore and Egloff (*Met. and Chem. Eng.*, Vol. 17 (1917), 66), studying the action of aluminum chloride on pure aromatic hydrocarbons, obtained a yield of 14.3 per cent of toluol from cymene.

Schorger (*J. Am. Chem. Soc.*, Vol. 39 (1917), 2671) studied the action of aluminum chloride on cymene under varying conditions of temperature, time, amount of reagent, etc. He mentions the interesting fact that B. T. Brooks, by removing the light, low-boiling reaction products as rapidly as they are formed, obtained forty per cent of toluol by treatment of cymene with seven per cent of aluminum chloride.

A still more interesting possibility is suggested by the work of Boedtke and Halse (*Bull. de la Soc. chim.*, Vol. 19 (1916), 444). By heating cymene, dissolved in ten times its weight of benzene, with aluminum chloride a true reversal of the Friedel-Crafts reaction was obtained. Ninety grams of cymene yielded forty-four grams of toluol and sixty-eight grams of cumene (eighty and eighty-five per cent, respectively of the theoretical yield).

If these results hold true on a commercial scale, a new source of toluol for munitions and dyestuffs is indicated. Furthermore, the ease of oxidation of cumene to benzoic acid suggests the release of the toluol which is now oxidized to benzoic acid.

It is unfortunate that Boedtke and Halse have included so few details of their investigation. The published results are so striking that they suggest the necessity of further work on this interesting reaction. Perhaps the mills have been throwing away material of far greater value than they supposed.

A REGRETTABLE DECISION OF THE DIRECTORS

At the Annual Meeting of the Directors on December 8th a report was presented by the Press and Publicity Committee of the Society urging an appropriation of $3,500 for the continuance of the work of that Committee during the year 1918. In the light of all of the estimates of expense presented to the Directors, the recommendation of the Committee was not approved; instead, a renewal of the present appropriation of $500 for this work was ordered, this amount to be used in sending to the press each month advanced copies of editorials in THIS JOURNAL which might be of public interest.

The press and publicity work during the past year has been carried on largely by a fund contributed by the New York Section from an available balance left from the contributions to the expenses of the General Meeting in New York City in 1916. This contribution was supplemented by $500 appropriated by the Society and by clerical help contributed by some members of the Committee without charge. The limited appropriation for the next year means therefore that the educational work carried on by the Committee through the newspapers of the country must be practically abandoned, the valuable connections of this service must be discontinued, and a well developed business representing a real asset of the Society must be discarded.

It is sincerely to be regretted that this important educational work of the Society must be discontinued. We sympathize fully with the critical and grave situation which the Directors faced in the preparation of the budget for 1918. The necessity of larger issues of the three Journals to supply the hoped-for increase in members made heavy inroads upon the estimated income; on the other hand, the uncertainties due to the war situation led to grave apprehensions as to what the actual income of the Society will be. This situation, nevertheless, should become clear by April 1st. If, then, the fears of decreased income have proved groundless and the hoped-for increase has materialized, we trust that the Directors will again take up this matter, having before them the full information as to the work of the Committee which can easily be placed at their disposal.

We live in a democracy, and under such conditions sure foundations can be laid only in broad educational work from the bottom upward. Our people through their newspapers should have opportunity to learn more of chemistry treated in a popular way, and should be brought into a more sympathetic relationship with American chemists through the record of their achievements. Such work is preëminently the function of the American Chemical Society, an organization which has no propaganda to promote other than the welfare of this country through increased appreciation of chemistry. It was largely for this reason that the newspapers of the country responded so sympathetically to the suggestions of the Committee that more and more of such material be carried in their columns. The great mass of clippings collected by the Committee furnishes ample proof of how wide-spread this response has been. The arbitrary reduction of the mailing list at one time to sixty papers was immediately followed by more than two hundred requests for continuance of the service. During the past year the work has been largely enhanced by the creation of similar committees in many local sections, whose work, in turn, has been coördinated with that of the general committee. This is too valuable a piece of machinery to be thrown away. The best means to ensure its continuance is a largely increased membership during 1918. In securing this increase each and every member of the Society can take part.

It is time to get busy!

THE MISSING FIVE THOUSAND

The great increase in the number of members of the American Chemical Society during the past year has been a source of deep satisfaction to all—not because of the natural American love of bigness, but from the conviction that when American chemists speak through the medium of this organization it is the voice of practically all chemists of the country.

Recently this feeling of satisfaction has had a rude jolt. Secretary Parsons' records show that on December 1, 1917, the membership of the Society reached the high total of 10,603. In the light of the figures that marked the very gradual growth during the years preceding the past decade the present number of members seems enormous, and it is so when compared with the membership of similar organizations in European countries.

The magnitude of the figures, however, is considerably dwarfed in the revelation made by the census of American chemists recently compiled by the Society and the U. S. Bureau of Mines in coöperation for purposes of possible war service. To the questionnaire sent out for that census a little more than 15,500 replies were received. This means that there are practically 5000 who stand ready to serve our country directly and individually in this period of war, yet have not felt disposed to serve it indirectly and collectively through the medium of the national organization of chemists. Why is this?

Can we be satisfied with reading the journals in the library of the university or the plant, conscious of the fact that these journals exist only as a result of the joint effort of fellow chemists? Is it because we take no interest in attending meetings of the Society? These meetings are of great help to all who attend, and spread the gospel of chemistry in every section where they are held. Moreover, the men who to-day are serving the country so loyally in the solution of immediate war questions are the very men who are most frequently seen at the meetings. Indeed, Washington to-day looks like an adjourned meeting of the American Chemical Society. Do we feel that we cannot afford the expense of the ten dollars a year dues? If so, let us watch carefully our expenditures along the lines of purely self-interest and see if the required sacrifice is indeed too great. Are we waiting to be asked to join? That is not necessary, for the doors are wide open to all reputable chemists. Has it simply not occurred to us to join?

To call attention to the opportunity before us is one of the purposes of this editorial. Whatever the explanation, the New Year is just upon us. Good resolutions can quickly be turned into deeds. Coöperation is in the air everywhere. The closer union of the Allies, so recently and so gladly acclaimed as the forerunner of more efficient action against a common enemy, should serve as an example of that desirable union of chemical strength which must prevail if we are to win the fight for the welfare of our country through the science which we represent.

ORIGINAL PAPERS

RECOVERY OF POTASH FROM GREENSAND[1]

By H. W. Charlton

In the original process as developed the material adopted was feldspar, but it was later found that glauconite, commonly called greensand, in many respects possesses marked advantages, although carrying a smaller percentage of potash. It exists in almost unlimited quantities in the Eastern states, particularly in New Jersey, and, unlike feldspar, requires neither blasting nor crushing.

It is an accepted fact that any commercially successful process of liberating potash in rocks, etc., must include a method of profitably employing the residue. In this case a building material is produced and has the advantages of an unlimited market, as well as being a superior product capable of being manufactured at a remarkably reasonable figure.

The method consists in digesting under pressure finely ground greensand with lime and water, thereby obtaining caustic potash of remarkable purity and at the same time converting the residue into a material of value.

The reaction is carried out in large digesters or autoclaves, heated by introducing into the charge high-pressure steam in sufficient quantity to maintain the desired pressure of about 225 lbs. for a period of from 2 to 4 hrs. To conserve the heat, at the completion of each digestion the steam is allowed to escape and be condensed in the greensand-lime-water mixture next to be treated, and the contents of the autoclave, which should have a cream-like appearance, is filtered to separate the dissolved caustic potash from the insoluble residue.

With sufficient lagging the unavoidable heat losses are very moderate, especially as the chemical action requires but little, if any, beyond the heat necessary to raise the temperature of the mass to the reaction point. For this reason the efficiency is largely dependent upon the thoroughness of the heat insulation.

On filtering, the potash appears in the filtrate as potassium hydrate associated with so few impurities that on concentration it may be sold as a high-grade product without further treatment.

Following is an analysis:

	Per cent
K_2O	77.2
SO_3	0.90
Cl_2	0.35
SiO_2	0.70
Al_2O_3	Free

From the origin of glauconite it would naturally be supposed that the percentage of impurities would be higher and the variety greater than is found to be the case. According to standard works on mineralogy, it is a hydrous potassium iron silicate, but this conclusion was probably based on the simple analytical figures, and there are very strong recent data to show that this is not its true composition. As greensand is at the present time being carefully investigated, it will very probably be shown to be a potassium iron compound enveloping free silica, but not a silicate. That it is of marine origin is undoubted, and its rich green color is probably due largely, if not entirely, to organic matter with which it is chemically combined.

The solid remaining on the filter, which is the insoluble portion resulting from the digestion, is employed in the manufacture of steam-hardened brick, tile, artificial stone, etc. It acts as a binding or cementing material and is incorporated with high silica sand, as is customary in the manufacture of steam-hardened products, but differs fundamentally in that, whereas lime has always previously been employed as a binding agent, in this case a pre-formed self-cementing hydrous silicate performs this function.

In the past, steam-hardened brick, commonly known as Sand Lime Brick, have not been the success predicted. They are not able to stand the weather without more or less crumbling, and the edges and corners are seldom perfect even in the freshly made brick. This is due primarily to the fact that all the binding power depends on the interaction of lime and sand during steaming, with the resulting formation of a surface coating of calcium silicate which binds the sand particles. If any one of the many factors governing this reaction are overlooked, the brick is faulty. Imperfect slaking of the lime, improper mixing, imperfect steaming, a deficiency or excess of moisture, or dull cornered sand, would each be sufficient in themselves to ruin the product. In fact, every detail has to be rigidly observed and little leeway is permissible.

It is also found that the adhesion between the sand and lime in the pressed but unsteamed brick is slight in every case and that these "green brick" crumble unless handled with the greatest care.

When employing the digestion solids as cementing material these troubles are largely overcome. The pre-formed cementing properties insure an unfailing bond in addition to any chemical action that may take place between the hydrous silicate and the sand during steaming. Any type, such as bank, sea or loamy sand is permissible. Ordinary ground rock will serve the purpose. One of the most convincing proofs of the self-cementing properties of the digestion material is its ability to bond ground limestone, with which there could not be any chemical action.

Sand and the cementing material may be mixed in widely varying proportions ranging from 98 and 2 to 40 and 60. In fact, it is almost true that the process is "fool-proof."

The chemical composition of the autoclave residue depends, of course, on the material treated. With feldspar it is probably a complex calcium aluminum silicate, and with greensand a calcium iron silicate. In both cases it possesses remarkable properties, being to a degree self-cementing but capable of acting,

[1] Presented at the 55th Meeting of the American Chemical Society, Boston, Mass., September 13, 1917.

when subjected to steam pressure, as a powerful binding agent, cementing sand so firmly that small enclosed quartz pebbles fracture before the bond gives way.

The cementing material resulting from the digestion of feldspar is superior to that from greensand, although the latter possesses sufficient cementing power to meet the most rigid requirements and produces a brick of a pleasing light green shade at a greatly reduced cost.

The feldspar brick are of a marble-like creamy whiteness, entirely devoid of a lifeless milky tint, and have surfaces so smooth that at a distance of a hundred feet they cannot be distinguished from marble.

If colored brick are desired, inorganic pigments may be mixed with the binding material, and if an ochre color is to be produced the coloring matter may be obtained as a by-product in the general process. It is necessary to calcine only a portion of the greensand-lime digestion product, under which treatment it becomes a rich ochre, and add it to either the feldspar or greensand cementing material.

The properties of these brick are best illustrated by tests on samples chosen from the general run by an inspector from the Building Department of New York City. The actual tests were carried out at Columbia University and Pittsburgh Testing Laboratory.

	Feldspar Brick	Required Standard
Crushing Strength, lbs. per sq. in.	9267	2000
Modulus of Rupture, lbs. per sq in.	1060	450
Average Absorption	4.44 per cent	Under 15 per cent

The low absorption may be explained partially at least by the voluminous, easily compressible, water-repellent nature of the bonding material. On being mixed with sand and subjected to the usual high pressure in brick presses it oozes in and completely fills all the interstices between the grains of sand.

Another feature, and in some respects perhaps the most important, is the plastic nature of the binding material which adds a toughness to the brick after compressing and before steaming. This makes possible the handling of the "green brick" without breaking off the corners.

While brick is referred to particularly, it is not intended to convey the impression that this is the only marketable product. The particular advantage of brick is the immense market.

In investigating the various factors governing the yield of potash it was found that a high pressure and a large excess of water were absolutely essential. In treating feldspar it is necessary to use eight times its weight of water, and ten is a fair amount. This necessitated a great deal of evaporation, materially reducing the capacity of the plant and requiring a large outlay for initial heating.

After a series of experiments it was determined by a process of elimination that the alumina was the cause of the trouble, and this naturally could not be removed in the case of feldspar, $K_2O.Al_2O_3.6SiO_2$, as it is an essential element in its composition. The only remedy consisted in the adoption of an alumina-free material, or one in which this element was partially or wholly replaced by a non-injurious one.

Greensand appeared very suitable and was tried. Although its true composition is in doubt, the results in this case were surprisingly satisfactory. It was found that the concentration could be doubled or in fact the water could be reduced to a point where it was just possible to agitate the mixture.

A difficulty that has been met in every process of recovering potash from feldspar is the invariable liberation of soda at the same time. This is always difficult and expensive to separate, and especially so where both alkalies are liberated as hydrates. Theoretically potash feldspar is soda-free, but in practice it invariably contains from 2 to 3 per cent.

Greensand is almost soda-free, which is all the more remarkable from the fact that it is of marine origin, being formed on the ocean bed by the selective absorption of potash from sea water by precipitated colloidal silica and ferric hydroxide.

Another difficulty encountered in applying this process to feldspar is the invariable presence of alumina in the digestion liquors. Efforts to entirely overcome this by adding more lime while reducing the amount do not in any case remove it entirely. In the greensand-lime digestions there is not a trace. This is surprising from the fact that the analysis of greensand always shows a little alumina present probably in adhering clayey matter. It must be present in some combination that this process does not break up. This is extremely fortunate.

Another important feature in the process is the employment of a high temperature and pressure in the digestion. The reactions are not only speeded up, as might be surmised, but are different. This is partially due at least to the production of a chemically active sub-hydrate of lime approximating the formula $CaO.CaO.H_2O$, which is formed at pressures of 200 lbs. and over.

That $CaO.H_2O$ should be partially dehydrated during digestion in a large excess of water, such as an amount equal to ten times the weight of the lime, appears to be paradoxical, but such is the case; and it supplies a plausible explanation of the increased activity of the lime in decomposing the feldspar at pressures above 200 lbs. and corresponding temperatures. It is found that the digestion of feldspar with lime at 150 lbs. pressure for any reasonable length of time scarcely liberates any potash, but above 200 lbs. pressure the reaction is rapid.

Greensand, on the other hand, is less refractory and may be liberated at lower pressures, but it is not advisable to employ them, as the yield is uncertain and the insoluble residue unsatisfactory.

Considered from an economic standpoint, it is believed that it is quite feasible to adapt this process to either greensand or feldspar and, in conjunction with the production of a marketable by-product, to

operate at a profit when selling the potash at pre-war prices. With feldspar, owing to the invariable presence of soda, the mixed hydrate required to be carbonated to effect a separation. The potash is then sold as hydrated carbonate. Carbonating is not necessary in the case of greensand as high-grade caustic potash is obtained in one operation. If potassium chloride is desired it is necessary only to modify the digestion by adding calcium chloride to the original mixture.

It is found in the case of feldspar that the percentage potash content does not give reliable data as to the possible yield, this being dependent on unknown factors pertaining to each individual deposit. Often feldspars that are valueless in pottery manufacture, being weathered and mixed with mica, give the highest yield, in some cases up to 90 per cent, while some very high-grade samples yield as low as 30 per cent.

Greensand contains usually from 6 to 7 per cent K_2O and it may be almost completely recovered, but it is found that 70 to 80 per cent of the total potash is a satisfactory yield after considering such factors as dilution, time of digestion, etc. This means the production of about 100 lbs. of K_2O, and binder material for from twenty to thirty thousand brick from each ton of greensand.

If artificial stone, building blocks, roof, floor or drain tile are manufactured, the resulting amount will vary with the composition and weight of the products. If desired, the digestion material without admixture with sand may be molded in its plastic condition, dried and employed as insulating fire-proof blocks. On the other hand, it is believed that brick have the most extensive market. The fact that the greensand beds are usually overlaid with a high silica sand lessens the cost of manufacture. The overburden, which has to be removed in any case, supplies the necessary sand.

The initial experiments and the commercial development of the process have been made possible by the scientific interest exhibited in the undertaking by Mr. Richmond Levering, who has, himself, borne the great expense entailed in its development.

Kaolin Products Corporation
120 Broadway, New York

TOLUOL BY CRACKING SOLVENT NAPHTHA IN THE PRESENCE OF BLUE GAS

By Gustav Egloff

Received November 20, 1917

All past estimates of the gallonage of toluol which would be required in this war have been far too low. May not the present estimate of Brigadier-General Crozier of 22,000,000 gallons of toluol[1] required by September, 1918, also be far too low for our war needs?

The cry is toluol, more toluol and more toluol!

One of the fruitful fields for increasing our toluol yield is by stripping carbureted water gas,[2] coal gas and oil gas, by means of suitable scrubbing towers, for their toluol content. But, to pass the sorely needed legislation, to change from a candle power to a heat standard will take time, unless the War Department, as a military necessity, commandeers or orders the erection of gas scrubbers in every commercial sized gas plant in this country. But it will take time to build scrubbers for the various gas plants. To quickly add 2,000,000 gallons of toluol to our supply, it is proposed in this communication to suggest the use of water-gas machines to crack solvent naphtha and produce toluol in the presence of blue gas.

It is calculated that there will be produced in the year 1917, 15,000,000 gallons of solvent naphtha from which, in round numbers, 2,000,000 gallons of toluol can be made by cracking solvent naphtha in carbureted water-gas machines. A more than sufficient number of carbureted water-gas machines are already installed throughout the country to more than take care of the cracking of 15,000,000 gallons of solvent naphtha from which 2,000,000 gallons of toluol can be quickly made.

SOLVENT NAPHTHA USED

The solvent naphtha used in the following experiment was derived from the thermal decomposition of coal and analyzed, using a standard Engler flask for distillation and the Westphal balance for specific gravity.

Distillation Analysis
Specific Gravity 0.867/15.5° C.

Temp. ° C.	Per cent by Vol.
135.5	1st drop
140.0	49.1
150.0	87.0
160.0	91.5
170.0	96.3
180.0	98.5
183.5	Dry point

CRACKING TEST

The following test of cracking solvent naphtha was conducted upon a Lowe 6′ carbureted water-gas set, over a period of 48 hrs. The operation of the plant in cracking solvent naphtha in the presence of blue gas for toluol is practically the same as when cracking gas oil in ordinary carbureted water-gas making, with the exception that the gallonage per hour of solvent naphtha into the cracking zone is higher. The data upon a 24-hr. basis averaged as follows for a carbureted water-gas set:

Make per 6′ set per day of gas formed	500,000 cu. ft.
Candle power of the gas	21 at 21° C.
Candle power of gas per gallon of oil	1.75 at 21° C.
Solvent naphtha cracked per 1,000 cu. ft. of gas formed	12.0 gal.
Gas per gallon of solvent naphtha cracked	83.3 cu. ft.
Coke used per 1,000 cu. ft. gas	46.0 lbs.
Steam used per 1,000 cu. ft. gas	38.0 lbs.
Temperature of superheater base	825° C.
Temperature of condenser outlet	15.5° C.
Length of run	4 min.
Length of blow	4 min.
Rate per hour solvent naphtha	250 gal.
Rate actual flow of solvent naphtha into system	500 gal.
Total gallonage of solvent naphtha passing through set in 24-hr. day	6,000 gal.
Light oils collected in drips and seals	57 per cent
Tar in gas holder	15 per cent

ANALYSIS OF LIGHT OIL

The light oil was distilled in a one-barrel still with steam to a temperature of 170° C. This cut was

[1] This Journal, 9 (1917), 1002.

[2] *Met. and Chem. Eng.*, 16 (1917), 492; Moore and Egloff, *Ibid.*, 17 (1917), 297.

analyzed by a method[1] already devised for the benzene, toluol and solvent naphtha content.

The analysis showed on the basis of light oil recovered from the cracking of solvent naphtha the following percentages of aromatic hydrocarbons:

	Per cent
Refined Benzol	14.5
Refined Toluol	23.7
Refined Solvent Naphtha	19.8
Crude Heavy Naphtha	9.7
Dead Oil	14.0

On the basis of 100 gallons of solvent naphtha cracked the following percentage of aromatics can be recovered:

	Per cent
Refined Benzol	8.3
Refined Toluol	13.6
Refined Solvent Naphtha	11.2
Crude Heavy Naphtha	5.5
Dead Oil	8.0

In these critical times, with a high scarcity of toluol, no quicker method lends itself to adding to our toluol supply than the cracking of solvent naphtha in carbureted water-gas machines. This being due to the fact that there is more than a sufficient number of carbureted water-gas machines already in operation, which could be used at once without any change for the adding of 2,000,000 gallons of toluol to our much needed supply.

THE ESTIMATION OF PHENOL IN THE PRESENCE OF THE THREE CRESOLS[2]

By G. W. Knight, C. T. Lincoln, G. Formanek and H. L. Follett

Received July 30, 1917

Of the many methods proposed for the estimation of phenol in the presence of the three cresols, only those based on the determination of physical constants of mixtures of these substances would have much practical value in the analysis of coal-tar distillates, for the reason that small amounts of xylenols and other impurities that are apt to be present in the final distillate would seriously affect the accuracy of any of the chemical methods.

Many methods of proximate analysis have been based on the determination of physical constants such as the specific gravity, index of refraction, solidifying point, optical rotation, etc., of the substance to be analyzed or a part of it that has been purified as much as possible. In the case of the determination of phenol in the presence of the cresols, advantage can be taken of variations in the solidifying points and specific gravities of the various constituents to determine the phenol.

Part of the problem of working out along these lines a really accurate method for the determination of phenol in the presence of the cresols was accomplished by Lowe,[3] and also by Weiss.[4] Very recently, Masse and Leroux[5] and Weiss and Downs[6] have investigated the problem further and have published methods in which they make use of the specific gravities and solidifying points or solidifying points alone obtained by them for certain mixtures of phenol and cresols.

The principal difficulty in working out a reliable and satisfactory method for the determination of phenol in the presence of cresols in coal-tar products lies in the fact that in coal-tar distillates there is no constant relation between the amounts present of any of the cresols, *i. e.*, any of the three cresols may be present in any amount varying over a very large range, and this is more particularly true now since *m*-cresol is being removed in some cases for making trinitrocresol. Attention has been called to this fact in the literature by Lunge,[1] Ihle,[2] Tiemann and Schotten,[3] Wegen,[4] Schulze[5] and even Weiss and Downs.[6] Nevertheless, the methods of Weiss and Downs and Masse and Leroux have been partly based on the arbitrary assumption that *m*-cresol and *p*-cresol occur in certain fixed proportions to each other in coal-tar distillates or crude tar acids. Weiss and Downs assumed this proportion to be 50 per cent of *m*- to 50 per cent of *p*-, and Masse and Leroux 60 per cent of *m*- to 40 per cent of *p*-cresol. Consequently, when the interproportion of *m*- to *p*-cresol present in the final distillate upon which the constants are determined is different from that upon which their methods are based, a condition very frequently met with in actual practice, the results obtained by the use of either of these methods are apt to be unreliable.

The following investigation was carried on in the hope of developing a method along similar lines that would eliminate this and other weaknesses in these methods, be capable of wider application, give more concordant results and be as short and concise as accuracy would permit.

EXPERIMENTAL

In order to accomplish this end it was necessary to obtain phenol, *o*-cresol, *p*-cresol and *m*-cresol in as pure a condition as possible and to work with as many samples from different sources as possible in order to study the effect produced by slight amounts of impurities on the constants of the different mixtures.

Various samples of the purest phenol obtainable were procured from different commercial sources. A large number of samples of the purest *o*-cresol made commercially was obtained from American sources and also from England. Most of the samples of phenol were synthetic, while the *o*-cresol was all obtained directly from coal tar. Some of the *m*-cresol used in the investigation was synthesized in this laboratory by the method of Staedel and Kolb,[7] while some was of coal-tar origin obtained from commercial sources. Likewise some of the *p*-cresol used was

[1] Egloff, *Met. & Chem. Eng.*, **16** (1917), 259.

[2] Contributed with the permission of the Secretary of the Treasury and the U. S. Appraiser, Port of New York.

[3] Lunge, "Coal Tar and Ammonia," 5th Ed., **1916**, 782.

[4] *J. Franklin Inst.*, **1912**, 683.

[5] *Compt. rend.*, **165** (1916), 361–3.

[6] This Journal, **9** (1917), 569.

[1] "Coal Tar and Ammonia," 5th Ed., **1916**, 784.

[2] *J. prakt. Chem.*, [2], **14** (1876), 442.

[3] *Ber.*, **11** (1878), 767.

[4] *Z. angew. Chem.*, **1909**, p. 391.

[5] *Ber.*, **20** (1887), 409.

[6] *Loc. cit.*

[7] *Ann.*, **259** (1890), 209.

synthesized in the laboratory by the method of Erdmann,[1] while the rest was bought from commercial houses, as having been obtained directly from coal tar. The specific gravities and solidifying points of these substances were determined by the methods and apparatus described later on. The various samples of phenol had solidifying points of from 40.4 to 40.7° C. and specific gravities of from 1.0640 to 1.0647 at 45° C./45° C. Those of *o*-cresol varied in solidifying point from 28.8 to 30.2° C. and in specific gravity (25° C./25° C.) from 1.0439 to 1.0451. The *p*-cresols varied in solidifying point from 31.9 to 34.4° C. and in specific gravity (25° C./25° C.) from 1.0334 to 1.0335, while the *m*-cresols varied from —3.3 to +3.0° C. in solidifying point and from 1.0248 to 1.0333 in specific gravity (25° C./25° C.). Of the various samples the following were selected as being either the purest or else freest from slight impurities that might introduce serious errors:

	Specific Gravity	Solidifying Point
Phenol	1.0647 at 45° C./45° C.	40.6° C.
o-Cresol	1.0439 at 25° C./25° C.	29.0° C.
p-Cresol	1.0335 at 25° C./25° C.	34.4° C.
m-Cresol	1.0333 at 25° C./25° C.	3.0° C.

These samples were selected after a considerable amount of preliminary work with mixtures of the various substances to determine the impurity present, if any, in each one. They represent as a rule those having the highest solidifying points, although this is not the case with the *o*-cresol. Another *o*-cresol sample had a solidifying point of 30.2° C. but was not selected because it appeared to contain 2 or 3 per cent of phenol.

The constants obtained by using these samples in making up the necessary mixtures were used in the final plotting of lines and calculation of formulae, while those obtained by the use of the other less pure samples were used for comparison and to study the effect of varying amounts of the different impurities.

The following mixtures of the pure substances mentioned above were made up and the constants of the mixtures determined and plotted on cross-section paper. Most of the constants obtained were checked by two or more chemists working independently in order to eliminate errors due to personal equation.

Mixtures of the *o*-cresol and the *p*-cresol were made containing varying quantities of *o*-cresol from 95 to 70 per cent by weight and *p*-cresol from 5 to 30 per cent by weight and the solidifying points and the specific gravities at 25° C./25° C. of these mixtures were obtained, using all precautions to have the data as accurate as possible. The values obtained were plotted using the specific gravities as abscissae and the solidifying points as ordinates. Other mixtures were made using varying proportions of *o*-cresol from 90 to 70 per cent by weight, *p*-cresol from 5 to 25 per cent by weight and phenol 5 per cent by weight in each mixture. Similar mixtures containing decreasingly proportionate amounts of *o*-cresol and *p*-cresol and increasing proportions of phenol in series of increments of 5 per cent were made up, the constants determined and the values plotted as before. The results are shown in Fig. I.

[1] *Anleitung Z. Darst. Org. Prap.*, 1894.

This process was repeated using the *m*-cresol in place of the *p*-cresol. The line representing mixtures of the *o*-cresol and the *m*-cresol and no phenol is shown in Fig. I, the lines representing those mixtures containing the increments of phenol being omitted to avoid confusion. Similar mixtures were made up using the other less pure samples of the different cresols and the constants determined and plotted. These results, being used only for comparison, were not plotted.

It was found that the tangent of the angle formed by the line representing mixtures of the purest *o*-cresol and the purest *p*-cresol and no phenol and a line drawn through the point representing 100 per cent *o*-cresol parallel to the axis (X = O) is numerically equal to 0.13. It was also found that the tangent of the angle formed by the *o*-cresol + *m*-cresol line in Fig. I and a line drawn through the point representing 100 per cent *o*-cresol parallel to the axis (X = O) is equal to 0.22. These angles are represented in Fig. I as "α *o.p.*" and "α *o.m.*," respectively. Calculated from this data the tangent of the angle formed by a line representing mixtures of *o*-cresol and a distillate composed of 50 per cent *m*- and 50 per cent *p*-cresol would be 0.175. The similar tangent calculated from the data obtained by Weiss and Downs for mixtures containing the same percentages of *o*-cresol and a coal-tar distillate containing 50 per cent *p*- and 50 per cent *m*-cresol using a line drawn through the maximum number of nearest points obtained by them was found to be 0.181, a very close agreement with the above, notwithstanding the fact that the constants themselves were very different.

With the other less pure samples various lines were obtained depending on the purity of the *o*-cresol, *p*-cresol or *m*-cresol used—the position of the line indicating the impurity present.

As may be seen by referring to Fig. I, lines drawn through the points represented by mixtures containing no phenol, 5 per cent phenol, 10 per cent phenol, etc., up to 30 per cent phenol, within the limits of the plot, are parallel in the case of *p*-cresol. This is also true of *m*-cresol and mixtures of *m*- and *p*-cresol in varying proportions. The general equation for the pure *o*-cresol + *p*-cresol lines, with or without phenol, as may be seen by inspection, is

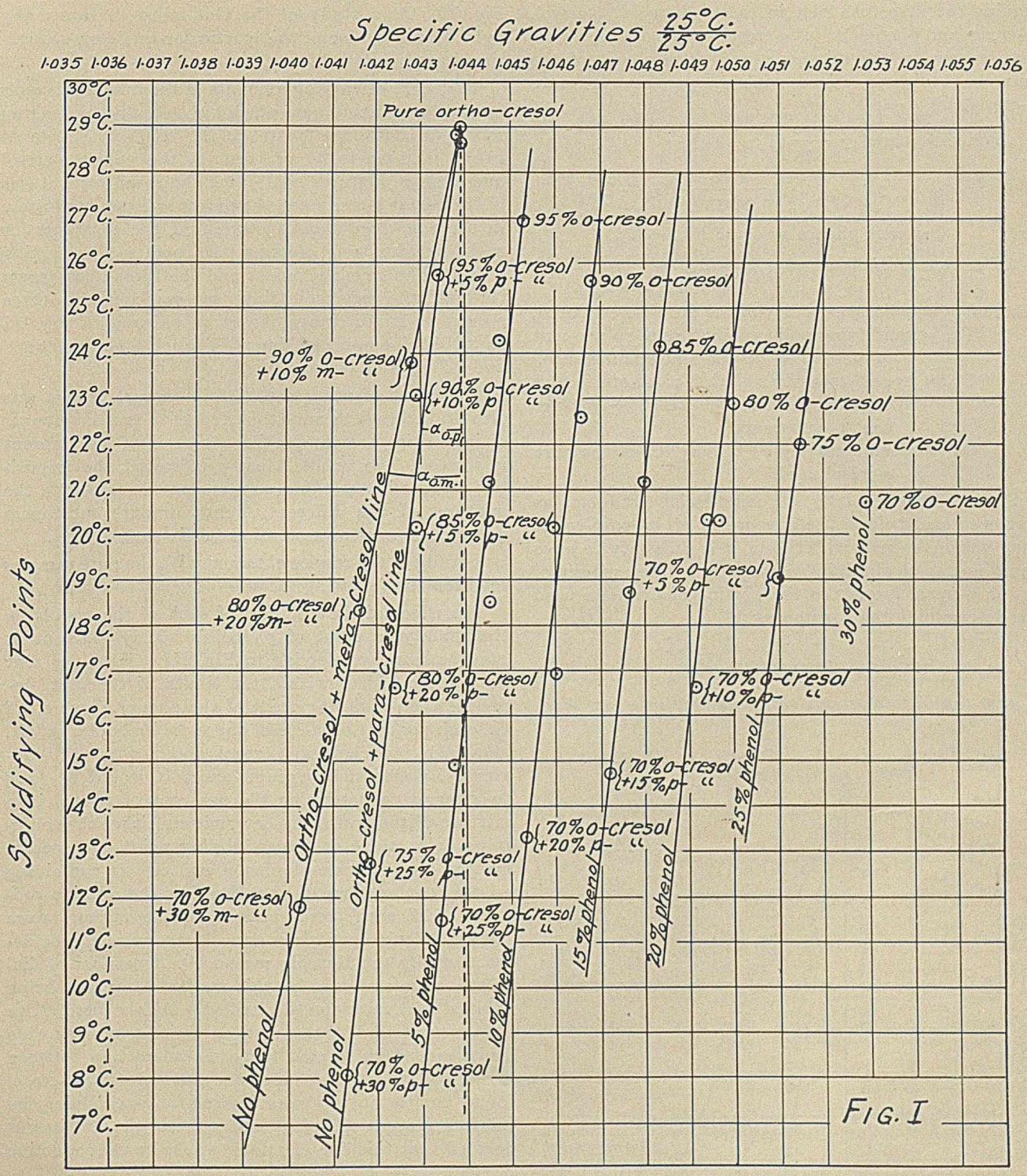
$$1000\,(G_o - G_p) - 0.126\,(T_o - T_o) = 0.$$

That for the pure *o*-cresol + *m*-cresol lines, with or without phenol, is

$$1000\,(G_o - G_m) - 0.218\,(T_o - T_m) = 0,$$

where G_o = sp. gr. 25° C./25° C. of the *o*-cresol,
G_p = sp. gr. 25° C./25° C. of the *p*-cresol,
G_m = sp. gr. 25° C./25° C. of the *m*-cresol,
T_o = solidifying point of the *o*-cresol,
T_p = solidifying point of the *p*-cresol,
and T_m = solidifying point of the *m*-cresol.

These lines, in addition to being parallel, are also equi-distant for equal increments of phenol, both in the case of *p*-cresol mixtures and *m*-cresol mixtures, although for the same increments the distances between the lines are greater in the case of *m*-cresol than in the



case of *p*-cresol. In other words, with mixtures of *o*-cresol, *p*-cresol and phenol containing more than 70 per cent of *o*-cresol and less than 30 per cent phenol, and of the same solidifying point, the per cent of phenol varies directly with the specific gravity. The same rule holds true with mixtures of *o*-cresol, *m*-cresol and phenol and mixtures of *o*-cresol, phenol and varying proportions of *m*-cresol and *p*-cresol within the same limits. In the case of mixtures of *p*-cresol, *o*-cresol and phenol, the solidifying point remaining the same, it was found that each per cent of phenol increased the specific gravity 0.0003367; in that of mixtures of *m*-cresol, *o*-cresol and phenol, 0.0003600; in that of mixtures of *p*-cresol, *m*-cresol, *o*-cresol and phenol proportionately intermediate values depending on the ratio of *p*-cresol to *m*-cresol.

Similarly it was found that, the specific gravity remaining constant, each per cent of phenol depressed the solidifying point 2.75° C. in case of the *p*-cresol mixtures, and 1.71° C. in that of the *m*-cresol mixtures.

These facts enable us to formulate an equation which will give the percentage of phenol without

having recourse to a plot in cases where (1) *o*-cresol, *p*-cresol and phenol, or (2) *o*-cresol, *m*-cresol and phenol are present in the mixtures, and 30 per cent of the mixture has been mixed with 70 per cent of pure *o*-cresol.

$$\text{Per cent phenol} = \frac{1.00}{2.73}(T_o - T_{so}) - \frac{1.00}{0.0003367}(G_o - G_{so}) \quad \text{(I)}$$

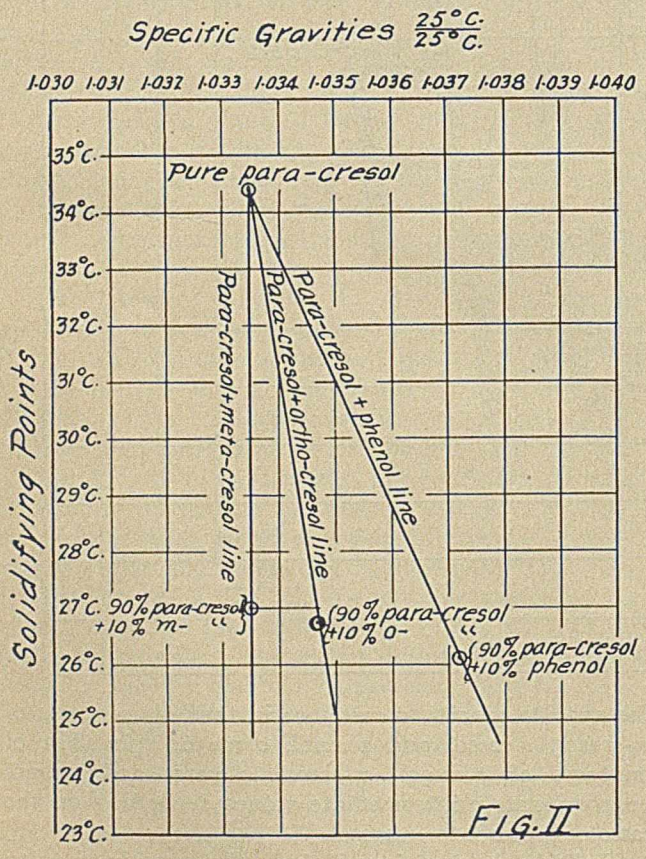
or,

$$\text{Per cent phenol} = 0.366\,(T_o - T_{so})$$

$$\text{Per cent phenol} = 0.585(T_o - T_{so}) - 2780(G_o - G_{so}) \quad \text{(II)}$$

where T_o = solidifying point of the pure *o*-cresol used,
T_{so} = solidifying point of mixture of 70 per cent of *o*-cresol + 30 per cent of substance,
G_{so} = specific gravity 25° C./25° C. of mixture of 70 per cent of *o*-cresol + 30 per cent of substance,
G_o = specific gravity 25° C./25° C. of the pure *o*-cresol used.

Since in the analysis of commercial products, as has been said before, the proportion of *m*- to *p*-cresol may vary over very wide limits, it is necessary to have some means of obtaining a measure of the amount of *m*- or *p*-cresol present in the portion of distillate used for determining the constants.



In the hope of finding such a means, mixtures of 90 per cent of pure *p*-cresol with 10 per cent of phenol and also with 10 per cent of *o*-cresol and 10 per cent of *m*-cresol, were made up separately, and the constants determined and plotted. The results are shown in Fig. II. As a study of the plot failed to throw any light on the problem, this particular line of investigation was abandoned.

The effect of varying amounts of the different cresols on the constants of pure phenol was studied by making mixtures containing 90 to 70 per cent of the purest phenol and 10 to 30 per cent of the purest *o*-cresol and similar mixtures containing the same percentages of the purest *p*-cresol and the purest *m*-cresol separately in place of the *o*-cresol, determining the constants for each mixture and plotting the points representing them. The terminal points and the three lines drawn through the nearest points representing the three classes of mixtures are shown graphically in Fig. III as "Phenol + *m*-cresol line," "Phenol + *o*-cresol line" and "Phenol + *p*-cresol line."

The effect of using the slightly impure cresols was also studied to determine the effect of the small amounts of impurities present on the constants of the different mixtures. The results clearly indicated the impurities present in the same way as was the case with the mixtures of the different slightly impure substances with 70 per cent or more of the different *o*-cresols.

A study of the results obtained with the pure samples revealed the following facts:

The effect of the addition of each of the cresols on the solidifying point of phenol is widely different as may be seen by referring to Fig. III. Each per cent of *o*-cresol added, within the limits of the plot, depresses the solidifying point of the phenol about 0.65° C., each per cent of *m*-cresol depresses it about 0.55° C., and each per cent of *p*-cresol about 0.83° C. Obviously, under such circumstances it would be folly to attempt to determine the per cent of phenol in a mixture of the cresols by determining either the solidifying point alone or the solidifying point and specific gravity of a mixture of phenol and cresols containing 70 per cent or more of phenol unless the relative proportions of each cresol present in the mixture were known at least approximately. Meta-cresol can be determined by the Raschig method.[1] A number of distillates were analyzed by this method after first being purified and fractionally distilled. As the percentage of *m*-cresol found by this method varied over very wide limits and there seemed to be no connection between the distillation point and the amount of *m*-cresol found and as no way was devised for determining the relative proportions of *o*- and *p*-cresol present it was decided that this line of attack would be unproductive of results.

Further study of the results obtained on the mixtures of phenol and the separate cresols containing more than 70 per cent of phenol showed that the effect of the addition of the different cresols on the specific gravity of the phenol is also different in each case, as may be seen by referring to Fig. III. Each per cent of *o*-cresol added, within the limits of the plot, lowers the specific gravity (45° C./45° C.) of the phenol 0.00031, each per cent of *p*-cresol lowers it 0.00040, and each per cent of *m*-cresol, 0.00044.

[1] *Z. angew. Chem.*, **1900**, 759.

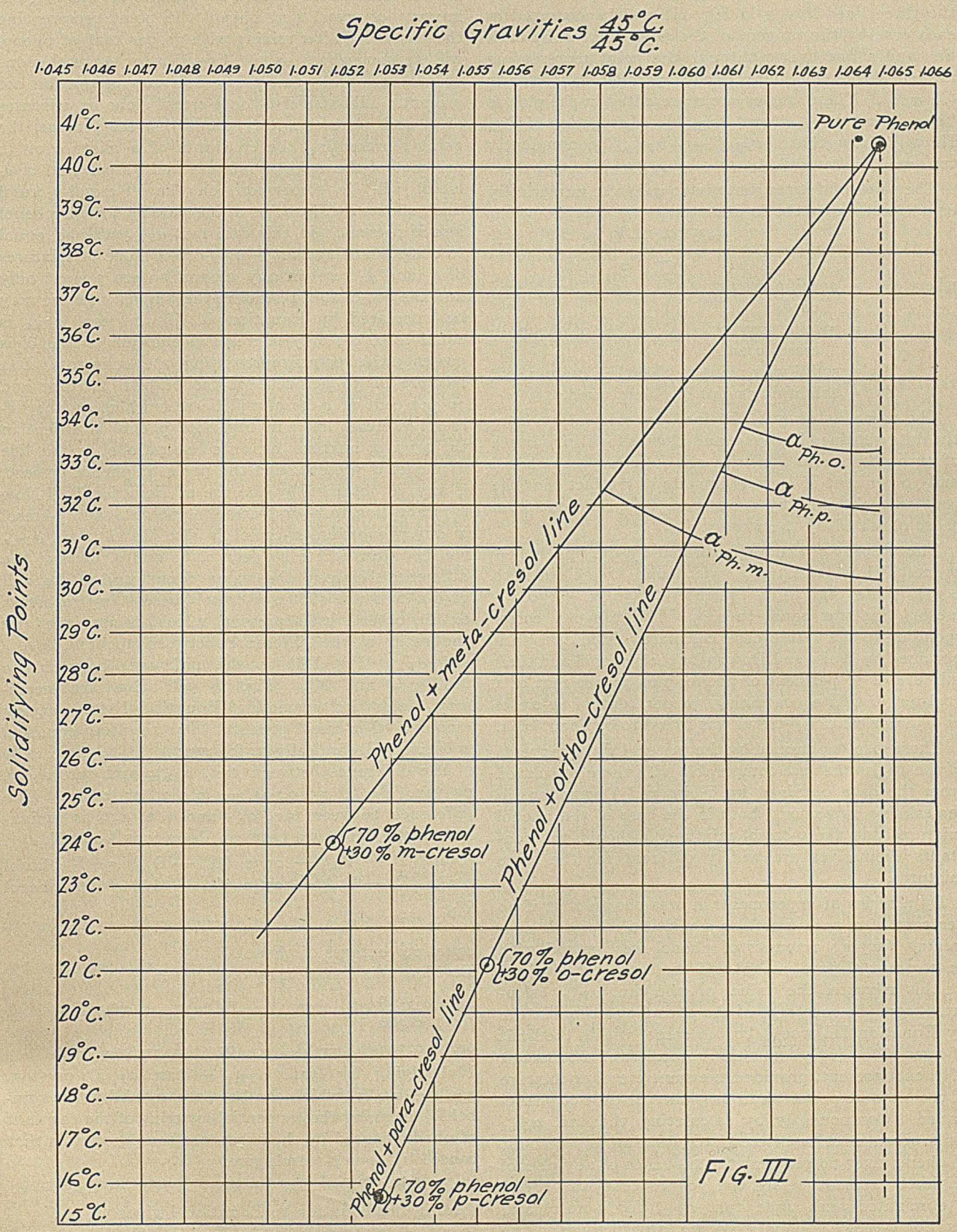

Specific Gravities 45°C./45°C.
1.045 1.046 1.047 1.048 1.049 1.050 1.051 1.052 1.053 1.054 1.055 1.056 1.057 1.058 1.059 1.060 1.061 1.062 1.063 1.064 1.065 1.066
Solidifying Points
41°C. 40°C. 39°C. 38°C. 37°C. 36°C. 35°C. 34°C. 33°C. 32°C. 31°C. 30°C. 29°C. 28°C. 27°C. 26°C. 25°C. 24°C. 23°C. 22°C. 21°C. 20°C. 19°C. 18°C. 17°C. 16°C. 15°C.
Pure Phenol
α Ph. o.
α Ph. p.
α Ph. m.
Phenol + meta-cresol line
Phenol + ortho-cresol line
Phenol + para-cresol line
70% phenol +30% m-cresol
70% phenol +30% o-cresol
70% phenol +30% p-cresol

FIG. III

The combined effect of each cresol on the solidifying point and specific gravity of phenol is represented by the three lines shown in Fig. III and is measured in each case by the tangent of the angle formed by each line and a line drawn through the point representing the constants for pure phenol parallel to the axis (X = 0). These angles are represented in the plot as "$\alpha_{Ph.o.}$" and "$\alpha_{Ph.m.}$" and "$\alpha_{Ph.p.}$" Inspection of Fig. III will show that "$\alpha_{Ph.o}$" = "$\alpha_{Ph.p.}$" consequently tan. $\alpha_{Ph.o.}$ = tan. $\alpha_{Ph.p.}$

The value of this tangent was found to be numerically equal to 0.482 by the formula

$$\tan.\ \alpha_{Ph.s.} = \frac{1000\ (G_p - G_{sp})}{T_p - T_{sp}}, \qquad \text{(III)}$$

where G_p = specific gravity 45° C./45° C. of phenol used,

G_{sp} = specific gravity 45° C./45° C. of phenol + cresol used,

T_{sp} = solidifying point of phenol + cresol used,

T_p = solidifying point of phenol used.

The same value was obtained by calculation from the data obtained by Weiss and Downs for their sample of pure phenol and their mixture of 70 per cent phenol and 30 per cent of *o*-cresol in spite of the fact that the constants obtained by them were very different from those obtained by the writers.

The tangent of the angle formed by the "phenol + *m*-cresol" line (tan. $\alpha_{Ph.m.}$) was found to be equal to 0.794, while that of a "phenol + (50 *m* + 50 *p*)-cresol" line was equal to 0.65. The tangent corresponding to the latter case calculated from the data obtained by Weiss and Downs for their phenol and their mixture of 70 per cent of phenol plus 30 per cent of a coal-tar distillate containing 50 per cent of *m*-cresol and 50 per cent of *p*-cresol was found to be about 0.64.

Those results obtained by the writers for the tangents of the angles that are comparable with those calculated from the data obtained by Weiss and Downs, are in remarkable agreement, both in the case of the phenol mixtures and the *o*-cresol mixtures, although the constants themselves are widely different for the same mixtures.

By a series of experiments it was shown that if 30 per cent of a pure cresol or a mixture of cresols containing varying amounts of phenol were mixed with 70 per cent of pure phenol and the constants obtained on this mixture, the value of the tan. $\alpha_{Ph.s.}$ calculated from the constants of the phenol and the mixture by Equation III would be the same, within the limit of error of the analytical work, regardless of the amount of phenol present, provided the same cresol or mixture of cresols were present and only the per cent of phenol varied. Consequently by calculating the tan. $\alpha_{Ph.s.}$ for a given mixture of cresols containing any amount of phenol over 70 per cent the influence of any phenol originally present before the 70 per cent was added is eliminated and since tan. $\alpha_{Ph.s.}$ for *o*-cresol and also for *p*-cresol is equal to 0.482, any increase in the value of tan. $\alpha_{Ph.s.}$ over 0.482 gives a measure of the amount of *m*-cresol present.

Now the "phenol + *o*-cresol line" in Fig. III is coincident with the "phenol + *p*-cresol line" and no matter how much phenol is present in the original mixture of cresol and phenol the point representing the constants after mixing with 70 per cent of phenol will lie somewhere on the line if *o*- or *p*-cresol alone or mixtures of *o*- and *p*-cresol in any proportion are present. Likewise if *o*- or *p*-cresol alone or mixtures of *o*- and *p*-cresol in any proportion are present, the point representing the constants of a mixture of 30 per cent of the original mixture and 70 per cent of *o*-cresol will lie somewhere on the "*o*-cresol-*p*-cresol line" shown in Fig. I, or a line parallel to it if phenol also is present. In this case tan. $\alpha_{Ph.s.}$ will be equal to 0.482, showing that *o*- or *p*-cresol alone or mixtures of *o*- and *p*-cresol in any proportion are present only and the per cent of phenol in the original mixture may be calculated by Equation I. If the tan. $\alpha_{Ph.s.}$ is equal to 0.794, only *m*-cresol in addition to phenol is present; the point representing the constants of a mixture of 30 per cent of the original mixture and 70 per cent of *o*-cresol will lie somewhere on the "*o*-cresol-*m*-cresol line" in Fig. I, if phenol is absent in the original mixture, or, on a line parallel to this line if phenol is present, and the per cent phenol present, if any, is obtained by the use of Equation II. Now if in addition to *o*- or *p*-cresol alone or *o*- and *p*-cresol in any proportion, *m*-cresol is also present, tan. $\alpha_{Ph.s.}$ will be intermediate between 0.482 and 0.794; and the difference between the value found and 0.482 will give a measure of the *m*-cresol present in proportion to the other cresols present, which, if multiplied by the ratio of the difference between the tan. $\alpha_{Ph.m}$ and $\alpha_{Ph.o.}$ (Fig. III) to the difference between the tan. $\alpha_{o.m.}$ and $\alpha_{o.p.}$ (Fig. I) will give the necessary factor for correcting Equation I for varying amounts of *m*-cresol present. The resulting equation is derived algebraically as follows:

The difference between tan. $\alpha_{Ph.m.}$ and tan. $\alpha_{Ph.o.}$, or tan. $\alpha_{Ph.p.}$, = 0.794 — 0.482, or 0.312. The difference between tan. $\alpha_{o.p.}$ and tan. $\alpha_{o.m.}$ is equivalent to the difference between Equations I and II.

$$0.366\ (T_o - T_{so}) - 2970\ (G_o - G_{so}) = \%\ \text{phenol}$$
$$0.585\ (T_o - T_{so}) - 2780\ (G_o - G_{so}) = \%\ \text{phenol}$$

or,

$$0.219\ (T_o - T_{so}) + 190\ (G_o - G_{so}) = 0, \quad \text{for equal percentages of phenol.}$$

Dividing this equation by 0.312 gives

$$\frac{0.219}{0.312}(T_o - T_{so}) + \frac{190}{0.312}(G_o - G_{so}) = 0$$

or, $0.702\ (T_o - T_{so}) + 609\ (G_o - G_{so}) = 0.$

Multiplying by (tan. $\alpha_{Ph.s.}$ — tan. $\alpha_{Ph.o.}$) or (tan. $\alpha_{Ph.s.}$ — 0.482) which can be represented by the symbol L_s, meaning the tangential lowering of the constant of phenol caused by the substance compared with that caused by *o*- or *p*-cresol, gives

$$0.702\ L_s\ (T_o - T_{so}) + 609\ L_s\ (G_o - G_{so}) = 0.$$

Adding this equation to Equation I gives

$$(0.366 + 0.702\ L_s)\ (T_o - T_{so}) + (609\ L_s - 2970)\ (G_o - G_{so}) = \text{per cent phenol}$$

or, $(0.366 + 0.702\ L_s)\ (T_o - T_{so}) + (2970 - 609\ L_s)\ (G_{so} - G_o) = \text{per cent phenol,}$ (IV)

where $L_s = \frac{1000\,(G_p - G_{sp})}{T_p - T_{sp}} - 0.482$

in which G_p = sp. gr. 45° C./45° C. of the phenol used,
G_{sp} = sp. gr. 45° C./45° C. of the 70 per cent phenol + 30 per cent cresol mixture,
T_{sp} = solidifying point of the 70 per cent phenol + 30 per cent cresol mixture
and T_p = solidifying point of the 70 per cent, phenol used,
and where G_o = sp. gr. 25° C./25° C. of the *o*-cresol used,
G_{so} = sp. gr. 25° C./25° C. of the 70 per cent *o*-cresol + 30 per cent cresol mixture,
T_{so} = solidifying point of the 70 per cent *o*-cresol + 30 per cent cresol mixture,
and T_o = solidifying point of the *o*-cresol used.

When the distillate analyzed is composed of *o*-cresol or *p*-cresol alone or a mixture of these two cresols in any proportion L_s becomes equal to 0.0 and Equation IV is transformed into Equation I. As the proportion of *m*-cresol to the other cresols present increases, L_s increases in value until 100 per cent of *m*-cresol is present, when L_s becomes equal to 0.312 and Equation IV is transformed into Equation II.

Although Equation IV does not give absolutely accurate results with all possible mixtures of the three isomeric cresols it does give them with any of the three cresols alone, with all possible mixtures of *o*- and *p*-cresol and all possible mixtures of *m*- and *p*-cresol. Where *o*-cresol and *m*-cresol are present in varying proportions and *p*-cresol is absent or present in very small quantities, results obtained are too low, the error increasing as *o*-cresol increases and *p*-cresol simultaneously decreases until the greatest is introduced where *p*-cresol is absent and less than 50 per cent of *m*-cresol and more than 50 per cent of *o*-cresol is present. Even in this case the error is compensated for, as the relative proportion of *o*- to *m*-cresol increases, by the factor ($T_o - T_{so}$) simultaneously decreasing proportionately, so the ultimate error is never very large in any case. Moreover, it is hard to conceive of a case in actual commercial practice where *o*- and *m*-cresol would occur together in the absence of, or in the presence of a small amount of *p*-cresol, since no evidence has ever been found that *p*-cresol was removed from a crude cresylic acid, as is the case with *m*-cresol, and, owing to the fact that *p*-cresol distils at a temperature between the boiling point of *o*-cresol and that of *m*-cresol, in the ordinary processes of distillation there is more likely to be a dearth of *o*- or *m*-cresol in a mixture of the three cresols in commercial products than of *p*-cresol. This fact is confirmed by Ihle[1] and by Tiemann and Schotten[1] who found "mostly *o*- and *p*-cresol with a little *m*-cresol" present, while Schulze[2] found "about 40 per cent *m*-, 35 per cent *o*- and 25 per cent *p*-cresol" in tar oils. In the latter case, as well as in practically all those cases ordinarily met with in commercial practice, where all three cresols are present in varying amounts, the probable error would amount to only a few tenths of a per cent in the final result, which is about the same as the probable error inherent to the determination of the constants of the different mixtures.

In the application of Equation IV to the determination of phenol in commercial products, such as crude cresylic acid, it is necessary to remove completely even small quantities of hydrocarbons, and to remove effectively xylenols, higher homologues and bases, inasmuch as it was found on practical application that the presence of even very small amounts of hydrocarbons would seriously affect the accuracy of the results while the presence of bases, xylenols and other higher homologues, though not affecting the ultimate result to so great a degree as the hydrocarbons, nevertheless introduced serious errors when present in very great amounts.

THE HYDROCARBONS were found to be more effectively removed by diluting the original sample with 2 volumes of benzol before extracting with caustic soda solution. In addition, this process in most cases renders unnecessary the preliminary distillation in the case of dark colored products.

THE BASES are effectively removed by the regular process of separating the tar acids, being left behind in the acid liquor on acidifying the carbolate solution.

The problem of separating effectively the XYLENOLS and HIGHER HOMOLOGUES from phenol and the cresols was investigated by comparing results obtained in actual analysis, using most of the still-heads enumerated and illustrated by Rittman and Dean[1] in their article on the analytical distillation of petroleum.

The results were far from satisfactory. Those still-heads that effectively removed the xylenols choked up and caused considerable annoyance and delay in the process of distillation, while those that distilled without choking up failed to remove the xylenols. To remedy these defects a special still-head was designed of the proper dimensions for this work. This still-head is described later on. It has been used for a long time now and has proved satisfactory.

Other details in the manipulation, the necessity for which will be obvious, were worked out and owing to the impracticability of obtaining thermometers and still-heads of exactly standard dimensions the distillation temperatures are given corrected for emergent steam, thus eliminating the necessity of having still-heads and thermometers of certain dimensions.

DESCRIPTION AND METHOD OF USE OF THE KNIGHT STILL-HEAD

This still-head is especially designed for use in separating xylenols and higher homologues from phenol and the cresols. It consists of three 2-in. bulbs joined by 2 glass tubes $^3/_{16}$ in. long and having a $^9/_{32}$-in. aperture. The upper bulb is connected with a glass tube open at the top ($^5/_8$ in. inside diam. and 3 in. long) and having a side tube ($^7/_{32}$ in. inside diam.)

[1] *Loc. cit.*

[1] THIS JOURNAL, 7 (1915), 755.

which is joined on about $1^1/_4$ in. above the upper bulb and is bent downward at any suitable angle and for any desired length. The lower bulb has a glass syphon tube ($^1/_8$ in. inside diam.) joined to the side of the bottom of the bulb and bent upward to slightly less than half way up the side of the lower bulb and then bent downward, following roughly the contour of the bulb, and passing through and down the center of another tube, $4^1/_2$ in. long and $^3/_8$ in. inside diam., along $3^1/_2$ in. of the lower part and $^7/_{32}$ in. inside diam.

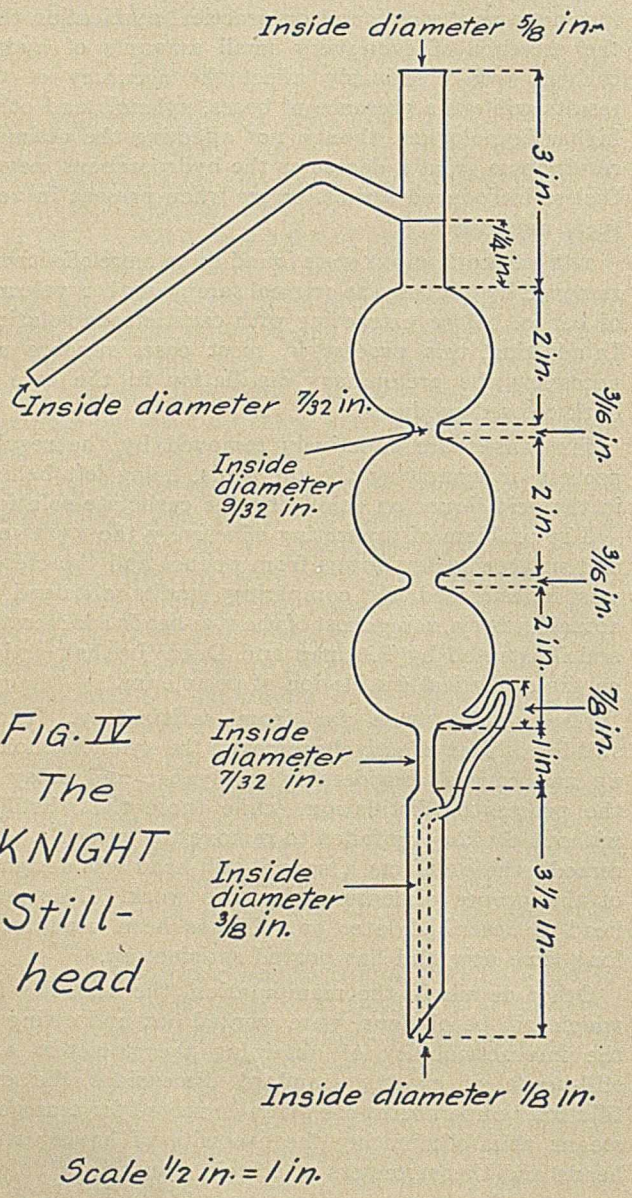


FIG. IV The KNIGHT Still-head

along 1 in. of the upper part where it is joined to the lowest bulb of the still-head. The syphon tube enters the $^3/_8$ in. diameter part of the lower tube about $1^1/_2$ in. from the bottom of the lower bulb and passes through the center of the tube to the bottom as shown in the accompanying diagram.

The dimension of the constriction in the lower tube is so calculated to the condensing area of the bulb of the still-head that when the distillation is carried on at the specified rate more vapor will condense than can run back into the distilling flask through the constriction; thus a layer of liquid collects in the bottom of the lowest bulb and acts as a liquid condenser for all vapors passing through it having a higher boiling point than the temperature of the liquid layer. In this way the xylenols and higher homologues which tend to pass over with the phenol and cresols are retained in the liquid layer, and the temperature of the liquid layer is kept hot enough by the vapors to prevent phenol from being condensed. When the height of this layer reaches above the level of the top of the outside portion of the syphon tube, the syphon automatically empties the bulb of the liquid layer and delivers the condensed liquid back into the distilling flask again, provided the rate of distillation is not too fast. A Tirrell burner should be used as a source of heat on account of the ease with which the rate of distillation may be controlled by its use.

Towards the end of the redistillation of the 190–202° fraction, when all the phenol has been removed, occasionally such a small amount of liquid remains in the distilling flask that scorching is liable to occur. In this case, and in other cases where it seems necessary to carry a small amount of liquid layer in the lower bulb, this may be accomplished by tipping the top of the still-head away from the condenser so that the still-head instead of being vertical is inclined at an angle from top to bottom toward the condenser. By regulation of this angle the syphon may be made to empty as frequently as the operator desires.

METHOD

Weigh out 100 g. of the sample (W) in a tared beaker to centigrams. Pour the oil into a separatory funnel (500 cc. capacity); rinse the flask with 200 cc. of benzol, adding the rinsings to the sample contained in the separatory funnel. Mix the contents of the separatory funnel, add 100 cc. of a 20 per cent NaOH solution, shake thoroughly for two minutes, allow to settle, and draw off the lower layer[1] into another separatory funnel of 600–700 cc. capacity.

Repeat the extraction of the benzol layer with successive 100-cc. portions of 20 per cent NaOH solution, drawing off the lower layer as before until no more tar acids are extracted, as shown by acidifying the last portion (3 or 4 shake-outs are usually sufficient). Shake the combined NaOH extracts out with 30-cc. portions of benzol until any hydrocarbons that may have been carried through into the NaOH extracts by benzol and tar acids have been removed as shown by heating the NaOH solution in a beaker to a gentle boil until the odor of benzol disappears and the characteristic odor of coal-tar hydrocarbons can no longer be detected. Wash the combined benzol extracts a couple of times with 10 cc. of 20 per cent NaOH solution and add the washings to the NaOH solution.

[1] Occasionally a black tarry sample will be encountered with which it will be difficult to distinguish the line of separation of the layers. In this case it will be necessary, first to distil enough of 100 grams of the sample to be sure that all of the phenol has been removed, and then pour the distillate into the separatory funnel, add the 200 cc. of benzol and proceed as above.

Acidify the combined caustic soda extracts with dilute sulfuric acid (50 cc. of concentrated acid mixed with 150 cc. of water). The solution is conveniently held in a 1-liter Jena Erlenmeyer flask. The acid must be added in small portions at a time, and the solution cooled by immersing the flask in water or holding it under a tap of running water so that the temperature does not rise above 40° C. as measured by a thermometer placed in the flask.

As it approaches neutrality the solution becomes light in color, and should be tested occasionally with litmus paper. When neutral, add 4 to 5 cc. more of the dilute sulfuric acid, transfer to a 700-cc. separatory funnel rinsing flask and allow to stand till the two layers separate well (from 1 to 4 hours are necessary according to the character of the sample).

Draw off the lower layer into another separatory funnel. Shake the acid-water layer with 30 cc. of benzol; allow the two layers to separate well, draw off the lower layer into another separatory funnel and repeat the extraction with 20-cc. portions of benzol until no more tar acids are extracted, as shown by evaporating a test portion just to dryness on the water bath (usually 4 extractions are enough). Reject the exhausted water layer, add the second benzol shake-out to the first; add the third benzol shake-out to the separatory funnel which had contained the second benzol shake-out and then add it to the first two benzol shake-outs. Repeat this process with the fourth benzol extract, etc., rinsing out each successive funnel with the last benzol extract, and combine all the shake-outs with the first. Wash the combined benzol extracts with 10 cc. of saturated salt solution and draw off and reject the salt solution. Draw off the tar acids into a 300-cc. round bottom, short neck, distilling flask, made of Jena or other heat-resisting glass; rinse out the separatory funnel with the combined benzol shake-outs of the acid-water layer, and add to the tar acids in the distilling flask. Distil off the benzol and water into a separatory funnel, using a medium size Wurtz still-head having an inlet tube below the first bulb $^9/_{32}$ in. inside diameter (both will come off practically completely below 170° C., and there will be an abrupt rise beginning at about 100–120° C.). The distilling flask should rest on a $^1/_4$ in. asbestos board 6 in. square with an opening in the center $3^1/_2$ in. in diameter and be enclosed entirely in an asbestos shield; the thermometer should be a standard thermometer, calibrated by the Bureau of Standards and accurate to $^1/_5$° C., over the range 170 to 210° C.; the condenser should be long enough, and cooled with sufficient cold water, to prevent loss by lack of proper condensation; the top of the bulb of the thermometer should be on a level with the bottom of the outlet tube of the still-head, and the upper part of this still-head and the one used later should be protected with thick asbestos cloth held in place with copper wire hoops and extending from the top of the upper bulb to the top of the still-head. When water and benzol are out of the condenser, stop the distillation (it does not matter if some oil distils over with the water).

Allow the still to cool; rinse out the Wurtz still-head with a small amount of benzol and add the rinsing to the benzol and water distillate. Saturate the water layer with salt, shake, separate, reject the salt water layer, and extract the benzol layer with 5-cc. portions of 20 per cent NaOH solutions until any tar acids in the benzol layer are removed (as shown by acidifying a test portion of the last shake-out with dilute sulfuric acid.) (Usually 3 or 4 extractions are enough.) Acidify the combined NaOH extracts with dilute sulfuric acid as before, allow to stand, separate any tar acids that collect, and add to the tar acids in the distilling flask. Continue the distillation, using a Knight still-head in place of the Wurtz still-head, and collect the distillate, first in a 10-cc. burette, until the oil passes over clear, then change to a tared 100-cc. cylinder, weighed to centigrams, and collect up to 193° C. (corr.).[1] Meanwhile saturate with salt any water layer that may be mixed with the tar acids in the 10-cc. burette and allow to stand. At 193° C. (corr.) change the receiver, stop the distillation, allow the still to cool, separate the tar acids from the saturated salt water, if any, contained in the 10-cc. burette, rejecting the salt water and drawing off the tar acids into the distilling flask; continue the distillation and collect the distillate up to 206° C. (corr.), distilling, as nearly as possible, at the rate of 0.5 to 1.0 cc. per minute.

Transfer the distillate collected from 193 (corr.) to 206° C. (corr.) to another flask and redistil at the same rate as before, collecting the distillate up to 201° C. (corr.) in the same tared cylinder used for collecting up to 193° C. (corr.) in the initial distillation. Weigh the cylinder containing the distillate to centigrams and calculate the weight of the distillate (D). Pour the distillate into a suitable size Erlenmeyer flask and mix thoroughly by pouring back and forth, and then stopper the flask.

Weigh out as accurately as possible 4. 5 g. of this distillate and 10.5 g. of *o*-cresol (solidifying point above 28° C.). Mix these two portions thoroughly; if necessary, heat cautiously in warm water to dissolve any crystals of *o*-cresol that may be undissolved, and keep in a stoppered flask.

Determine the SPECIFIC GRAVITY (G_{50}) of this mixture, at 25° C./25° C., in a carefully calibrated and tared 10-cc. Geissler pycnometer, having a thermometer carefully calibrated to within 0.1° C. at 25° C., being careful to make consecutive weighings and to wipe off the pycnometer thoroughly between weighings, until the weight is constant to a few tenths of a milligram.

Determine the solidifying point of the same mixture, using the apparatus and method described below.

The SOLIDIFYING POINT determination should be

[1] This temperature and all subsequent distillation temperatures are given corrected for stem exposure, using the formula: stem correction = 0.00016 N (T° — t°), where N = number of degrees exposed, T° = temperature of the thermometer bulb, and t° = average temperature of the exposed stem. This correction will make a difference of 3 to 40° C. at these temperatures, but the corrected temperatures will be consistent regardless of the thermometer used, provided it is a standard thermometer. A corrected temperature of 193° C. will usually give an observed reading of 190° C. although this will vary slightly with different thermometers.

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made in an apparatus composed of a cylindrical glass vessel 6 in. in diameter by $7^1/_2$ in. high filled with water or iced water at a temperature about 5° C. below the expected solidifying point and containing a cylindrical salt-mouthed bottle of about $3^1/_2$ in. diameter and about $6^1/_4$ in. high, clamped in position so that the bottle is almost completely immersed. The bottle is closed with a cork stopper through which passes a short test tube 4 in. long by $^7/_8$ in. diameter, fitted snugly into the stopper so that none of the tube extends above the top of the stopper. The test-tube is closed with a rubber stopper through which pass the standard thermometer and a looped platinum stirrer. The thermometer used should be a standard thermometer reading to tenths and calibrated by the Bureau of Standards to hundredths of a degree over the range between 6 and 41° C. The determination should be conducted as follows:

Pour enough of the mixture into the test-tube to give a layer more than sufficient to cover the bulb of the thermometer. Insert the thermometer and the platinum stirrer passing through the rubber stopper into the mixture; press the stopper tightly into the test-tube and stir the mixture continuously with the platinum stirrer till the temperature is near the expected solidifying point. Then introduce a few fine crystals of *o*-cresol into the mixture and continue the stirring until the mass crystallizes, and the temperature rises to a maximum point and remains constant. This temperature is the solidifying point (T_{so}).

Repeat the determination of the specific gravity and solidifying point (T_{sp}) of the distillate, using phenol of 40° C. or higher solidifying point, instead of *o*-cresol, and determining the specific gravity at 45° C./45° C. (G_{sp}), instead of 25° C./25° C.

The following procedure should be followed in determining the specific gravities:

In the case of phenol and phenol mixtures, where the specific gravity is determined at 45° C., the pycnometer with the cap and thermometer removed is filled with the phenol or phenol mixture which has previously been heated very cautiously in warm water at a temperature of about 50° C. until the phenol crystals have dissolved and the phenol reached a temperature of about 45° C. The thermometer is then placed in the pycnometer and the pycnometer immersed in water at a temperature slightly higher than 45° C. The water in the bath is then repeatedly adjusted until it is at 45° C. at the same time that the pycnometer thermometer registers 45° C. (The pycnometer is immersed in the warm water almost up to the point where the thermometer enters the pycnometer.) The pycnometer is then removed from the water, the cap put on, the whole pycnometer carefully wiped dry, weighed to tenths of a milligram, removed from the scale pan, wiped again and weighed again until two successive weighings check to within a few tenths of a milligram.

In the case where the specific gravity is determined at 25° C. and the room temperature is above 25° C., the mixture to be tested, after first being heated, if necessary, in water at about 30–35° C. to melt any *o*-cresol crystals, should be first cooled in cold water to a few degrees below 25° C. and then the pycnometer filled, immersed up to the neck in water slightly above 25° C., etc., the same procedure being followed as described above. The cap in this case should have a slight perforation at the top to relieve any pressure that might raise the cap and cause loss.

The per cent of phenol in the original substance is calculated in the following manner:

First calculate the relative tangential lowering of the specific gravity of the phenol-distillate mixture (L_s) by the equation

$$L_s = \frac{1000\,(G_p - G_{sp})}{T_p - T_{sp}} - 0.482.$$

Then calculate the per cent phenol in the sample by the following equation:

$$\text{Per cent phenol} = 100\ D\ [(T_s - T_{so})\ (0.366 + 0.702\ L_s) + (G_{so} - G_o)\ (2970 - 609\ L_s)]/30W,$$

where G_p = sp. gr. 45°/45° C. of the phenol used,
G_{sp} = sp. gr. 45°/45° C. phenol + distillate mixture,
T_p = solidifying point of the phenol used,
T_{sp} = solidifying point of the phenol + distillate mixture,
D = weight of total distillate below 197° C.,
G_o = sp. gr. 25°/25° C. of the *o*-cresol used,
G_{so} = sp. gr. 25°/25° C. of the *o*-cresol + distillate mixture,
T_o = solidifying point of the *o*-cresol used,
T_{so} = solidifying point of the *o*-cresol + distillate mixture,
and W = weight of the sample used,

SUMMARY

For the determination of phenol in the presence of the three cresols, a feasible method is developed which not only obviates the necessity of referring to a plot in calculating results, but gives concordant and reliable results with all the different combinations and percentages of the different cresols and phenol likely to be met with in commercial practice; in addition, the method is not dependent for its accuracy on the purity of the particular *o*-cresol used by the investigators for the derivation of their formula for calculating the per cent of phenol. In applying the principle involved to the practical determination of phenol in crude commercial tar acids, suitable provision is made for the complete separation of the small amounts of hydrocarbons that are usually present in crude cresylic acids, especially those made from blast furnace tar, which would otherwise introduce serious error. A new still-head, especially designed for this kind of work, is used for the more complete and satisfactory removal of the xylenols and higher homologues.

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THE DETERMINATION OF MANGANESE IN STEEL IN THE PRESENCE OF CHROMIUM AND VANADIUM BY ELECTROMETRIC TITRATION

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The determination of manganese in steel in the presence of chromium and vanadium has long offered difficulties to the analyst in steel works laboratories. Numerous methods have been developed with the object of alleviating or overcoming these difficulties. Cain[1] and Watters[2] recommend devices for the separation of the manganese. Cornelius[3] and Dedericks,[4] although not particularly concerned with the analysis of steel, have recommended procedures available for the quantitative separation of manganese from chromium and vanadium. Talminger[5] has proposed a method of the latter type, using von Knorre's procedure, *viz.*, the precipitation of manganese by ammonium persulfate. Koester[6] has investigated Engel's method for the electrodeposition of manganese in the presence of chromium, and finds chromium occluded. Cain[7] finds that the Ford-Williams method gives high results due to the occlusion of chromium. Even in the Volhard-Wolff[8] method chromium and vanadium interfere.

The two methods most in use for the determination of manganese in steel are known as the persulfate and bismuthate methods. In the first of these the manganese in a nitric acid solution of the steel is oxidized with ammonium persulfate and silver nitrate, after which it is titrated with sodium arsenite. Wdowiszewski[9] reports good results with this method, even in the presence of 1 per cent chromium. In this laboratory, however, it has been noted that the method rapidly becomes less useful as the percentage of chromium rises, owing to the obscurity of the end-point. In the bismuthate method the manganese in a solution of the sample is oxidized with sodium bismuthate, the excess filtered out and an added excess of ferrous sulfate titrated with permanganate. Here even a trace of chromium may cause trouble and this difficulty rapidly increases with the larger percentage of chromium often met in commercial steels. By cooling the solution thoroughly with ice before oxidizing the manganese the tendency of the chromium to oxidize is depressed, and if this procedure is followed by rapid filtration fairly satisfactory determinations of manganese may be made even in the presence of 5 per cent of chromium in the sample. The consistently successful analysis of such material by this method, however, requires a high degree of skill. Demorest[10] suggests titrating the solution with sodium arsenite until the color of the permanganate disappears. He has tested this method by titrating solutions of steel to which chromium corresponding to 3 per cent of the weight of the sample has been added as chromate immediately before titrating. Under the usual conditions of analysis most of the chromium is present as chromic salt and such amounts of chromium in this state make the end-point obscure. In the presence of 5 per cent or more of chromium all of these methods, except those which involve the separation of manganese, are extremely uncertain.

In this paper we describe a method which has sufficient accuracy for all technical purposes and which, without the separation of chromium and vanadium, is not interfered with by these elements under the conditions of analysis. The oxidation of the manganese in this method may be accomplished either by the bismuthate or persulfate procedures, and titration is made electrometrically, using mercurous nitrate as the reducing agent. In the course of the examination of a long list of reducing agents this was the only reagent found which would reduce permanganate quantitatively and rapidly at ordinary temperatures without reducing chromates or vanadates.

THE STANDARDIZATION OF THE MERCUROUS NITRATE SOLUTION

10.5 g. of mercurous nitrate are dissolved in 150 cc. of water to which 2 cc. of nitric acid have been added. Any undissolved salt is removed by decantation and the solution made up to a volume of one liter. This is compared electrometrically on the apparatus made for this laboratory by the Leeds & Northrup Company,[1] with a solution of potassium permanganate which has been standardized against sodium oxalate. The permanganate solution contains 0.5 g. of Mn per liter, each cc. being equivalent to 0.05 per cent of Mn in a 1-g. sample of steel. The medium in which the titration is made is a solution containing 50 cc. of sulfuric acid (sp. gr. 1.58) and 200 cc. of water. The temperature should not be above 40°. For purposes of this titration, permanganate is added to the solution in any convenient amount and titrated with mercurous nitrate. The details of the titration will be given at a later point in this article.

THE REACTION

When titration is complete, the solutions have a brown color suggesting dissolved manganese dioxide. The solutions, however, appeared to be quite stable. When solutions containing 10 cc. of permanganate had been titrated and were allowed to stand in a stoppered Erlenmeyer flask at room temperature, no precipitates appeared after some weeks. Filtration removed only a small amount of the solids. With solutions containing as much as 40 cc. permanganate solution, a faint turbidity appeared after 24 hrs. On warming, even to 40°, manganese dioxide was precipitated.

After titrating 40 cc. of the $KMnO_4$ solution with mercurous nitrate, the titration was continued with ferrous sulfate of equivalent concentration on the same apparatus. This was found to require 12 cc.

[1] This Journal, 3 (1911), 630.
[2] *Met. & Chem. Eng.*, 9 (1911), 244.
[3] *Pharm. Ztg.*, 58, 427.
[4] *Ibid.*, p. 446.
[5] *Chem.-Ztg.*, 34 (1910), 1877.
[6] *Z. Elektrochem.*, 17 (1911), 57.
[7] *Loc. cit.*
[8] *Stahl u. Eisen*, 33 (1913), 633.
[9] *Ibid.*, 28 (1908), 1067.
[10] This Journal, 4 (1912), 19.

[1] This Journal, 9 (1917), 780.

of ferrous sulfate. It is believed that the latter reaction was the reduction of quadrivalent manganese to the bivalent state. Our efforts to prove this point were not entirely successful. When the solutions after titration were warmed, both in the original volume of 250 cc., and diluted to larger volumes up to one liter, the amount of MnO_2 precipitated varied in an uncertain manner. Changing the temperature from 40° to boiling did not serve to indicate a procedure which would give consistent results. The MnO_2 so precipitated was collected on asbestos and, after washing, mixed with dilute sulfuric acid. An excess of ferrous sulfate was then added and the solution titrated with permanganate electrometrically. From 8 to 10 cc. of ferrous sulfate were required for titration, an amount always less than that required for a similar titration before precipitation. One possible explanation of this is that the manganese dioxide as formed is in a hydrated condition and while in this condition it may be that it very readily undergoes decomposition in part into manganous sulfate and oxygen. That there is a diminution in oxidizing power by precipitation is shown by the fact that the oxidizing power of the precipitate and filtrate combined is insufficient to oxidize 12 cc. of ferrous sulfate as is done when the titration with ferrous sulfate is made without precipitation.

In the foregoing discussion 40 cc. of the solution were taken as a unit in the study of the quantitative precipitation of manganese dioxide. In the discussion which follows we shall adhere to this volume.

To determine the amount of mercurous salt present in the mercurous nitrate solution 40 cc. were diluted to 200 cc., and 200 cc. of a solution containing 5 g. of sodium chloride gradually added with stirring. This was followed by the addition of 10 g. of sodium acetate in the form of a filtered solution. The precipitate was washed with water containing a little sodium chloride and finally with water alone. It was dried at 150°. Two determinations gave 0.3005 g. and 0.2999 g., respectively. The $Hg_2(NO_3)_2$ present in 40 cc. of this solution was found from the average of these determinations to be 0.3340 g.

From the data supplied by the known concentrations of the permanganate and mercurous nitrate solutions, and from the oxidizing power of the solution towards ferrous sulfate after titration with permanganate, we can construct the following equation:

$$4\ Mn^{VII} + 14\ Hg^{I} = 3\ Mn^{IV} + 1\ Mn^{II} + 14\ Hg^{II}$$

Basing our calculation on the known strength of the permanganate solution, theory requires that the mercurous nitrate in 40 cc. should be 0.3346 g., which corresponds closely with 0.3340 g. found. Correspondence is also found in that 12 cc. of an equivalent solution of ferrous sulfate would be required for the reduction of three atoms of quadrivalent manganese.

While the reaction given above quite certainly indicates with accuracy the oxidizing power of the solution as left after titration, it has seemed to us necessary to make an effort to secure additional information in its support. We give below a brief outline of some of our observations with their implications as understood by us, omitting, however, experimental details because of the inconclusive character of the work.

When manganous sulfate is added to the solution of permanganic acid before titration with mercurous nitrate, it has the effect of diminishing the amount of mercurous nitrate necessary. The effect, however, is not a regular one, for the addition of small amounts of manganous salt produces a proportionately larger effect upon the titration than large additions. Such additions noticeably alter the color of the solution, changing it from brownish yellow to brownish red, suggesting the formation of manganic salts. Barnebey[1] reviews the explanations which have been offered to account for the effect of manganous salts upon the titration of ferrous iron with permanganate in the presence of hydrochloric acid. He quotes Volhard as suggesting that the action of manganous salts on the permanganate results in the formation of quadrivalent manganese, while Birch suggests the formation of trivalent manganese. When the solution after titration with mercurous nitrate is treated with manganous salt, the same reddish color appears as when the manganous salt is added before titration. If we are correct in our belief that the product of the reaction is manganic sulfate in both instances, this would constitute additional evidence of the presence of quadrivalent manganese in the titrated solution.

From the fact that we are unable to remove MnO_2 from the solution by filtration after titration, this substance, if present, must be evident either as a sulfate or in the colloidal condition. Witzemann,[2] discussing the conditions under which colloidal solutions of manganese dioxide are stable, points out that small amounts of either salts or acids cause immediate precipitation. Evidence for the existence of sulfates of quadrivalent manganese is meagre. Fremy[3] states that $MnO(SO_4)$ is formed by acting on hydrated MnO_2 with concentrated sulfuric acid in air. The fact that a moderately high concentration of sulfuric acid is necessary to prevent the precipitation of manganese dioxide in this titration may be construed as indicating the formation of a sulfate of quadrivalent manganese.

From the reaction as given above it appears that after titration one-fourth of the manganese is present as manganous salt. We precipitated the quadrivalent manganese by boiling a diluted solution and determined the manganese in the filtrate. The filtrate from the titration of 40 cc. of permanganate should have contained the equivalent of 10 cc. of this solution. We always found it to be larger than this (about 15 cc.), as might have been expected from the fact that the manganese dioxide precipitated was always too small in amount to correspond to the theory. Blum[4] states that precipitated manganese dioxide is not

[1] *J. Am. Chem. Soc.*, **36** (1914), 1441.
[2] *Ibid.*, **37** (1915), 1079.
[3] *Compt. rend.*, **82** (1876), 475.
[4] *J. Am. Chem. Soc.*, **34** (1912), 1394.

oxidized by sodium bismuthate in nitric acid. We added 30 cc. of nitric acid (sp. gr. 1.13) to a solution in which 40 cc. of permanganate solution had been titrated and which therefore probably contained quadrivalent manganese. The solution was then oxidized with sodium bismuthate, filtered through asbestos and titrated. The average of four determinations indicated a manganese content corresponding to 31.5 cc. of the permanganate solution. To test the completeness of oxidation of manganous salts under these conditions, we oxidized a solution of manganous sulfate in a similar mixture of acids and found the oxidation to be complete. Our failure to secure an amount or permanganic acid corresponding to 40 cc. of the original solution of permanganate may have been caused by the failure of the quadrivalent manganese to oxidize completely, owing to the nature of the solution. A colloidal solution of manganese dioxide, if it were possible for it to exist, might be expected to react as in this case.

From the foregoing and other considerations, our quandary as to the course of the reaction may be set forth as follows: (1) The relation of permanganate and mercurous salt seems to be definitely established. (2) The presence of manganese corresponding in oxidizing capacity to 3 MnO_2 for 4 $KMnO_4$ reduced, appears equally certain. (3) The presence of so large an amount of MnO_2 apparently in solution or suspension seems improbable. (4) The solution upon filtration through paper or asbestos after titrating leaves too much on the filter to correspond to complete solution. (5) If we accept the statement that undissolved manganese dioxide is not oxidized by sodium bismuthate in nitric acid solution, less than one-fourth of the manganese can be present in that form instead of three-fourths as shown in the reaction. (6) The ease with which warming the solution precipitates MnO_2 from these solutions after titration might correspond to the precipitation of suspended manganese dioxide or to the decomposition of trivalent or quadrivalent manganese sulfates. It is not impossible that the reaction might lead to $2\ Mn(SO_4)_2 + Mn_2(SO_4)_3$, but the color of the solution after titration does not indicate the presence of manganic salt. (7) The red color produced by the addition of manganous salts to the titrated solution is probably due to the formation of manganic salts and therefore furnishes evidence of the probable presence of compounds of quadrivalent manganese. The fact that a red color is not produced by interaction between the Mn^{IV} and Mn^{II} shown in the reaction we explain as due to the low concentration of Mn^{II}, for the effect described appears only when relatively large additions of manganous salt are made. (8) Since the final equilibrium corresponds to the disappearance of septivalent manganese and the formation of compounds of quadrivalent and bivalent manganese, we are at a loss to understand why the reaction should not have been either $2\ Mn^{VII} + 6Hg^{I} = 2\ Mn^{IV} + 6\ Hg^{II}$ or $2\ Mn^{VII} + 8\ Hg^{I} = Mn^{IV} + Mn^{II} + 8\ Hg^{II}$ instead of the more complex one first shown, which is the sum of these.

THE TITRATION OF PERMANGANIC ACID IN THE PRESENCE OF CHROMATES AND VANADATES

This titration is best carried out in the presence of a moderately high concentration of sulfuric acid. We have used 50 cc. of acid of sp. gr. 1.58, and 200 cc. of water. With a lower concentration of acid, manganese dioxide separates from solution and irregular results are obtained in titration. Nitric acid does not interfere, but it must be free from nitrous acid, which is best accomplished by treating it with a small amount of sodium bismuthate and filtering to remove the excess. To titrate permanganic acid, the resistance of the electrometric titration apparatus is adjusted to bring the beam of light on the scale. During the addition of the mercurous salt the beam remains stationary or shows a slight anomalous rise of potential until the end of the titration is approached. At this time the addition of more mercurous nitrate causes the beam to move in the opposite direction from which it returns more or less slowly after each addition until the end-point is reached, when it usually remains off the scale. The addition of a few drops of $KMnO_4$ serves to cause it to return. The titration having been carried out rapidly to this point, may be completed by adding the mercurous nitrate solution drop by drop. The end-point is sharp, and it is not affected by the presence of chromates or vanadates, but it is subject to the influence of temperature.

TABLE I—THE TITRATION OF POTASSIUM PERMANGANATE WITH MERCUROUS NITRATE IN THE PRESENCE OF CHROMATES AND VANADATES

Titrations made in 50 cc. H_2SO_4 (sp. gr 1.58) and 200 cc. H_2O

$KMnO_4$ Cc.	$Hg_2(NO_3)_2$ Cc.	G. Cr as Chromate	G. V as Vanadate
5.0	5.0	None	None
5.0	5.0	0.020	0.020
10.0	9.95	None	None
10.0	9.95	0.020	0.020
20.0	19.85	None	None
20.0	19.90	0.020	0.020
40.0	39.85	None	None
40.0	39.80	0.020	0.020

TABLE II—THE INFLUENCE OF TEMPERATURE

Volume and Concentrations as in Table I

Temperature	$KMnO_4$ Cc.	$Hg_2(NO_3)_2$ Cc.
20°	20.00	19.90
20°	20.00	19.90
40°	20.00	19.95
40°	20.00	19.90
60°	20.00	19.90
60°	20.00	19.95
80°	20.00	21.1
80°	20.00	21.4

The titrations shown in Tables I and II were made with a solution of permanganate containing 0.0005 g. of Mn per cc. This corresponds to 0.05 per cent Mn in a 1-g. sample of steel.

THE DETERMINATION OF MANGANESE IN STEEL AFTER OXIDATION WITH SODIUM BISMUTHATE

This method of oxidation is carried out exactly as described by Blair.[1] After filtering, a small piece of ice is added, followed by 50 cc. of sulfuric acid (sp. gr. 1.58). The volume should be 250 cc. and the temperature not above 40° at the time of titration. The procedure in titration is then as described above (Table I).

In Table III analyses of samples of steel issued by the Bureau of Standards are given. To certain of

[1] "The Chemical Analysis of Iron," 7th Ed., p. 122.

these, 0.02 g. Cr as chromate was added immediately before titration.

TABLE III—ANALYSES OF STEELS WITH AND WITHOUT CHROMIUM ADDED AS CHROMATE AFTER OXIDATION WITH SODIUM BISMUTHATE

Sample	Mn Found: No Cr Added	Mn Found: 0.020 g. Cr Added	Mn Present†
9a	0.895	0.910	0.915
9a	0.910	0.905	
19a	0.850	0.850	0.850
19a	0.860	0.850	
30*	0.560	0.560	0.563
30	0.565	0.560	
31*	0.155	0.155	0.156
31	0.160	0.155	
32*	0.215	0.216	0.216
32	0.220	0.215	
35	0.305	0.305	0.300
35	0.310	0.305	

* Sample 30 contains 1.35 percent Cr and 0.21 per cent V; Sample 31 contains 3.51 per cent Cr and 19.55 per cent W; Sample 32 contains 0.89 per cent Cr.

† Except on Samples 30 and 31 the official values given throughout this paper are those obtained by bismuthate oxidation.

In oxidizing manganese with sodium bismuthate in steel containing chromium, it is customary to add large amounts of ice and to filter quickly, for in cold solutions in which the bismuthate is allowed only a short time to act the oxidation of chromium is reduced to a minimum. Success in this method, however, depends largely upon compensating errors, for some chromium is always oxidized and the oxidation of manganese tends to be slow or incomplete at these very low temperatures. In this new method we had much better success by oxidizing between 20 and 35°. The only danger here is that after the removal of the bismuthate the permanganate may oxidize some of the chromic salt, being itself reduced. When the titration is made with ferrous sulfate and permanganate in the ordinary way this causes no error. That it does not cause error in this method can be due only to the fact that at temperatures below 40° the oxidation of chromium by permanganate proceeds slowly. It is at once evident, however, that with high percentages of either chromium or manganese the danger of error from this source will be diminished (1) by oxidizing in the neighborhood of 20°, (2) by adding ice after oxidation is complete and before filtering, and (3) by titrating immediately after filtration.

TABLE IV—DETERMINATION OF MANGANESE IN STEELS CONTAINING 17 PER CENT OF CHROMIUM

Samples	Mn Found after Separation	Mn by Electrometric Titration
A 1201	0.385	0.395
A 1204	0.260	0.258

In Table IV manganese is shown as determined in steels containing 17 per cent of chromium. Since these steels are not readily soluble in nitric acid, the samples were dissolved in hydrochloric acid and repeatedly evaporated to a small volume with nitric acid. The solutions were then oxidized with sodium bismuthate as usual. Manganese was also determined in these samples after precipitation with ammonium persulfate.

In Table V the influence of time is shown where the percentages of chromium and manganese are both high. Bureau of Standards' Sample 9a was treated with 1 g. of potassium dichromate before solution and 1 g. afterwards. This gave rise to a very large amount of chromic salt as well as much chromate. These solutions were then titrated after different intervals.

Where such large amounts of chromium are present (over 30 per cent) it would be safer to oxidize both the chromium and the manganese.

TABLE V—THE EFFECT OF TIME UPON THE MANGANESE FOUND WHEN THE PERCENTAGES OF BOTH MANGANESE AND CHROMIUM ARE HIGH

Time of Standing after Filtration, Minutes	Percentage Found	Percentage Present
1	0.895	0.915
1	0.910	....
10	0.875	....
10	0.815	....
20	0.830	....
20	0.885	....

To test the suitability of the method for determining the higher percentages of manganese, we dissolved the Bureau of Standards sample of manganese ore, No. 25, in hydrochloric acid and evaporated with sulfuric acid until fumes appeared. It was then diluted to a liter. To portions of this representing 0.04 g. of the sample, nitric acid and sodium bismuthate were added. Fourteen titrations gave results ranging from 56.17 to 56.44. The average was 56.27. Blum[1] says that the most probable value for the manganese in this sample lies between 56.20 and 56.30. While these results are good the method is not recommended for determinations where such a high percentage of accuracy is needed as is the case in ores and ferro-manganese. In steels an error of one- or two-hundredths of a per cent is almost unavoidable under all methods and is rarely important. It is in this field that the usefulness of the method lies.

THE DETERMINATION OF MANGANESE IN STEEL AFTER OXIDATION WITH AMMONIUM PERSULFATE

One of the advantages of the ammonium persulfate method for determining manganese is that the filtration of the solution is not necessary. Where many routine determinations are made this is a valuable quality in a method because of the time saved. We accordingly attempted to develop this method for use on the electrometric apparatus. In titrating permanganate in sulfuric acid with mercurous nitrate in the presence of ammonium persulfate the relation of one solution to the other is slightly different from that which obtains when the persulfate is absent, but the relation is definite. This titration has the disadvantage of being more sensitive to temperature differences than is the titration in sulfuric acid alone. However, it gives results generally accurate enough for most technical purposes.

TABLE VI—THE TITRATION OF POTASSIUM PERMANGANATE IN THE PRESENCE OF AMMONIUM PERSULFATE

Solutions contained 50 cc. H_2SO_4 (sp. gr. 1.58), 2 g. ammonium persulfate and 200 cc. of water. Temperature, 20°

Cc. $KMnO_4$	Cc. $Hg_2(NO_3)_2$	Factor[1]
10.0	9.9	1.010
10.0	9.8	1.020
20.0	19.5	1.026
20.0	19.5	1.026
30.0	29.0	1.034
30.0	29.1	1.031
40.0	38.8	1.031
40.0	38.8	1.031

[1] The subtraction of a blank of 0.1 cc. from the mercurous nitrate makes the factor more nearly constant.

In Table VI titrations of potassium permanganate at 20° are shown. The effect of temperature is demonstrated in Table VII.

[1] *Loc. cit.*, p. 1396.

TABLE VII—THE INFLUENCE OF TEMPERATURE UPON THE TITRATION OF POTASSIUM PERMANGANATE IN THE PRESENCE OF AMMONIUM PERSULFATE

The solution was identical with that used in Table VI

Temp. °C.	Cc. $KMnO_4$	Cc. $Hg_2(NO_3)_2$	Factor
10	20	19.6	1.020
10	20	19.7	1.015
15	20	19.5	1.026
20	20	19.5	1.026
20	20	19.5	1.026
25	20	19.6	1.020
30	20	19.8	1.010
35	20	19.8	1.010
35	20	20.5	0.97
35	20	20.0	1.00
40	20	19.8	1.01
40	20	21.0	0.95
60	20	21.6	0.93
60	20	21.8	0.92
80	20	21.6	0.93
80	20	22.0	0.91

It will be evident from the results shown in Table VII that the temperature of the solution should be kept close to 20° C. The increase in the amount of mercurous nitrate used in titrating at the higher temperature is undoubtedly due to the partial reoxidation of the manganese. At low temperatures this proceeds so slowly as to cause no trouble. Additional difficulties arise in trying to work at temperatures above 40° C. in that the behavior of the galvanometer is irregular.

When the steel is dissolved in nitric acid it is not generally possible to use more than 0.2 g. of the sample. We have found a preferable procedure to be the use of a 0.5 g. sample in sulfuric acid. However, where the manganese is below 0.5 per cent 1 g. samples may be used. Our method is to dissolve 0.5 g. of the steel in 65 cc. of sulfuric acid of sp. gr. 1.20 and when solution is complete to oxidize with nitric acid added dropwise. After boiling a minute or two the solution is diluted with hot water to a volume of 200 cc., heated to boiling and 10 cc. of silver nitrate solution (2.5 g. in a liter) and 20 cc. of ammonium persulfate solution (100 g. in a liter) added. Boiling is allowed to continue about one minute when the solution is allowed to cool slowly, or rapidly with the aid of ice, according to convenience. When the solution is nearly cool enough, a little more sulfuric acid is added and the solution adjusted to about 20°. Titration is then made.

At the time titration is made in this method all of the chromium and vanadium present in the steel is in the oxidized condition, while in the method previously described these elements are oxidized only in part by the sodium bismuthate. In Table VIII analyses of Bureau of Standards sample steels are shown, some of which already contain chromium and vanadium, but an additional amount of chromium as chromate has been added in alternate determinations to illustrate the independence of the presence of chromic acid shown by this method. Samples weighing 0.5 g. were used and titration was made with permanganate and mercurous nitrate of such strength that 1 cc. was equivalent to 0.05 per cent in a half-gram sample.

In this method it is not important to make the titrations at once, as in the case after the filtration following oxidation with sodium bismuthate. Eight portions of Sample 35 were oxidized at the same time

TABLE VIII—THE DETERMINATION OF MANGANESE IN STEELS AFTER OXIDATION WITH AMMONIUM PERSULFATE

Temperature, 10 to 25° C. Volume, 250 cc. Sample, 0.5 g.

	Mn Found		
Sample	0.02 g. Cr Added as Chromate	No Cr Added	Mn Present
9a	0.896	0.896	0.915
9a	0.900	0.902	
19a	0.844	0.844	0.850
19a	0.830	0.850	
30	0.545	0.556	0.563
30	0.556	0.558	
31	0.158	0.154	0.156
31	0.165	0.144	
32	0.205	0.220	0.216
35	0.299	0.301	0.300
35	0.298	0.309	

and titrated at intervals during the succeeding 24 hrs. The lowest result was 0.298 and the highest 0.314 less than 0.02 per cent difference.

The two methods have been in use in this laboratory during some months. Young men without previous chemical training and with only a few weeks' experience in laboratory work after a few minutes' instruction have been able to make analyses of steels containing chromium, vanadium, molybdenum and tungsten, which could have been made by other methods only by men of large experience and a high degree of skill. Approximately a thousand determinations have been made by these methods and compared with other standard methods.

SUMMARY

I—A method has been shown for the determination of manganese in the presence of chromium or vanadium.

II—A method in two modifications has been shown for the electrometric determination of manganese.

III—A study of the reaction between permanganic acid and mercurous nitrate has been made.

IV—The method does not require special skill for its application.

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REAGENTS FOR USE IN GAS ANALYSIS
VI—THE ABSORPTION OF HYDROGEN BY SODIUM OLEATE

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Bosshard and Fischli[1] have suggested the use of a solution of sodium oleate containing nickel in suspension, for the gas-analytical absorption of hydrogen. Inasmuch as they did not determine definitely the optimum conditions for the use of the reagent or its specific absorption,[2] experiments were undertaken to obtain data on these points. At the very outset the authors met with the difficulty of not being able to duplicate the results of Bosshard and Fischli in getting complete absorption of hydrogen. After various attempts, the method was abandoned, and this note has been prepared for publication in order that this experience with the reagent may be placed on record.

The procedure that is recommended by Bosshard

[1] *Z. angew. Chem.*, 28, I (1915), 365.
[2] Anderson, THIS JOURNAL, 7 (1915), 587.

and Fischli for preparing the catalyst and carrying out the absorption, the one which the authors first tried to duplicate, is as follows:

Metallic nickel is prepared by the reduction of nickel oxide[1] by hydrogen at 340° C. The nickel oxide is placed in a glass tube provided with constrictions dividing it into compartments of such size as to hold easily about 4.3 g. nickel oxide each, and hydrogen is passed slowly through this tube. After reduction of the nickel oxide, the nickel is cooled in a current of hydrogen and the constrictions sealed off, thus separating the nickel into portions of about 3 g. in air-free containers. The reagent, which consists of a concentrated solution of sodium oleate in water to which about 3 per cent nickel has been added, is placed over mercury in a Hempel pipette, preferably modified by substituting for the long capillary connection a short glass tube of somewhat larger bore. To effect the absorption of hydrogen from a sample of gas, the sample is shaken with the reagent in the pipette for three minutes, allowed to stand under diminished pressure for three minutes as an aid in breaking up some of the troublesome foam which forms, and is then passed into a second pipette along with the remaining foam. Here the sample is shaken with the reagent for three minutes, and then to it is added about 1 cc. of alcohol to destroy the foam and enable the remaining gas to be drawn back into the burette for the reading of the decrease in volume.

Bosshard and Fischli used a lead bath for heating the tube. The authors found it preferable to employ a gas-heated combustion furnace of the usual form, taking proper precautions to avoid local overheating.

After first employing the bulbed tube as suggested by Bosshard and Fischli, and sealing off at the constrictions to preserve the nickel in an atmosphere of hydrogen, the authors substituted for it a straight tube about 3 cm. in diameter with a stopcock at each end, one of them having a bore of about 5 mm. After cooling the nickel in this tube in an atmosphere of hydrogen, the stopcocks were closed, thus preserving the entire product in one container. When a portion of the catalyst was desired, the tube was placed in a vertical position, with the stopcock of large bore at the lower end, and the proper amount of nickel allowed to pass out through the lower stopcock, pressure being furnished by the admission of hydrogen through the upper stopcock. This procedure simplified materially the preparation of the catalyst.

No figures are given by Bosshard and Fischli as to the actual concentration of sodium oleate in the solution which they employed. The authors used a 10 per cent solution of sodium oleate for the greater part of the experiments. Such a solution must be prepared shortly before using since it jellies rather rapidly on standing. Stronger solutions solidify too rapidly to be of use.

In the absence of any description of the method of introducing the nickel into the solution of sodium oleate without access of air, the following procedure was adopted: To the tip of the modified Hempel pipette for use with mercury was attached a short-stemmed funnel by means of a piece of rubber tubing. The air was forced out of the pipette by filling the bulb with mercury. With hydrogen flowing into the funnel through a glass tube inserted almost to the bottom, the desired amount of nickel was allowed to drop into the funnel from the tube in which the product was kept, the solution of sodium oleate being added immediately and the mixture drawn into the pipette by lowering the leveling bulb.

With the reagent finally in the pipette, samples of hydrogen were placed in contact with it, but with practically no absorption. Many attempts were made to obtain an active reagent, using metallic nickel prepared from nickel oxide of various degrees of fineness down to 200 mesh, but with no success. A temperature of 80° C. was maintained in the reagent in one case, but to no advantage. It was noticed, however, that the solutions of sodium oleate to which nickel had been added hardened much more quickly than those of the same concentration that contained no nickel. It was assumed that this was due to the "hardening" of the solution by the hydrogen adsorbed by the nickel. Accordingly, the preparation of nickel was modified by substituting a current of nitrogen for the hydrogen at the point when the reduction of the nickel oxide had been completed, continuing the heating of the material for a short time to drive off occluded hydrogen. The nickel was finally cooled in nitrogen and stored in an atmosphere of this gas. When this material was employed as a catalyst, the sodium oleate showed no tendency to harden sooner than it would have done in the absence of nickel, entirely in accordance with the suggested explanation, but the reagent thus obtained did not absorb hydrogen from gas mixtures placed in contact with it.

At this juncture, the attempt to ascertain the conditions under which complete absorption of hydrogen by sodium oleate in solution might be obtained was abandoned, because of certain objections inherent in the method which would make it of little value even when standardized and found capable of giving satisfactory results. Among these objections might be mentioned the following:

I—The time and effort required for the preparation of the catalyst is considerable, and the necessity of keeping it out of contact with air adds to the difficulty of its use.

II—The reagent foams badly and this renders the absorption process itself a lengthy and tedious operation.

III—The rapidity with which even moderately dilute solutions of sodium oleate solidify renders it necessary to prepare fresh solutions frequently. Also, old solutions must be discarded before they solidify in the pipette, otherwise they can be removed only with difficulty.

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[1] Bosshard and Fischli used nickelic oxide; the authors used nickelous oxide.

REAGENTS FOR USE IN GAS ANALYSIS VII—THE DETERMINATION OF BENZENE VAPOR

By R. P. Anderson

Received August 16, 1917

In connection with the development of a new method for the determination of benzene vapor in gas, a brief history of the determination of this substance has been prepared, and is here presented. Following this historical summary, there is a brief statement of the principle of this new method, upon which considerable preliminary work has been done. The various methods that have been employed are taken up in chronological order.

FUMING NITRIC ACID METHOD

Berthelot[1] appears to have been the first to suggest a procedure for the determination of benzene vapor in illuminating gases. A sample of gas whose benzene content was desired was placed in contact with fuming nitric acid and the approximate amount of benzene determined either by weighing the dinitrobenzene formed or by determining the decrease in volume of the sample. Olefines were removed by bromine water previous to the treatment with fuming nitric acid. Treadwell and Stokes[2] found that the volumetric method gave unreliable results because treatment with bromine water for the removal of olefines results in the absorption of some of the benzene, and because fuming nitric acid, the reagent for benzene, also oxidizes carbon monoxide. Drehschmidt[3] found the method unsatisfactory for the same reasons, and it does not appear to have been used to any great extent.

DINITROBENZENE METHOD

The gravimetric method suggested by Berthelot was developed by Harbeck and Lunge[4] into one with which accurate results can be obtained. The gas to be examined is passed through a mixture of equal parts of fuming nitric acid and concentrated sulfuric acid, thereby quantitatively converting the benzene vapor into dinitrobenzene. The separation of the greater part of the dinitrobenzene from the acid is effected by diluting with water and neutralizing with sodium hydroxide. The crystals of dinitrobenzene which separate from the liquid on standing are separated by filtration, dried, and weighed. The dinitrobenzene remaining in solution is recovered by extraction with ether. The procedure recommended by Pfeiffer[5] differs from that just described in that the nitration is carried out on a sample of gas enclosed in a special container and in that the dinitrobenzene that is formed is not weighed, but is titrated with stannous chloride according to the method of Limpricht.[6]

COMBUSTION METHOD

Bunsen,[7] by making combustions on samples of illuminating gas before and after the absorption of benzene vapor and olefines by fuming sulfuric acid, obtained data from which he computed the amounts of benzene, ethylene, and propylene. The accuracy of this method depends upon the amount of other hydrocarbons, absorbable by fuming sulfuric acid, which may be present in the gas.

ALCOHOL METHOD

Bunsen[1] also determined the amount of benzene vapor and other hydrocarbon vapors present in illuminating gases by absorption in absolute alcohol. The hydrocarbons thus removed from the gas, consisting chiefly of benzene, are separated from the alcohol by pouring it into a large volume of a concentrated solution of sodium chloride, whereupon the hydrocarbons are obtained as an oily liquid upon the surface of the salt solution. Their amount is determined by weighing. By the method of Hempel and Dennis,[2] alcohol may be employed for the gas-volumetric determination of benzene vapor by employing 1 cc. of absolute alcohol in a pipette over mercury, and measuring the decrease in volume that results from contact of gas with the alcohol. Later Dennis and O'Neill[3] showed that, while concordant results may be obtained by the alcohol method, absorption of benzene by this reagent is by no means complete.

PHOTOMETRIC METHOD

Knublauch[4] has devised a method for the determination of benzene and ethylene in illuminating gases based upon the determination of the illuminating power of the gas and the total amount of benzene and ethylene present. From these data and a knowledge of the illuminating powers of benzene and ethylene in the pure state, the amounts of each can be determined. Graul[5] has utilized the photometric method by comparing the illuminating values of the gas before and after the removal of benzene. In the method employed by Reineke,[6] the amount of benzene is determined from the candle power of the flame, possible variations in the luminosity due to other constituents of the gas being disregarded.

CONDENSATION METHOD

Deville[7] has developed a method for determining the benzene vapor in gas mixtures by cooling to —22° C. and weighing the solid benzene which separates. Correction must be made for the vapor pressure of benzene at the temperature employed. Application of the principle of this method has been made by Neubeck.[8] According to the procedure followed by Burrell and Robertson,[9] the benzene vapor is condensed from a sample of gas by using a mixture of solid carbon dioxide and ether or acetone as a refrigerant. The gas which remains is pumped out and then the benzene is allowed

[1] *Compt. rend.*, **82** (1876), 871, 927; **83** (1876), 1255; *Ann. chim. phys.*, [5] **10** (1877), 171; **12** (1877), 289; *Bull. soc. chim.*, **50** (1888), 660.

[2] *Ber.*, **21** (1888), 3131.

[3] Post, "Chem.-techn. Analyse," 2nd Ed., Vol. I, pp. 108, 179.

[4] *Z. anorg. Chem.*, **16** (1898), 41.

[5] *J. Gasbel.*, **42** (1899), 698; *Chem.-Ztg.*, **28** (1904), 884.

[6] *Ber.*, **11** (1878), 35.

[7] "Gasometrische Methoden," **1877**, 2nd Ed., p. 142.

[1] "Gasometrische Methoden," **1877**, 2nd Ed., p. 144.

[2] *Ber.*, **24** (1891), 1162; *J. Gasbel.*, **34** (1891), 414.

[3] *J. Am. Chem. Soc.*, **25** (1903), 503.

[4] *J. Gasbel.*, **22** (1879), 652; **23** (1880), 253, 274.

[5] U. S. Patent No. 1,163,654, December, 1915.

[6] German Patent No. 285,920, June, 1914.

[7] *J. Gasbel.*, **32** (1889), 652.

[8] *Ibid.*, **58** (1915), 616. See also anonymous article in *Gas World*, **64** (1916), 224.

[9] This Journal, **7** (1915), 669.

to vaporize, the pressure exerted by the vapor being determined from a manometer attached to the apparatus. Knowing the atmospheric pressure, the per cent by volume of benzene vapor is computed. A modification of the apparatus employed by Burrell and Robertson has been suggested by Whiton[1] as being more desirable for use in determining the efficiency of the benzol scrubbers used on coke-oven gas.

FUMING SULFURIC ACID METHOD

The determination of the combined benzene and ethylene content of an illuminating gas by fuming sulfuric acid may be utilized for the indirect determination of benzene when the amount of ethylene is determined by some other method. Haber and Oechelhäuser[2] have employed this procedure, determining the ethylene content of the gas mixture by treatment with standardized bromine water, and subsequent determination of the excess of bromine. Since benzene is also absorbed by bromine water, the combined benzene and ethylene content can be determined approximately by bromine water, as well as by fuming sulfuric acid. Haber and Lunge[3] have described a method for determining ethylene in the presence of benzene by causing the ethylene to combine with hydrogen in the presence of platinum black. The amount of benzene is then arrived at indirectly by taking the difference between the combined benzene and olefine content, as determined by fuming sulfuric acid, and the ethylene content.

PARAFFIN OIL METHOD

Müller[4] has proposed that benzene vapor in illuminating gas be determined by passing the gas through cooled paraffin oil. The greater part of the benzene vapor can be absorbed by this method. Nowicki[5] had described a special absorbing device for carrying out this determination. The method has been elaborated by Krieger.[6] Neubeck[7] has modified the procedure by distilling off the benzene taken up by the oil, but does not recommend the method on account of the difficulty in maintaining air-tight joints during the distillation. Copp[8] has described the procedure adopted by him in obtaining more efficient absorption of the benzene vapor.

SPECIFIC GRAVITY METHOD

In Lunge's "Chemisch-technische Untersuchungsmethoden," Vol. 2 (1900), p. 586, there is described a method for determining the benzene content of an illuminating gas from the specific gravity of the gas and the amount of olefines in it. This method is open to the objection that possible variations in the amounts of the other constituents of the gas are not considered.

AMMONIACAL NICKEL CYANIDE METHOD

Dennis and O'Neill[9] developed a gas-volumetric method for the determination of benzene, employing as a reagent an ammoniacal solution of nickel nitrate. Later Dennis and McCarthy[1] suggested the use of an ammoniacal solution of nickel cyanide instead of nickel nitrate, having found that more uniformly reliable results could be obtained with the former reagent.

SULFURIC ACID METHOD

Morton[2] has suggested the use of concentrated sulfuric acid for the absorption of benzene vapor in the presence of ethylene. Dennis and McCarthy[3] found that this reagent does not give satisfactory results both on account of the fact that some ethylene is absorbed by it, and also because the absorption of benzene is not complete.

SATURATION METHOD

The Société Roubaisienne d' Eclairage par le Gaz and RR. L. H. Forrieres[4] have developed a method for benzene based upon the determination of the amount of benzene that is required to saturate a known volume of gas. After computing the amount that would be required, under the conditions of the experiment, for gas containing no benzene vapor, the benzene content of the gas is gotten by difference.

THE NEW METHOD

During the summer of 1915, in attempting to develop a method for determining benzene vapor in gas simply, quickly, and accurately, the author did considerable preliminary work upon a method which appears more nearly to satisfy these requirements than any of the methods that have been mentioned. In the proposed method, a measured quantity of gas containing an unknown amount of benzene vapor is placed in contact with benzene in a special apparatus and the increase in volume read. By determining what the increase in volume would have been, had the gas contained no benzene vapor, the amount of benzene vapor actually present is easily computed. That this idea is not entirely new was learned when a search of the literature was made and reference to the German Patent described under the previous heading was found. The procedure that has been employed is, however, much simpler and quicker than that described in the patent.

Owing to the failure of attempts to obtain, under present conditions, apparatus considered essential for the proper standardization of the method, its further development has been temporarily postponed.

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[1] This Journal, 8 (1916), 733.
[2] *Ber.*, 29 (1896), 2700; *J. Gasbel.*, 39 (1896), 804.
[3] *Z. anorg. Chem.*, 16 (1898), 26.
[4] *J. Gasbel.*, 41 (1898), 433.
[5] *Ibid.*, 48 (1905), 292.
[6] *Ibid.*, 58 (1915), 61.
[7] *Ibid.*, 58 (1915), 815.
[8] *Gas World*, 66 (1917), 222.
[9] *J. Am. Chem. Soc.*, 25 (1903), 503.

RESEARCH ON THE DETECTION OF ADDED WATER IN MILK

By Halsey Durand and Reston Stevenson

Received September 13, 1917

At the annual meeting of the American Chemical Society, held in New York City, September 27, 1916, one of the authors read a paper on "The Detection of Added Water in Milk,"[5] in which the importance of devising a rapid and accurate method was brought

[1] *J. Am. Chem. Soc.*, 30 (1908), 233.
[2] *Ibid.*, 28 (1906), 1732.
[3] *Ibid.*, 30 (1908), 233.
[4] German Patent No. 267,491, May, 1913.
[5] This Journal, 9 (1917), 44.

out and a review of the existing methods was presented.

The *first* was the determination of the refractive index of the milk serum, which, while having the advantage of speed, proved unreliable for the detection of less than 10 per cent of added water, vastly too great a margin. The *second* was the determination of the freezing point,[1] the elevation above that of normal milk indicating the percentage of added water; this is an excellent method, but one requiring too much time for a routine laboratory. A *third* method, the determination of the specific gravity of the whole milk and of the serum, was also mentioned as having been in use for many years, but never having given satisfactory results.

A brief outline was given, in which methods for further research were proposed and the results obtained are the subject of this contribution.

I—The first of these methods to be investigated was based on the theory that added water would increase the solubility of inorganic salts in the serum. A series of determinations was made using a weighed amount of anhydrous lead subacetate. The reagent was that used in Horne's methods for sugar analysis. Experiment showed that 3 g. were required for the coagulation of 100 cc. of milk. After the addition of the subacetate, the contents of the flask were vigorously shaken to coagulate the milk thoroughly. The contents of the flask were poured on a dry folded filter and 50 cc. of the serum collected for the determination. The lead was precipitated with 25 per cent of sulfuric acid, and alcohol added to facilitate the precipitation. The lead sulfate was collected in an alundum crucible, washed with water and finally with alcohol, ignited and weighed. Several determinations were made by the above method.

The results proved unreliable, in that a variable amount of the subacetate in solution is adsorbed by the coagulum, and that, owing to the slowness of the filtration, it proved impractical to wash out all of the organic matter not coagulated, this latter causing a reduction of a portion of the lead sulfate when ignited.

[1] *Chem. News*, **110**, No. 2870, p. 259; No. 2871, p. 275; No. 2872, p. 283.

II—A second series of determinations was made, in which weighed amounts of finely divided silver nitrate was used for the coagulation. The procedure was the same as described under I. The silver in 50 cc. of the serum was determined by titration with $N/10$ ammonium sulfocyanate, after addition of nitric acid and using ferric ammonium sulfate as indicator. This method is much more accurate and rapid than Method I, but the results show that the differences in the number of cc. used, in milks of known purity, are sometimes greater than those between whole milk and samples watered in the laboratory. The method was, therefore, abandoned as useless.

III—The third method, the determination of the electrical conductivity by method of Kohlrausch of the whole milk, and of the serum after coagulation with electrolytes and non-electrolytes, has been tried out in an exhaustive manner during the past year by the authors.

Through the courtesy of Dr. Charles Baskerville, director of the Department of Chemistry, of the College of the City of New York, permission was obtained to carry on these experiments in the laboratories of that institution.

The first series of experiments (Table I) was performed in a cell used for conductivity experiments in the laboratory, in which the electrodes were kept at a uniform distance, but were placed in the cell after filling without regard to their proximity to the sides. This cell was designated as No. 1. A constant temperature was maintained during all of the following determinations, by warming the water by a coil of resistance wire, and stirring by bubbling compressed air, the current in the coil being regulated by a rheostat. It will be observed from these results that there is a decided similarity in the results on whole milk, and also following the theory, the milks to which water has been added give a lower conductivity.

In the second series of experiments, Table I, Cell 2, a cell similar in construction to Cell 1 but of greater capacity and with larger electrodes than the above, was used.

Here as with Cell 1, the samples of known purity gave excellent results. The results on the samples

TABLE I—PRELIMINARY EXPERIMENTS

Cell No.	Sample	No.	Temp. ° C.	Conductivity
1	Whole Milk *a*	1	25.2	0.00527
	b	2	25.17	0.00520
	c	3	25.15	0.00520
	b + 10% Distilled Water	4	25.10	0.00479
	a + 10% Croton Water	5	25.17	0.00478
	c + 10% Distilled Water	6	25.07	0.00466
	Whole Milk *a*	7	24.95	0.00513
2	Milk from Individual Cow	1	25.0	0.00522
		2	25.0	0.00523
		3	25.0	0.00522
	Suspicious Sample	4	25.0	0.00549
		5	25.0	0.00517
	Sealect, Grade A	6	25.0	0.00503
	After Standing in Ice-box for 2 days	7	25.0	0.00585
		8	25.0	0.00530
		9	25.0	0.00521
		10	25.0	0.00571
		11	25.0	0.00624
		12	25.0	0.00755
		13	25.0	0.00560
		14	25.0	0.00515
		15	25.0	0.00569

TABLE II—TESTS USING TEST-TUBES AS CELLS

Temperature, 25° C.

Sample	No.	Conductivity
Authentic Sample	1	0.00543
Authentic Sample	2	0.00504
Same as 2	3	0.00504
Same as 1	4	0.00518
Same as 2	5	0.00475
Authentic Sample	6	0.00504
Authentic Sample	7	0.00495
Authentic Sample	8	0.00460
Authentic Sample	9	0.00563
Same as 1	10	0.00559
Same as 2	11	0.00605
Same as 3	12	0.00712
Same as 4	13	0.00727

TABLE III—TESTS USING CELL NO. 2, ACCURATELY FILLED TO MARK

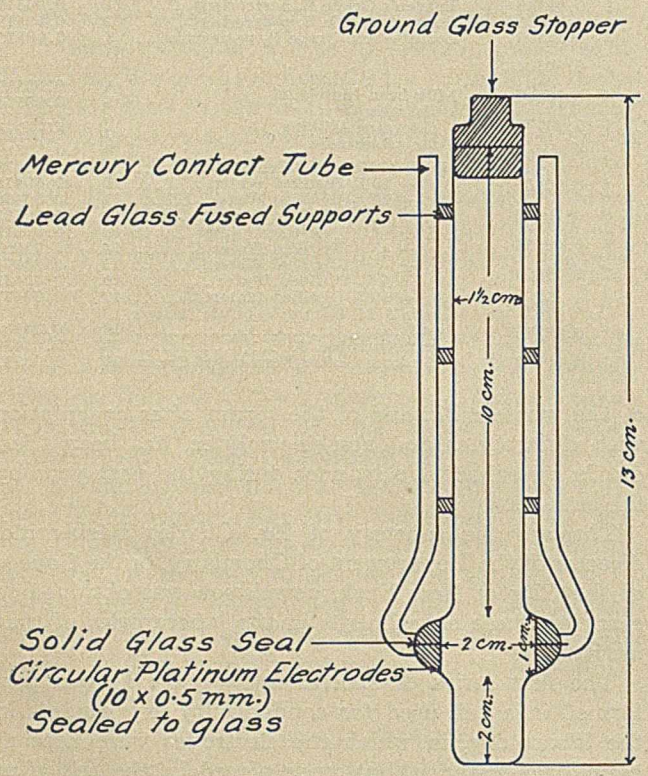
Temperature, 25° C.

Sample	No.	Conductivity
Borden's Grade B, pasteurized	1	0.00519
Borden's Grade B, pasteurized	2	0.00519
Locust Farm Grade B, pasteurized	3	0.00516
Milk from Individual Holstein Cow (Morning Milking, unpasteurized)	4	0.00519
	5	0.00516
	6	0.00519
	7	0.00513
	8	0.00519
No. 4 + 10% Distilled Water	9	0.00478
+ 10% Distilled Water	10	0.00478
+ 20% Distilled Water	11	0.00430
+ 50% Distilled Water	12	0.00307
+ 1.3% Distilled Water	13	0.00513
+ 3% Distilled Water	14	0.00503
+ 5% Distilled Water	15	0.00491
+ 7% Distilled Water	16	0.00482
+ 10% Distilled Water	17	0.00477
Grade A Milk from 1/2 bottle (2 days old)	18	0.00503
Cream from No. 8	19	0.00439
Milk from 1 after Removal of Cream	20	0.00532

marked, "in ice-box 2 days," are not to be relied on, as change in composition has probably taken place.

In Table II, test-tubes, of the same commercial size, were used to facilitate the work, as a number of tubes could be placed in the bath at the same time, to bring them to the required temperature. The same methods were used as in Table I. In this series a wide deviation was observed on different tubes containing the same milk, amounting at most to 37.0 per cent in the conductance. This was found to be due to the difference in size of the tubes and to the amount of sample contained. To avoid a continuance of these errors a file mark was made on Cell 2 and in the subsequent determinations the cell was carefully filled to this mark.

The results in Table III for the whole milk are much more uniform than in the previous determinations, but a variation still persists. The samples to which



water has been added show a regular decrease in conductivity as the amount of water added increases. A search of the literature on electrical conductivity, while discussing the size and distance of the electrodes and the form of the cell, fails to make mention of the error introduced by using varying amounts of solution. This phenomenon is being made the subject of a separate investigation.

As a final effort to determine the cause of the above variations in the whole milk a special cell was constructed as shown in the accompanying drawing. This cell has the advantage that the electrodes are sealed in a permanent position, a constant distance apart, and with the same amount of liquid above and below them.

The results in Table IV are most unsatisfactory,

TABLE IV—TESTS USING SPECIAL CELL (No. 3)

Temperature, 28° C.

SAMPLE OF MILK	No.	Conductivity
Grade A (Sealect), 1 day after pasteurization	1	0.00546
Raw Herd Milk from Fresh Cows	2	0.00540
No. 2 Pasteurized at 67 to 72° C. (½ hr.) 4 hrs. after pasteurization	3	0.00541
Grade B pasteurized (Borden's)	4	0.00563
Same, another sample	5	0.00559
Same, another sample	6	0.00559
Grade B pasteurized (Sheffield)	7	0.00544
Grade B pasteurized (Clover Farm)	8	0.00569
Same, another sample	9	0.00566
Grade B pasteurized (Mutual-McDermott)	10	0.00563
No. 4 + 2 per cent distilled water	11	0.00546
No. 4 + 5 per cent distilled water	12	0.00537
No. 4 +10 per cent distilled water	13	0.00512
No. 7 + 2 per cent distilled water	14	0.00536
No. 7 + 5 per cent distilled water	15	0.00523
No. 8 + 5 per cent distilled water	16	0.00541
Grade B collected from shop	17	0.00539
	18	0.00541
	19	0.00550
	20	0.00560
	21	0.00561
	22	0.00555
No. 22 repeated after 5 minutes	23	0.00554
Grade B collected from shop	24	0.00558
	25	0.00577
	26	0.00579
	27	0.00535
	28	0.00558
No. 27 repeated	29	0.00536
Grade B collected from shop	30	0.00560
	31	0.00575
	32	0.00554
	33	0.00567
	34	0.00566
	35	0.00563
	36	0.00564
	37	0.00563
	38	0.00577
	39	0.00554
	40	0.00537
	41	0.00546
Grade A collected from shop	42	0.00555
	43	0.00552
	44	0.00532
	45	0.00534
	46	0.00535
	47	0.00530
	48	0.00548
Grade A, mixed samples, 1st bottle	49	0.00652
2nd bottle	50	0.00633
Authentic sample	51	0.00678
No. 51 second reading	52	0.00682
Authentic sample	53	0.00450
	54	0.00643
	55	0.00843
No. 53 + 7 per cent water	56	0.00435
AUTHENTIC SAMPLE, unpasteurized	57	0.00555
Milk from 3 or 4 mixed breed cows	58	0.00552
Same as above after 10 minutes	59	0.00565
No. 59 after 40 minutes	60	0.00569
Same as No. 57	61	0.00575
	62	0.00551
No. 62 second reading	63	0.00545

in that a wide discrepancy in conductivity exists even in authentic samples. It was then decided to separate the milk and cream and to determine the conductivity of the skimmed milk. Through the courtesy of Messrs. Paul and Terhune of the DeLaval Separator Company, a cream separator was obtained and the samples separated. Determinations were made on whole milk, skimmed milk and cream.

The determinations in Table V were made under ideal conditions. The cell was accurately filled to the mark, the temperature kept at 28.0° C. ±0.05 and correction made for each deviation. A large number of the samples were collected under the personal supervision of department inspectors so that there could be no doubt as to their authenticity. The method of measurement was sufficiently sensitive to detect 0.5 per cent of added water, and the fact that the cell constant did not vary was confirmed by frequent determinations, using $N/50$ potassium chloride solution. To preclude the possibility of error through improper running of the separator, a representative of the

TABLE V—DETERMINATION ON WHOLE AND SKIMMED MILK AND CREAM

Authentic Samples. From 5 Cows. Milk from 4 Cows in Each Can. Morning Milkings (1–13)

Temperature, 28° C.

SAMPLE	No.	Conductivity
Whole Milk, Can No. 1	1	0.00561
No. 1 after separation	2	0.00590
Whole Milk, Can No. 2	3	0.00592
No. 2 after separation	4	0.00629
Whole Milk, Can No. 3	5	0.00567
No. 3 after separation	6	0.00605
Whole Milk, Can No. 4	7	0.00595
No. 4 after separation	8	0.00621
Whole Milk, Can No. 5	9	0.00555
No. 5 after separation	10	0.00594
No. 5 after separation and filtering to remove air bubbles	11	0.00595
No. 4 after separation, coagulated with rennin and filtered	12	0.00672
No. 3 after separation, coagulated with pancreatin and filtered	13	0.00643
One Holstein cow producing 16 qts. per day	14	0.00539
One Jersey cow producing 14 qts. per day	15	0.00601
Mixed Jersey and Holstein herd	16	0.00555
	17	0.00547
Holstein herd	18	0.00554
No. 14 after separation	19	0.00576
No. 15 after separation	20	0.00627
No. 16 after separation	21	0.00596
No. 17 after separation	22	0.00581
No. 18 after separation	23	0.00586
No. 18 after separation and filtration	24	0.00586
Grade B, pasteurized (Borden's)	25	0.00565
Grade B, pasteurized (Sheffield)	26	0.00543
Grade B, pasteurized (Clover Farms)	27	0.00580
Grade A, pasteurized (Locust Farms)	28	0.00573
Grade A, pasteurized (Sealect Sheffield)	29	0.00560
No. 25 after separation	30	0.00596
No. 26 after separation	31	0.00581
No. 27 after separation	32	0.00605
No. 28 after separation	33	0.00599
No. 29 after separation	34	0.00586
No. 29 coagulated with rennin and filtered	35	0.00611
No. 28 coagulated with rennin and filtered	36	0.00645
One Holstein cow	37	0.00590
One Durham cow	38	0.00538
Mixed Holstein and Durham herd	39	0.00560
	40	0.00559
	41	0.00560
No. 37 after separation	42	0.00607
No. 38 after separation	43	0.00574
No. 39 after separation	44	0.00587
No. 40 after separation	45	0.00599
No. 41 after separation	46	0.00599
1 qt. morning milk 4 or 5 cows	47	0.00538
	48	0.00562
Mixed common herd unpasteurized	49	0.00561
	50	0.00561
	51	0.00603
No. 47 after separation	52	0.00574
No. 48 after separation	53	0.00589
No. 49 after separation	54	0.00616
No. 50 after separation	55	0.00593
No. 51 after separation	56	0.00632
Separated cream from all samples mixed	57	0.00395
Separated milk from all samples mixed	58	0.00601
Separator run by representative of DeLaval Co. Milk from single Holstein unpasteurized	59	0.00576
	60	0.00555
	61	0.00536
	62	0.00606
	63	0.00569
No. 59 after separation	64	0.00606
No. 60 after separation	65	0.00586
No. 61 after separation	66	0.00569
No. 62 after separation	67	0.00614
No. 63 after separation	68	0.00610
Mixed separated milk + 5 per cent separated cream	69	0.00593
+ 10 per cent separated cream	70	0.00589
Mixed separated milk, all samples	71	0.00602
Mixed separated cream, all samples	72	0.00445
Grade A, certified unpasteurized (Sheffield)	73	0.00554
Grade A, pasteurized (Locust Farms)	74	0.00581
Grade A, pasteurized (Sheffield, Sealect.)	75	0.00573
Grade A, pasteurized (Sheffield, Sealect)	76	0.00552
Grade A, pasteurized (Mutual-McDermott)	77	0.00547
No. 73 after separation	78	0.00591
No. 74 after separation	79	0.00619
No. 75 after separation	80	0.00595
No. 76 after separation	81	0.00575
No. 77 after separation	82	0.00570
Separated cream from No. 73	83	0.00448
Separated cream from No. 74	84	0.00431
Separated cream from No. 75	85	0.00435
Separated cream from No. 76	86	0.00414
Separated cream from No. 77	87	0.00417
Grade B raw taken from cans	88	0.00585
	89	0.00592
Nos. 88 and 89 mixed	90	0.00589
Grade B raw taken from cans	91	0.00545
	92	0.00537
Nos. 91 and 92 mixed	93	0.00540
Nos. 88, 89, 91, 92 mixed	94	0.00563
No. 89 second reading	95	0.00555
Nos. 88, 89, 91, 92 mixed, after separation	96	0.00589
	97	0.00596
	98	0.00592
	99	0.00594
No. 95 after separation	100	0.00597
No. 88 after separation and standing 24 hours	101	0.00590

DeLaval Company, separated the samples in Determinations 59 to 72.

As the milk after separation contains air bubbles, the milk was filtered to remove them. It was found that the readings before and after filtration did not vary (Nos. 10 and 11).

As the samples were run through the separator one after another, it was deemed advisable to determine if the samples were affected by the ones preceding. Four samples were mixed thoroughly, then divided again into 4 samples and run through the separator successively (Nos. 96 to 99). Three of these results were fairly uniform.

It will also be observed that the average of the readings on individual milks corresponds very closely with the reading after mixing Nos. 88 to 94.

With all known sources of error eliminated the readings on authentic samples still showed so wide a difference as to render the method useless.

In the freezing-point determination the fat and protein of the milk play no part and the constant depends entirely on the concentration of the substances in solution.

In the conductivity measurements, however, the fat and protein of the milk decrease the specific conductance by decreasing the number of ions between the electrodes in just the same manner as would glass beads placed in the cell between the electrodes.

A final series of determinations (Table VI) was made on samples of milk coagulated with basic lead acetate

TABLE VI—TESTS USING MILK SERA

Temperature, 28° C.

SAMPLE	CHEMICAL ANALYSIS Total Solids	Fat	No.	Conductivity
AA–223	11.82	3.3	1	0.00653
AA–226	12.01	3.4	2	0.00645
AA–227	13.18	3.6	3	0.00647
AA–228	11.94	3.4	4	0.00647
AA–230	12.06	3.5	5	0.00649
AA–232	11.90	3.6	6	0.00645
AA–233	11.78	3.5	7	0.00645
AA–234	11.94	3.4	8	0.00649
AA–235	12.13	3.5	9	0.00643
B–456	11.94	3.4	10	0.00651
B–457	12.13	3.5	11	0.00649
B–460	11.70	3.2	12	0.00649
B–461	12.38	4.0	13	0.00653
B–463	12.28	3.8	14	0.00647
2A–501	12.36	3.4	15	0.00647
2B–505	11.87	3.4	16	0.00643
2A–505				
Serum + 5 per cent water			17	0.00653
Serum from authentic milk Grade A raw			18	0.00682
			19	0.00659
			20	0.00667
			21	0.00682
			22	0.00657
			23	0.00667
As above + 5 per cent water			24	0.00639
+ 5 per cent water			25	0.00663
+ 10 per cent water			26	0.00628
+ 10 per cent water			27	0.00616
+ 20 per cent water			28	0.00573
+ 20 per cent water			29	0.00591

(Horne's). One hundred cubic centimeters of the milk were taken and 3 g. of the acetate accurately weighed and added, thoroughly shaken and filtered to 50 cc. Readings were then made on the clear sera.

The determinations made on laboratory samples 1 to 16 show a fair degree of uniformity. It will be observed from a comparison of the conductivity and the chemical analysis, that the differences in fat and total solids content bear no relation to the differences in conductivity. The sera from authentic samples 18 to 23 show a far greater variation than has been observed in any of the foregoing determinations and the results are entirely unreliable.

In the authentic samples adulterated in the laboratory (24 to 29) the water was first added to the samples and 100 cc. of the adulterated milk were then taken and coagulated as described above.

These results show great differences, even at the same adulteration and these differences are greater than those between the authentic and adulterated samples. This is probably due to an irregular adsorption of the lead salt by the coagulum, which would account for the lack of uniformity in the results, as was the case in experiments mentioned under Method I at the beginning of this paper.

Having tried out the method and investigated all of the modifications at hand in a most exhaustive manner and being unable to obtain any uniformity in results it was decided to abandon the method as impractical.

It is to be regretted that this method proved ineffective, as a rapid and accurate method of this sort would be of great value to the food analyst.

One of the authors, Durand, proposes at an early date to continue this research, making use of the osmotic pressure of milk, in a cell specially constructed to measure the differential osmotic pressure between milks and a standard saline solution.

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THE LOGANBERRY AND THE ACID CONTENT OF ITS JUICE

By Milo Reason Daughters

Received September 24, 1917

Attention has been called to the composition of loganberry pulp and juice and to the drying properties of loganberry oil.[1] This paper gives the composition of the fresh, ripe, whole berry and some data on the juice, with special reference to its acid content.

Table I—Composition of the Loganberry[2]

	Per cent
Total Solids	20.74
Moisture	79.26
Citric Acid (anhydrous)	1.52
Invert Sugar	7.15
Sucrose	Absent
Proteins (N × 6.25)	4.55
Fat (ether extract)	0.613
Crude Fiber	1.38
Ash	0.571

[1] This Journal, 9 (1917), 1043.

[2] Colby reported the analysis of a sample of California loganberries. California Experiment Station Report, 1895, 177.

The sample (Table I) was taken from 14 lbs. of berries gathered at the close of a uniformly dry season. Total moisture was obtained by heating *in vacuo* at 70° C. to constant weight. An electric muffle furnace heated to dull redness was used for the ash determinations. Citric acid was estimated by the method given in the *Journal of the Association of Official Agricultural Chemists*, Vol. 2 (1916), 183.

Table II—Composition of the Juice

Sample No.	I	II	III	IV
Date of Collection (1917)	July 18	July 25	July 28	August 7
Specific Gravity (25° C.)	1.0526	1.0548	1.0565	1.0599
Acidity (as anhydrous citric)	1.904	1.60	1.515	1.54
Citric Acid (anhydrous)	1.82	1.521	1.511	1.54
Volatile Acids (acetic)	....	0.048	0.025	....
Total Solids	....	12.84	12.49	14.74
Invert Sugar	8.55	8.80	9.06	8.74
Protein (N × 6.25)	....	0.871	0.497	0.37
Ash	....	0.499	0.45	0.39

The first three samples of juice were pressed from 4 to 5 lbs. of berries purchased in the open market. The berries were ground in a food chopper and then pressed in a small fruit press lined with doubled bird's-eye cotton cloth. Sample IV was obtained in a similar manner in a larger press from 14 lbs. of berries after removing the sample for the analysis given in Table I. The specific gravity readings were made by the pycnometer method on the juice which was kept in a constant temperature bath at 25° C.

Dunbar and Lepper[1] have made a study of the Kunz[2] modification of Stahre's method[3] for the quantitative estimation of citric acid and have announced its applicability to fruit products. This method was applied directly to the juice without preliminary precipitation of the citric acid as the barium salt in the last three samples. Twenty-five grams of juice were placed in a volumetric flask of 100 cc. capacity, and 2 cc. of dilute sulfuric acid and 5 cc. of freshly prepared bromine water added, and then made up to the mark with distilled water. Aliquots of 25 cc. each were used in the analysis. Approximately 40 cc. of 5 per cent potassium permanganate were required to complete the oxidation of the citric acid, pectins, sugars, etc. Pentabromacetone separated in a very satisfactory manner as a white semicrystalline solid, leaving a clear supernatant liquid after the addition of ferrous sulfate.

Samples II and III were examined for volatile acids, which were found to be present in traces. Tartaric acid was found in traces by Jorgensen's method.[4] Dunbar and Bacon's[5] uranyl acetate method for malic acid was tried on Sample I, but with negative results.

In conclusion, it may be stated that citric is the chief acid of the loganberry. Traces of tartaric and volatile acids are also present. Malic acid is absent.

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[1] *Jr. A. O. A. C.*, 3 (1916), 182; No. 4 (1917), 175.

[2] *Arch. Chem. Mikros.*, 7 (1914), 285; *Chem. Abs.*, 9 (1915), 687.

[3] *Nordisk Tidsskrift*, 2 (1895), 141; *Z. anal. Chem.*, 36 (1897), 195.

[4] *Z. Nahr. Genussm.*, 17 (1909), 397; Abderhalden, "Handbuch Biochem. Arbeitsmeth.," 2 (1910), 35; *Chem. Abs.*, 3 (1909), 1781.

[5] U. S. Dept. of Agr., Bureau of Chemistry, *Circular* 76; *Jr. A. O. A. C.*, 2 (1917), 179; This Journal, 3 (1911), 826.

REACTION OF HAWAIIAN SOILS WITH CALCIUM BICARBONATE SOLUTIONS, ITS RELATION TO THE DETERMINATION OF LIME REQUIREMENTS OF SOILS, AND A RAPID APPROXIMATE METHOD FOR THE DETERMINATION OF LIME REQUIREMENTS OF SOILS[1]

By Maxwell O. Johnson

Received October 1, 1917

The importance of liming for the maintenance of soil fertility is so well recognized that a number of methods for determining the lime requirements of soils have been proposed. Most of these methods are based on reactions which do not parallel those occurring in the field. Whether lime is applied as oxide, hydroxide or carbonate the main reaction of the limed soil would appear to be with calcium bicarbonate in solution.

Hutchinson and MacLennan[2] and MacIntire[3] have proposed methods for determining the lime requirements of soils using calcium bicarbonate solutions. In the Hutchinson-MacLennan method, 10-20 g. of soil are shaken for 3 hours with 200 to 300 cc. of an approximately 0.02 *N* bicarbonate solution. After filtering, a portion of the filtrate is titrated with 0.1 *N* acid, using methyl orange as an indicator to determine the calcium carbonate absorbed by the soil. In the MacIntire method 150 cc. of bicarbonate solution are evaporated with 10 g. of soil to a thin paste and the excess calcium carbonate estimated by the CO_2 liberated with acid.

An investigation has been made of the reaction of typical Hawaiian soils with calcium bicarbonate solutions under various conditions. As a preliminary announcement of results, it may be stated that the extent of the reaction has been found to depend on the usual factors influencing absorption, *i. e.*, the nature of the soil, the concentration of solution, the period of contact and the ratio of soil to solution. This would account for the variations in results obtained by the Hutchinson-MacLennan and by the MacIntire methods when slight variations are made in the methods of procedure.[4]

The absorption by the soils from calcium bicarbonate solutions increased with the period of contact and approached an equilibrium. As the concentration of the bicarbonate solution was decreased, the absorption decreased in amount but an increasing percentage of the total calcium carbonate in the bicarbonate solution was absorbed. This would show that by using solutions of decreasing concentrations or by using increasing weights of soil a point would be reached where absorption would be practically complete under prolonged contact sufficient to insure equilibrium of the soil with the solution. The total amount of calcium carbonate (calculated as per cent of the weight of the soil) in the solution at and below whose concentration absorption by a given soil is complete, would appear to express a definite absorptive capacity for that soil. This definite absorptive capacity has been designated the "minimum absorption." An amount of calcium carbonate slightly in excess of the minimum absorption would appear to be the correct application to make in the field as being sufficient to insure a slight alkaline reaction. In theory, the lime requirements of a soil by the Veitch method[1] should lie very slightly above the minimum absorption, since the Veitch method depends, in principle, upon the satisfying of the minimum absorption of a soil and the presence in the solution, which is allowed to stand in contact with the soil over night, of sufficient calcium bicarbonate to give an alkaline reaction to phenolphthalein when 50 cc. are boiled down to 5 cc. Under the practical conditions of the method, however, some of the factors introduced may cause the results to differ from the minimum absorption. The lime requirements of soils by the Hutchinson-MacLennan method,[2] by the MacIntire method,[3] by the Tacke method,[4] by Süchting's modification[5] of the Tacke method, and by the Vacuum method of Gaither[6] would be much greater than the minimum absorption and depend on the conditions selected, since the results are determined from the absorption when the soil is in equilibrium with a large excess of calcium bicarbonate in solution.

The minimum absorption of a soil may be determined as defined above by subjecting to prolonged contact a constant weight of soil with decreasing concentrations of bicarbonate solution or increasing weights of soil with a constant concentration of bicarbonate solution and determining the point where complete absorption occurs.

For the routine examination of soils, where great accuracy is not required, a rapid approximate method of determining lime requirements has been worked out and appears to give good results. It was found that when "acid" Hawaiian soils were shaken with solutions of sufficient concentration to insure a fairly rapid contact of solute with soil particles, an extemely rapid absorption reaction takes place, approaching in velocity that of an ionic reaction with a soluble acid, which reaction is followed by a much slower increase in the absorption with the time. This is illustrated by the following experiment:

200 cc. portions of 0.01 *N* calcium bicarbonate solution were measured out in 500 cc. Erlenmeyer flasks. The soils used were three typical acid Hawaiian soils and an alkaline station soil containing 1.63 per cent CaO. 10 g. of soils were added to each flask and the flasks immediately stopped and shaken vigorously by hand for 1, 2, 3, 4, 5, 7 and 10-minute periods. At the conclusion of the period of shaking, the flasks were opened, and the contents filtered through a 24 cm. folded filter paper, discarding the first 40 or 50 cc. of filtrate. 100 cc. of the filtrate were titrated with 0.1 *N* HCl, using methyl orange as an indicator. The absorption was measured by the difference in titration between

[1] Published by permission of the Secretary of Agriculture.
[2] *J. Agr. Sci.*, [1] **7** (1915), 75–105.
[3] This Journal, **7** (1915), 864–867.
[4] See *Jour. Assoc. Off. Agr. Chem.*, **3** (1917), 133–149.

[1] *Jour. Amer. Chem. Soc.*, **24** (1902), 1120–1128; **26** (1904), 637–662.
[2] *Loc. cit.*
[3] *Ibid.*
[4] *Chem.-Ztg.*, **21** (1897), 174–175.
[5] *Z. angew. Chem.*, **21** (1908), 151–153.
[6] This Journal, **8** (1916), 243–246.

100 cc. of the original bicarbonate solution and of the filtrate, 0.1 cc. of 0.1 *N* acid difference in titration being equivalent to an absorption of 0.01 per cent calcium carbonate by the 10 g. of soil. The results are given in Table I and in graphical form in Fig. 1.

TABLE I—ABSORPTION FROM CALCIUM BICARBONATE SOLUTIONS BY HAWAIIAN SOILS UNDER VARIOUS PERIODS OF CONTACT

Absorption expressed as calcium carbonate in per cent of the weight of the soil

Time of shaking Minutes	Haiku Soil	Kaiwiki Soil	Waipio Soil	Alkaline Station Soil
1	0.17	0.34	0.24	0.03
2	0.20	0.39	0.29	0.04
3	0.23	0.41	0.35	0.05
4	0.25	0.43	0.36	0.05
5	0.26	0.45	0.37	0.05
7	0.28	0.48	0.39	0.06
10	0.30	0.50	0.41	0.06

An examination of Table I and Fig. I shows, with the Haiku and Kaiwiki soils, the very rapid reaction taking place during the first minute of shaking and the much slower absorption which follows. With the Waipio soil, the rapid reaction apparently requires 3 minutes' shaking for completion. The alkaline station soil shows a slight, slowly increasing absorption. It should be noted that the absorption during the first rapid

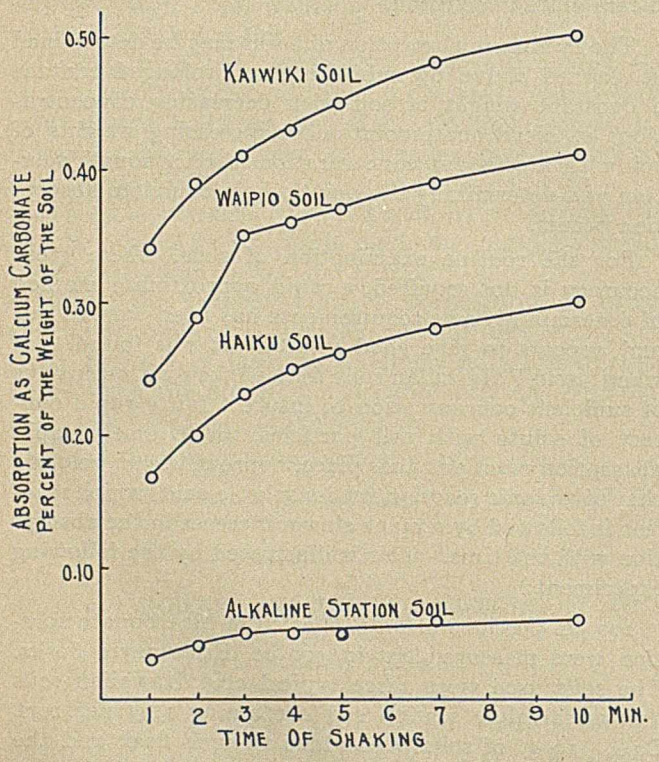

FIG. I—CURVES SHOWING THE EFFECT OF THE TIME OF SHAKING UPON THE ABSORPTION BY HAWAIIAN SOILS FROM CALCIUM BICARBONATE SOLUTION

reaction corresponds closely with the lime requirements by the Veitch method[1] which are 0.17, 0.34, and 0.32 per cent calcium carbonate for the Haiku, Kaiwiki and Waipio soils, respectively.

The method of examination used in the above experiment has been applied to over 80 Hawaiian soils, and the absorption during the first rapid reaction appears to offer quite an accurate measure of the lime requirements of these soils. Determining the lime requirements of a soil by the absorption during a single shaking of one minute appears sufficiently accurate for routine soil examinations.

Due to the known peculiar nature of Hawaiian soils, 48 soil samples were secured for camparison from 8 different mainland states and the method used in the above experiment applied to these samples. It was found that the time of shaking could be shortened to 10 seconds for these mainland soils. The absorption during this 10 seconds' shaking corresponded closely with the lime requirements for these soils by the Veitch method and with the amounts of lime which general experience has found best in field trials, running from 1 to 3 tons of calcium carbonate per 2,000,000 lbs. of soil for ordinary acid soils and about 6 to 8 tons for acid peats. The method appeared to distinguish easily alkaline from acid soils as the alkaline soils had but a small absorption (less than 0.06 per cent calcium carbonate). For mainland soils, the following procedure is therefore recommended as a rapid, approximate method of determining lime requirements:

Measure out 200 cc. of 0.01 *N* calcium bicarbonate solution into a 500 cc. Erlenmeyer flask. Add 10 g. of the soil to be examined to the flask, stopper and shake vigorously by hand for 10 seconds. Filter through a large folded filter paper, discarding the first 40 or 50 cc. of filtrate. Titrate 100 cc. of filtrate with 0.1 *N* acid, using methyl orange as an indicator. The 0.1 difference in titration between 100 cc. of the filtrate and of the original solution is equivalent to 0.01 per cent calcium carbonate required. Multiplying by 10 the percentage calcium carbonate required gives directly the tons of calcium carbonate per 2,000,000 lbs. of soil, which is the weight of soil per acre commonly assumed as being in reaction with applied forms of lime. As filtration is very rapid, it appears that the absorption by this method is sufficient to induce flocculation. A clear filtrate, easily titrated, is always secured, even with peat soils.

For preparing calcium bicarbonate solutions, MacIntire[1] gives in detail a method of preparation by passing carbon dioxide through a suspension of calcium carbonate. The method of preparation made use of by Hutchinson and MacLennan[1] is more convenient. A refillable soda water syphon is used, which is charged by means of small bulbs of compressed carbon dioxide. In this laboratory, about 10 g. of C. P. calcium carbonate are placed in the carbonic syphon which is filled to the mark with distilled water and charged. Solution is sufficiently complete in about 15 min. if the syphon is gently shaken. The syphon is then opened and the contents poured into a 2.5-liter bottle and diluted to about 1500 cc. After the solid calcium carbonate has settled, the liquid is decanted, in portions, into a 600-cc. beaker, from which, after settling, it is decanted into a large filter paper. A glass stirring rod placed in the funnel along the sloping side underneath the filter paper aids the rapidity of filtration. Decanting and filtering in this manner makes the filtration a very rapid process. The filtrate is shaken to insure uniformity and

[1] *Loc. cit.*

[1] *Loc. cit.*

50 cc. are titrated with 0.1 *N* acid, using methyl orange. The filtrate is then diluted to the desired concentration, which can be done with sufficient accuracy by measuring the filtrate and the diluting water into a 4-liter bottle with a 500-cc. graduated cylinder. The accuracy of the dilution is confirmed by titrating 100 cc. of the diluted solution. A 0.01 *N* solution is used as this concentration is fairly stable provided the containing bottles are kept stoppered. It was not found necessary to displace the air in the flasks with carbon dioxide during determinations when this concentration was used. The calcium carbonate which settled when the liquid was decanted is returned to the syphon which is recharged and set aside until a fresh solution of bicarbonate is required. While the 0.01 *N* solution is fairly stable and may be kept under pressure, it is better, however, to prepare the bicarbonate solution fresh each day. Any solution remaining unused from the previous day may be added to the fresh solution before filtration.

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REVERTED PHOSPHATE

By CARLTON C. JAMES

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As there has been so much published recently concerning the reversion of acid phosphate, its value after reversion, and its effect upon plant growth, it seems advisable to set forth some of the work done by the writer along these lines during the last eight years.

This work was inaugurated and continued in order to control better the complete fertilizer mixtures, and to provide a more effective phosphate for soil conditions in Hawaii. Moreover, the contradictory results and opinions of investigators and control chemists elsewhere has made it necessary to verify or disprove them when applied to conditions in Hawaii. It has been generally held that iron and aluminum phosphates are of little value as a source of phosphorus. Now comes a recent publication by McGeorge[1] showing that in sand cultures with millet, ferric and aluminum phosphate produced more vigorous plants than acid phosphate, sodium phosphate, phosphate rock or Thomas slag. Similarly, it has been held that reverted phosphate is of less value than acid phosphate. Considering the results obtained here by an acid phosphate which has been reverted, we are inclined to believe that under certain conditions prevailing in Hawaii, reverted phosphate gives the better results.

EXPERIMENTAL

In a previous article[2] the writer showed that some reversion may be expected from the action of lime, carbonate of lime, and a mixture of carbonate and phosphate of lime in mixed fertilizers. In this article methods, means and materials used to revert the acid phosphate completely, are considered.

In the first experiment four laboratory samples were prepared, the constants of which were acid phosphate and brown guano, the name given to a low-grade Laysan Island phosphate containing coral sand. The variable was lime, CaO. Each sample contained 200 g. acid phosphate and 200 g. brown guano: in addition, No. 1 contained 7.4 g. of lime, the theoretical amount to revert all water-soluble lime phosphate, disregarding whatever effect the calcium carbonate in the brown guano might have. No. 2 contained twice as much lime, 14.8 g. To Nos. 3 and 4 were added 2 g. and 4 g. of lime, respectively. The samples became appreciably warm, and one hour after mixing, the temperatures in Nos. 1 and 2 were 35 and 36° C., respectively, a rise of 9 and 10° C. over room temperature.

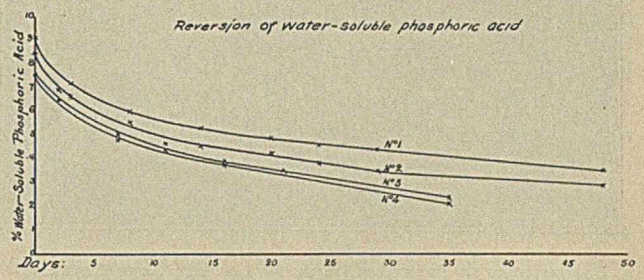
TABLE I—PER CENT WATER-SOLUBLE PHOSPHORIC ACID IN MIXTURES ALLOWED TO STAND

A—ACID PHOSPHATE & GUANO

Period of Standing	Mixture No. 1	No. 2	No. 3	No. 4
On mixing	9.1	8.6	7.6	7.5
2 days	....	....	7.0	6.63
3	7.25	6.72	....	....
7	....	....	5.08	5.39
8	6.08	5.67	....	....
11	....	....	4.47	4.72
14	5.37	4.6	....	....
16	....	....	3.98	3.82
20	4.8	4.3	....	....
24	4.59	3.8	....	....
29	4.47	3.54	....	....
35	....	....	2.44	2.23
48	3.55	2.97	....	....

B—LIME SUPERPHOSPHATE & LIME

Period of Standing	Mixture Containing 15% Lime	30% Lime
On mixing	15.81	13.02
2 days	10.17	6.93
6	9.05	6.23
10	8.34	5.52
14	7.87	5.05
18	7.23	4.70
21	7.23	3.82
25	6.99	3.98
28	6.76	4.58
35	6.64	4.19
40	6.46	4.11
54	6.51	5.67
68	6.46	5.62
458	0.93	4.60
1580	0.48	2.90



At intervals, analyses were made by the uranium volumetric method for water-soluble phosphoric acid, the results of which are shown in Table I*A*.

This table shows a reversion of from 5.16 to 5.63 per cent of water-soluble phosphoric acid, and also that the greater reversion is caused by the greater amount of lime.

These points have been laid out diagrammatically on quadrille paper and a smooth line drawn through the points plotted to show the rapidity with which the action takes place at first and how it is gradually retarded. It will be seen that if the lines were extended, considerable time would elapse before all the phosphoric acid would become reverted. While these results were satisfactory, it was deemed advisable to remove the brown guano as the supply was becoming limited, and to try larger samples over a longer period of time.

Some time later, with this in mind, another laboratory experiment was carried on with lime superphosphate, the analyses being made at close intervals

[1] Hawaii Agric. Exp. Station, *Bull.* **41**.
[2] THIS JOURNAL, **9** (1917), 682.

for about two months, the next analyses after 458 days, and the final complete analyses after 1580 days or approximately 4 years and 5 months. To 1000 g. of acid phosphate in each of two bottles were added 150 and 300 g. lime, CaO. The analyses of water-soluble phosphoric acid are shown in Table I*B*. On mixing, the sample with 15 per cent lime contained 15.81 per cent water-soluble P_2O_5 and 17.18 per cent total P_2O_5; after standing 1580 days, 0.48 per cent water-soluble, 13.89 available, and 20.02 total P_2O_5. The sample to which 30 per cent lime was added contained on mixing 13.02 per cent water-soluble P_2O_5 and 14.15 per cent total P_2O_5; after 1580 days, 2.9 per cent water-soluble, 13.69 per cent available and 16.62 per cent total P_2O_5.

The sample containing 15 per cent lime shows a

Unfertilized in Front of Stake: 90 Lbs. per Acre Reverted Phosphate at Right

continued reversion over the whole period as was expected, but what was responsible for the irregularity in the sample with 30 per cent has not been explained. It will be noticed that some reversion to tri-calcium phosphate has taken place, but the greater part remains as di-calcium phosphate.

Since these laboratory experiments indicated in a general way the trend and rate of reaction it was considered advisable to continue experimenting on a larger scale under factory conditions. Consequently, the following series of experiments were conducted with lots of one ton or more.

In Experiment 1, lime and acid phosphate were mixed in a ball mill in proportions of 10 parts lime to 90 parts acid phosphate. The material after grinding through a coarse screen was caught in bags and set out on the floor in order that the reaction could go on to completion and the temperature drop to that of the atmosphere. Experiments 2, 3 and 4 were conducted in the same manner as No. 1, the only difference being that the proportion of lime to acid phosphate was increased in each succeeding experiment.

The method of handling was not satisfactory, as the heat and dust soon drove the men away from the mill.

Table II—Factory Experiment of Mixing Acid Phosphate and Lime

	Mixture		Analyses of Mixture		
Percentages	Lime	Acid Phosphate	Total P_2O_5	Soluble and Available P_2O_5	Water-Soluble P_2O_5
No. 1	10	90	19.16	17.61	2.18
2	15	85	18.56	17.16	2.92
3	20	80	17.06	15.71	1.50
4	25	75	16.70	15.33	2.88

Samples for analyses of the first series of experiments with lime and acid phosphate were taken 18 hrs. after mixing. Reaction started from 10 to 20 mins. after mixing, and the material lost water rapidly. At the same time it took on a lighter color and a more friable powdery condition. One-half hour after mixing, the temperature in Nos. 1, 2 and 3 was approximately 110° C., while in No. 4 it rose to 190° C. The results of this series of experiments are given in Table II.

Unfertilized at Left: 90 Lbs. per Acre Reverted Phosphate at Right

The reaction goes on more rapidly as the percentage of lime is increased. The water content of the acid phosphate and also the length of time it ages in the bin before mixing affect the rapidity of reaction and intensity of heat generated.

Having studied the reverting action of lime, our attention was next turned to carbonate of lime and combinations of carbonate of lime with lime and acid phosphate, the object being to obtain a fertilizer which would contain a considerable part of the phosphoric acid in the reverted form and also to effect a less dusty mechanical condition. The dusty nature of the reverted mixture makes a very difficult and disagreeable product to handle on a large scale.

The results of experiments with calcium carbonate (coral sand) and acid phosphate are given in Table III. It will be noticed that reversion takes place quite rapidly at first but as the time increases, the rate of reversion diminishes. As with lime, the

Table III—Percentages Water-Soluble P_2O_5 in Mixtures of Acid Phosphate and Coral Sand

Mixture			
Acid Phosphate:	90%	85%	80%
Coral Sand:	10%	15%	20%
On mixing	16.3	15.38	14.48
After 24 hours	15.46	13.04	10.98
48 hours	15.18	11.92	9.58
120 hours	14.44	11.18	8.86
11 days	13.32	9.68	8.2

reversion increases with increasing proportions of carbonate of lime. With the carbonate of lime, however, there is very little rise in temperature. It is unfortunate that only the water-soluble phosphoric acid determinations were made on this series of experiments, as a comparison of the soluble and available would have been valuable and interesting.

In an endeavor to get more satisfactory results with lime and acid phosphate on a factory scale, mixtures of 90 per cent acid phosphate and 10 per cent lime, and also 85 per cent acid phosphate with 15 per cent lime were again ground together in a ball mill. These mixtures were allowed to cool and after 24 hrs. samples were taken for analyses. The mixtures were sampled again after one week.

TABLE IV—MIXTURES OF ACID PHOSPHATE AND LIME

	90% Acid Phosphate & 10% Lime			85% Acid Phosphate & 15% Lime		
Per cent P_2O_5	Water-Soluble	Soluble and Available	Total	Water-Soluble	Soluble and Available	Total
After standing						
24 hours...	3.03	18.50	19.42	None	17.56	19.1
1 week.....	1.66	17.97	19.28	None	16.55	18.64

The reversion here was quite complete and little if any of the acid phosphate was changed to the tricalcium form. The appearance of the material was quite similar to precipitated phosphate. It was found impractical to work this material through a ball mill, however, on account of the gradual accumulation of the mixture in the mill and also the heat generated by the reaction.

A similar experiment was then undertaken with mixtures of acid phosphate, lime and coral sand with the object of obtaining the same result: *i. e.*, a reverted phosphate, but with the idea of retarding and tempering the violence of the reaction. The limited capacity of the ball mill and its tendency to choke and to accumulate heat led us to run the remaining tests through a cage disintegrator. The reversion which took place in this material is shown in Table V.

TABLE V—EXPERIMENT WITH ACID PHOSPHATE, LIME AND CALCIUM CARBONATE

Mixture:	85% Acid Phosphate 10% $CaCO_3$ + 5% CaO			80% Acid Phosphate 15% $CaCO_3$ + 5% CaO		
Per cent P_2O_5:	Water-Soluble	Soluble and Available	Total	Water-Soluble	Soluble and Available	Total
After standing						
24 hours.....	4.94	...	...	3.26	...	...
10 days.....	4.52	15.64	17.36	2.42	14.77	16.48

The disintegrator makes a sufficiently homogeneous mixture which passes rapidly through the machine, and which is discharged almost before reaction begins. Reaction attains its height about 30 minutes after leaving the disintegrator, which allows sufficient time for handling. The heat generated removes excess of moisture, causing a loss in weight of about 5 per cent and leaving a free, dry powder, the phosphoric acid of which consists mainly of di-calcium phosphate.

Thus with a 40-in. cage disintegrator, from 20 to 25 tons per hour may be mixed direct into containers, doing away with the handling of a very dusty material, and avoiding excessively high temperatures.

AGRICULTURAL EXPERIMENTS

With regard to the effect of reverted phosphate on growing crops, and also its commercial value, there are differences of opinion. In 1914 the state chemists of North Carolina, South Carolina, Alabama, Mississippi and Georgia were all opposed to a reverted phosphate. Dr. Cameron, then of the Bureau of Soils at Washington, is also quoted as not favoring lime being mixed with superphosphates.

Possibly in the majority of cases the water-soluble phosphate is the one used. There are exceptions, however, and we have found in numerous cases that the reverted phosphate is just as valuable or even more valuable than the water-soluble when applied to cane upon upland soils. These soils are, as a rule, highly ferruginous clays. On soils which have not been cropped for several years, the reverted phosphate gives excellent results. The accompanying photographs show the difference between cane unfertilized and that receiving per acre 90 lbs. of phosphoric acid in reverted form. In the check plot the canes per stool ranged from 5 to 9 while in the reverted phosphate plot the variation was from 9 to 15. These photographs were taken in a series of experiments run by the Hawaiian Sugar Planters' Experiment Station, on land of the Oahu Sugar Co. Experiments made by the U. S. Agricultural Experiment Station[1] upon rice, also show favorable results from reverted phosphate, particularly the Gold Seed rice which has a long growing period. A gain of 132 per cent over the check plot is recorded.

In view of these results and the fact that the reverted form is preferred by certain growers to any other, it would seem that the practice of condemning or setting arbitrarily a lower value on reverted phosphate is open to criticism.

Credit is due and acknowledgment hereby made to H. M. McCance for aid in the analytical work reported in this paper.

PACIFIC GUANO & FERTILIZER COMPANY
HONOLULU, HAWAII

ELECTRIC FURNACE SMELTING OF PHOSPHATE ROCK AND USE OF THE COTTRELL PRECIPITATOR IN COLLECTING THE VOLATILIZED PHOSPHORIC ACID

By J. N. CAROTHERS

Received October 8, 1917

The work described in this article is a continuation, on a commercial scale, of preliminary work which was carried on more than a year ago. In the preliminary work,[2] furnace operation was not continuous for a period of days, consequently no conclusion could be drawn as to cost of installation and operation.

The work of these later tests was made possible only by the coöperation of the Bureau of Soils with several

[1] Hawaii Experiment Station Report 1907–1908.
[2] THIS JOURNAL, 9 (1917), 26.

firms which were interested in this line of investigation.[1] The apparatus was installed near the plant of the R. B. Davis Co., Hoboken, N. J. Fig. I is a view of the precipitator and furnace housing. Power was secured from the Public Service Co.

From the transformer ratings, the plant was a 200 K. W. installation. The incoming power was quarter phase, 2400 volts, which was transformed to 3 phase, 220 volts by a bank of Scott connected transformers. A second bank of transformers, and a set of double-throw switches made it possible to have either 220 volts or 110 volts in the furnace. This arrangement was adopted so as to use the higher voltage for starting and the lower voltage for operating. For the best operating conditions 110 volts were found satisfactory.

The furnace consisted of a water-cooled crucible, with the cooled section extending no higher than the region of the molten slag. It was lined with fire-clay

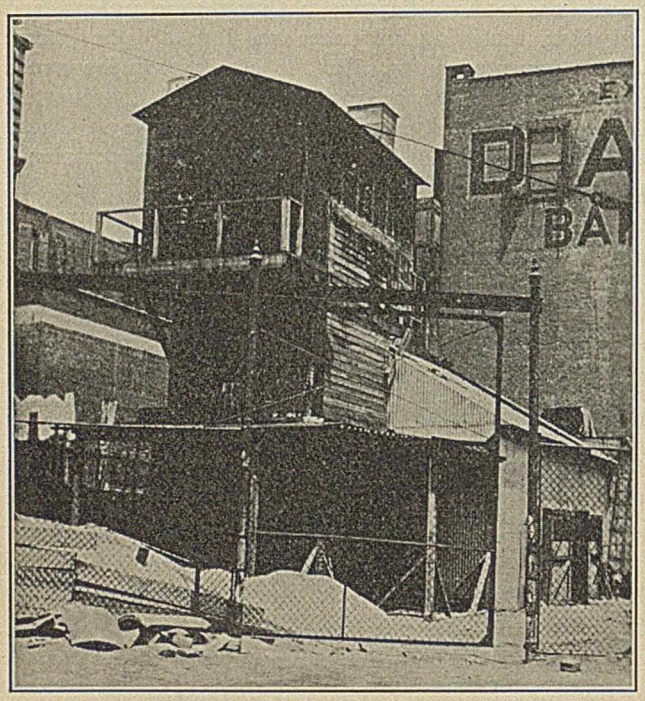


Fig. I—Precipitator and Furnace Housing

brick, but silica brick would prove more satisfactory. The portion not exposed to the action of slag was lined with a fire-clay brick. All gas mains and the cooling tower had a fire-clay brick lining. The heat from the gases served to harden the exposed surface, and thus improve the service of the brick. The electrodes entered through the top of the furnace, but below a line where the charge entered. Care should be taken in the design of such furnaces that the angle of the electrodes conform with the angle of repose of the charge. Thus as the charge falls in a natural pile, the breakage of electrodes is eliminated. Electrodes may be conveniently controlled by hand, or mechanically. Hand control was used in this experiment, with the control so located that the switchboard and instruments could be observed. Six-inch and four-inch graphite electrodes were used. The life of a 4-in. electrode was about 7 days, while the 6-in. electrodes lasted on an average of 10 days under favorable conditions. Thus it may be seen that with such a low consumption, electrodes may be operated by hand, since the chief movement of electrodes is when they are consumed. In this experiment the charge was fed by hand; however, this is obviously impractical in a large installation where mechanical apparatus should be used. During regular operation about 2000 lbs. of rock were consumed per 12-hour period.

A slag pit filled with water was used to quench the molten slag as it flowed from the furnace. The slag thus chilled slid to one end and was removed mechanically. The P_2O_5 content of the slag was approximately 2 per cent, although it is possible to reduce it to 1.5 per cent or even 1 per cent for regular operation. The P_2O_5 content of the slag is largely a matter of the mixing of the charge, and using the proper proportions of rock, sand, and coke.

The average production was 0.3 lb. H_3PO_4 per K. W. hr. absorbed; however, there were periodic yields, during times of good operating conditions, in which 0.4 lb. H_3PO_4 per K. W. hr. was produced. Judging from the average results of this experiment it seems reasonable to assume that a production of 0.6 lb. H_3PO_4 per K. W. is possible. Of course, the production is entirely dependent upon the efficiency of the furnace. In the case of this work, no means were adopted to utilize the heat absorbed by the water surrounding the crucible, or in the gases carried over from the charge. Also there were heat losses from the oxidation of phosphorus to phosphorus pentoxide (P_2O_5) and carbon monoxide (CO) to carbon dioxide (CO_2) which, if utilized, would materially have increased the efficiency of the process.

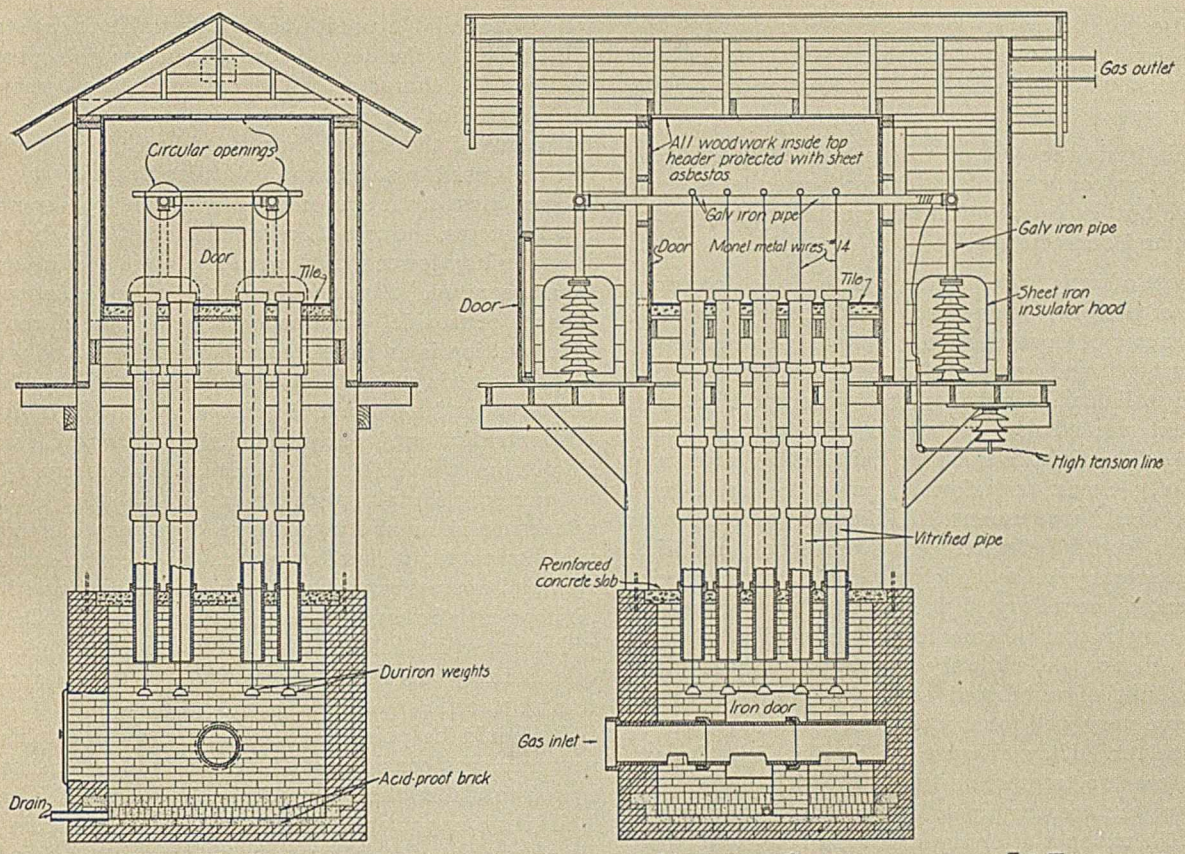
As the gases were removed from the furnace, they passed through a cooling tower before entering the treater. This tower was installed to afford sufficient radiation, so that the gases entered the treater at 250 to 300° C. Above these temperatures in the treater, electrical and mechanical difficulties arise, which make higher temperatures undesirable.

The treater consisted of a header of common brick, with a reinforced concrete top to support the pipes, and 20 treater tubes of vitrified sewer pipes, 12 in. in diameter and 15 ft. in length. All joints were packed loosely with silica to prevent air from entering at these points. The pipes were enclosed to prevent cracking, due to heat differences, and to maintain an even flow of gas.

All pipes at the top were inclosed in a common hood. Supports for the conductors rested on insulators within

[1] The R. B. Davis Co. of Hoboken, N. J., first proposed the coöperative plan, and were instrumental in interesting some of the dealers of phosphate rock, and electrical machinery. The Lakeland Phosphate Co. supplied a high-grade Florida pebble, the Cummer Lumber Co. a high-grade Florida land rock, the Phosphate Mining Co. a screening and two sizes of pebbles, the Farmers Ground Phosphate Co. a large brown lump of Tennessee rock, the Central Phosphate Co. a brown Tennessee rock in large lump, and the Hoover and Mason Co. a blue Tennessee rock in lump and fine material mixed.

The General Electric Co. supplied all transformers and instruments for use in connection with the furnace. The Research Corporation furnished the electrical equipment used in connection with the treater for collecting the gas. They also gave some very helpful suggestions as to treater design, construction and operation.



TRANSVERSE SECTION LONGITUDINAL SECTION FIG. II

the treater hood. Complete clearance was given to 2,000 cu. ft. of gas entering at 300° C., with a velocity of 3 linear feet per second (see Fig. II for diagrammatic sketch of a transverse and a longitudinal section of the treater).

Power was supplied the treater from a 150-volt motor generator set, and transformed to higher voltages by a 7.5 K. V. A. transformer. A 5-point switch on the low-tension side of the transformer, connecting the various turns of the coils, made a variation of voltages possible. It was found that 70 kilo volts was sufficient to give complete precipitation of the gases, at the above stated volumes and velocity.

As the acid fell from the pipes it was caught in a receiving basin of vitrified brick set in acid-proof cement. From this basin the acid flowed out and was disposed of by pumping to a receiving vat. The concentration of the acid collected was controlled by the temperature of the gas in the treater. At a temperature of less than 100° C. the concentration is not likely to exceed 50 per cent H_3PO_4, while a temperature of 250 to 300° C. will yield an acid of 85 to 93 per cent H_3PO_4. In one case an acid of 97 per cent was produced. An acid above 85 per cent H_3PO_4 will probably solidify when it reaches atmospheric temperatures, and therefore the pumping apparatus and pipe lines should be so constructed as to prevent clogging.

Any unscreened rock is undesirable for such a process if a concentrated acid is to be collected; however, if a dilute acid be collected no difficulties are encountered. The fine dust is carried over with the phosphorous gases, and precipitated in the lower section of the treater pipes. There it reacts with the concentrated acid, and forms mono-calcium phosphate which is a stiff paste under such conditions as exist in the treater. This mass gradually accumulates until the distance to the conductors is so close that disruptive discharges set up.

It should be borne in mind that when a rock free from dust is used, the only impurities likely to be in the resultant acid are: carbon in the form of coke dust; silica dust from the sand and rock; and any volatilized fluorine or arsenic, which is absorbed in the acid as the gases pass through the treater. Therefore, if an acid of high purity is desired these impurities must be removed; however, this is largely a matter of filtering apparatus, and a question for individual installations.

Below is given an estimate as to the cost of operation for such a plant. A 3,000 K. W. unit is nominally chosen to show the production and cost of operation.

TOTAL ANNUAL PRODUCTION.....6,480,000 lbs. H_3PO_4
MATERIAL NEEDED FOR A 300-DAY YEAR:
7,800 tons 34 per cent P_2O_5 Phosphate Rock, assuming 90 per cent recovery
3,510 tons sand
1,758 tons coke (86 per cent carbon)

ITEMS	COST
7,800 tons phosphate rock @ $1.25 per ton	$ 35,100.00
3,510 tons sand @ $1.25 per cu. yd	3,327.00
1,758 tons coke @ $4.50 per ton	7,911.00
25 tons electrodes @ $10 per 100	5,000.00
8 Laborers @ $2.00 per day	5,280.00
2 Electricians @ $100 per mo	2,400.00
1 Analyst @ $80 per mo	960.00
1 Superintendent @ $150 per mo	1,800.00
Power @ $25 per H. P. Y. (equivalent to 0.285 ct. per H. P. Hr.) 28,800,000 H. P. Hr	100,000.00
Power for machinery, lights, etc., 100 K. W	3,283.00

Based on 0.3 lb. H_3PO_4 per K. W. hr. a 3,000 K. W. furnace would produce 21,600 lbs. H_3PO_4 per 24-hour day. Such a plant should average at least 300 operating days per year.

On this basis the cost of acid per lb. H_3PO_4 is 2.55 cents or 3.37 cents per lb. P_2O_5 for power labor, and material, but exclusive of investment charges, maintenance, and depreciation.

The cost of installation is more difficult to determine because of the present unsteady market conditions and the character of construction employed; consequently no attempt is made to make an estimate covering the cost of installation. However, it may be said that most equipment needed for a plant of this type is stock material. The furnace must be built from design, and is special. Stock transformers may be used, also switches and instruments. Likewise, all elevator equipment could be purchased from stock material. The treater may be so constructed that little special equipment is necessary. The treater base or header may be constructed of common brick, with a lining of vitrified brick or tile, while the top supporting the pipes may be built of reinforced concrete. Vitrified sewer pipes serve very well for treater tubes, although stoneware is better. If an exhaust fan be placed in the gas main before the treater, no special hood is needed for the top of the treater pipes; however, if it be desired to have the exhaust after the treater, an air-tight hood is necessary, which should be lined with vitrified sheet asbestos or tile. Some of the brick for the furnace might necessarily be of special shape, if standard shapes were not available and it were not desirable to cut standard shapes to the desired form. The foregoing briefly outlines the character of the equipment necessary for an installation for the production of phosphoric acid by means of the electric furnace, where electric precipitation is used to collect the volatilized gases.

Since most of the equipment is available from standard stock sources, the cost of an installation of this character is materially lower than it would be, were special equipment required. Also the simplicity of collecting phosphorus pentoxide, or phosphoric acid, by electrostatic precipitation is an improvement over the use of water-absorption towers, not only in tower cost of installation but in operation as well. Furthermore an acid of higher concentration may be collected. By having a gravity flow from the collecting basin to the receiving vat all pumping equipment and many of the storage tanks, which are necessary in the case of absorption towers, are eliminated. Therefore, with a lower cost of installation and operation of the treater, as compared with the absorption towers, the application of the Cottrell precipitator in collecting phosphorus pentoxide, unquestionably advances the possibilities in the application of electric smelting along this line.

It should be pointed out that the yield of this experiment was considerably below that of a furnace designed to utilize the energy from the heat in the gases. This very important feature is a large factor in the development of the process of smelting phosphate rock by means of an electric furnace.

Bureau of Soils
Washington, D. C.

LABORATORY AND PLANT

A CONSTANT TEMPERATURE AND HUMIDITY ROOM FOR THE TESTING OF PAPER, TEXTILES, ETC.

By F. P. Veitch and E. O. Reed

Received July 23, 1917

Variations in the relative humidity of the atmosphere have a decided effect on the physical properties of paper. The results of all physical tests on paper are affected to a greater or less degree by the ordinary variations of the relative humidity in the testing room and certain tests are valueless unless conducted under uniform temperature and humidity conditions. Especially is this true with the determination of the folding endurance, a most important test for indicating the flexibility and probable durability of paper. Though it is generally understood that the physical qualities of paper are affected by changes in humidity conditions, there is but little appreciation of the rapidity with which these changes affect it. Paper is so exceedingly sensitive to changes in atmospheric humidity that, in order to obtain concordant results which may be duplicated at other times and by other laboratories, it is necessary to make all physical tests upon it in a room where both uniform temperature and relative humidity are maintained.

All physical testing of paper done by the Bureau of Chemistry, U. S. Department of Agriculture, has been conducted since December, 1909, in a specially constructed and automatically controlled constant temperature and humidity room. So far as is known, this laboratory was the first in this country to maintain uniform temperature and humidity conditions in the testing of paper, textiles, leather, etc.

MEASUREMENT OF HUMIDITY

Humidity is expressed either as relative or absolute. Absolute humidity is the weight in grains of the water vapor in a cubic foot of air, while relative humidity is the percentage of saturation of the air at any particular temperature and pressure. Saturation at the designated temperature and pressure is taken as 100 per cent. The higher the temperature of the air the more moisture required to give the same percentage of saturation or relative humidity.

The measurement of humidity[1] is preferably made with a U. S. Weather Bureau sling psychrometer. Thermometers graduated to 0.1° F. should be used, since every degree difference between the wet and dry bulb temperatures gives from 4 to 6 per cent variation in relative humidity, at the ordinary temperatures of from 50 to 80° F. At lower temperatures this variation increases, as for instance at 32° F. one degree gives a difference of 10 per cent relative humidity. The sling psychrometer, method of handling and

[1] "Final Report of the Committee on Standard Methods for the Examination of Air." *Am. J. Pub. Health*, No. 1, 7, p. 54.

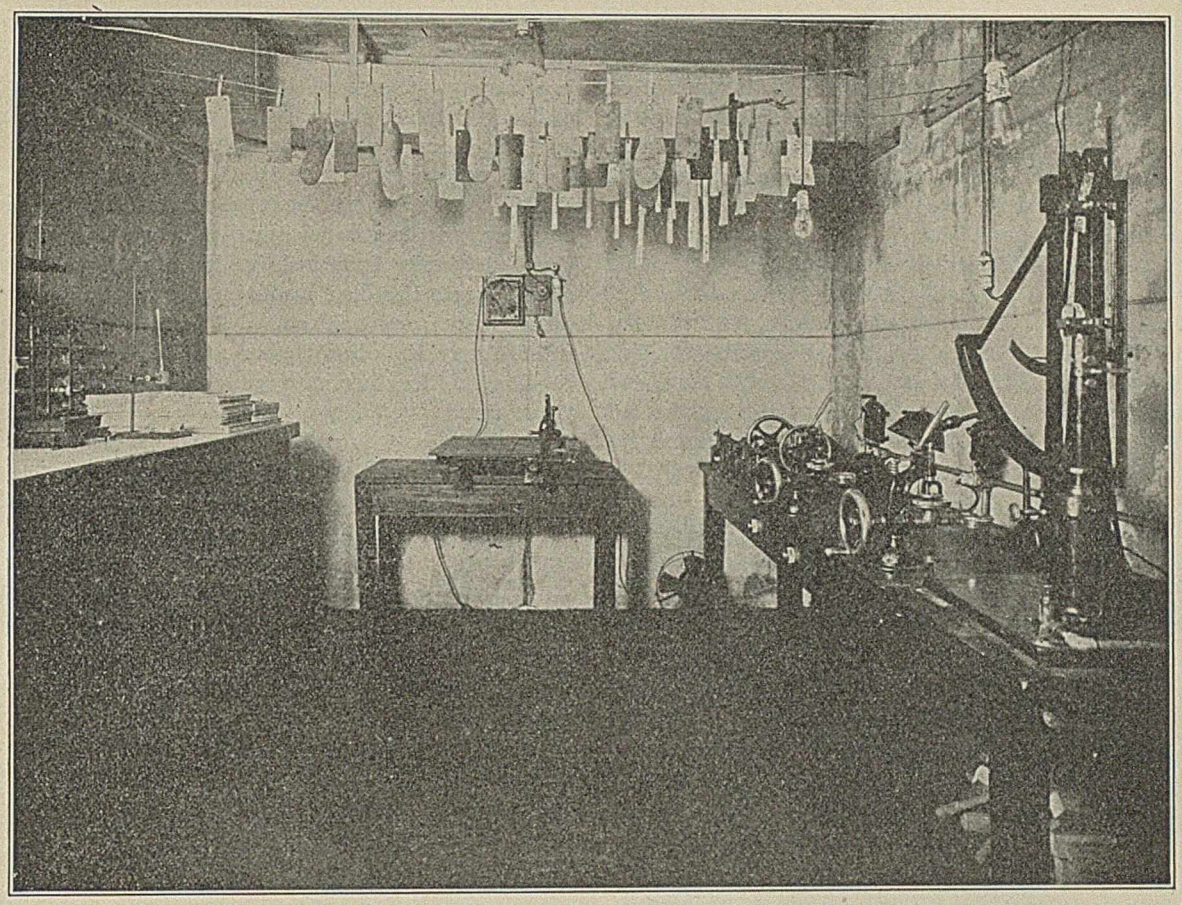


FIG. I—VIEW OF INTERIOR OF ROOM TAKEN FROM THE DOORWAY
On the Floor in the Rear Will Be Seen One of the Fans for Keeping the Air Uniform within the Room and along the Left Side and Back of the Room near the Ceiling Is the Outlet Flue.
The Method of Exposing Samples to Be Tested by Suspending with Clamps from Wires Stretched across the Room Is Also Shown

tables necessary for calculating relative humidity and dew point from the readings of the wet and dry bulb temperatures are described by the U. S. Weather Bureau.[1] There are many instruments for recording the temperature and humidity on charts, but these instruments must be frequently checked with a standard sling psychrometer or other accurate form of wet and dry bulb instrument.

INDOOR AND OUTDOOR HUMIDITY

During the six to nine months of the year when artificial heat is required in most localities, the average relative humidity indoors is as low as 20 to 40 per cent, unless mechanical means for humidifying have been installed, while the average outdoor relative humidity in most localities in the U. S. is over 65 per cent. These facts are not generally appreciated, and erroneous statements on this subject are often made. Wilson[2] states that during the winter months the normal outdoor relative humidity over the more populous portions of the United States, especially east of the Missouri and north of the Ohio Rivers, is 72 per cent and that the average diurnal range is from 60 to 85 per cent.

In Table I are given the indoor temperatures and relative humidities for Dayton, Ohio, and Washington, D. C., recorded by this laboratory, and the outdoor readings for the same localities taken from the Annual Reports of the Weather Bureau.

[1] Psychrometric Tables, U. S. Weather Bureau *Bull.* **235.**

[2] "Atmospheric Moisture and Artificial Heating," Proceedings of the Convention of Weather Bureau Officers, **1898.**

TABLE I—AVERAGE MONTHLY OUTDOOR AND INDOOR TEMPERATURES AND RELATIVE HUMIDITIES

Dayton Ohio	Outdoor Temp. ° F.	Outdoor Rel. Hum.	Indoor[1] Temp. ° F.	Indoor[1] Rel. Hum.	Washington D. C.	Outdoor Temp. ° F.	Outdoor Rel. Hum.	Indoor[2] Temp. ° F.	Indoor[2] Rel. Hum.
1911, Nov.	38.0	83%	74.5	29%	1912, Aug.	73.4	72%	83.5	49%
Dec.	37.8	80	74.5	28	Sept.	70.4	82	76.5	65
1912, Jan.	18.4	78	75.0	19	Oct.	59.3	75	75.0	46
Feb.	23.2	75	75.0	21	Nov.	46.9	67	74.5	39
Mar.	34.4	79	74.5	26	Dec.	40.4	69	74.0	35
Apr.	53.6	75	75.0	35	1913, Jan.	43.6	72	73.0	35
May	64.4	75	75.5	43	Feb	36.6	63	74.5	31
June	68.4	69	76.0	44	Mar.	49.0	66	74.0	31
July	74.9	76	79.5	58	Apr.	55.5	60	76.5	33
Aug.	71.0	80	78.0	60	May	64.4	65	77.5	41
Sept.	68.2	76	77.0	56	June	72.8	66	80.0	49
Oct.	56.6	71	72.5	41	July	77.6	66	87.0	44
Average	50.7	76	75.5	38	Average	57.5	68.5	77.1	41.5

[1] Readings taken by the Bureau of Chemistry in the Mercantile Corporation Factory.

[2] Readings taken in laboratory room Bureau of Chemistry. As open steam baths are located in all rooms used for laboratory purposes the indoor humidity is slightly higher than was found in other buildings.

The results given in Table I are representative of the average indoor conditions at Dayton, Ohio, as determined by observations made during several years. It has been observed in Washington, in several of the different government bureaus and in offices using large amounts of paper, that the average yearly indoor relative humidity during working hours is between 35 and 40 per cent. The average yearly indoor relative humidity is close to 40 per cent both in Dayton, Ohio, and Washington, D. C., but in no case does it approach the average outdoor relative humidity,

averaging from 30 to 40 per cent less. These results are in close agreement with those quoted by Wilson,[1] to the effect that the indoor relative humidity in heated buildings in several widely separated parts of the country on the coast and in the interior varies from 24 to 33 per cent and that during the winter months the indoor relative humidity is about 42 per cent lower than the outdoor.

The average winter indoor humidity in the United States is lower than that of the driest climate known.[1] This fact has led to investigations as to the physiological effects of temperature and humidity for the purpose of setting standards for the best living and working conditions. Such work has been conducted by the New York State Commission on Ventilation for several years.[2]

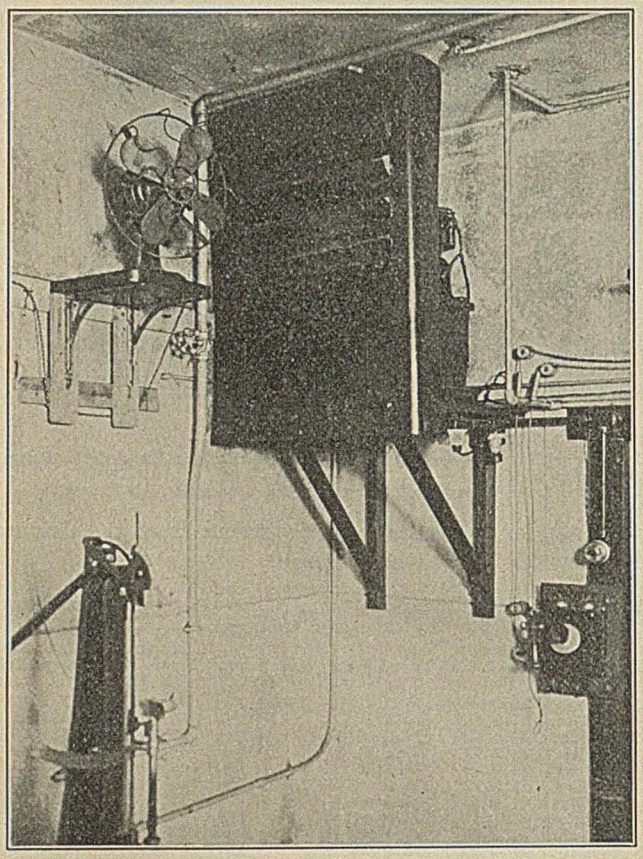


FIG. II—VIEW OF THE AIR INTAKE WHICH SUPPLIES TEMPERED AIR AND MOISTURE TO THE ROOM
Back of the Baffle Plate Will Be Seen the Motor of the Sirocco Fan, which Serves to Circulate Air through the System; in Front of It the Other Fan which Is Used to Distribute the Air throughout the Room

STANDARD TESTING CONDITIONS

The German Imperial Testing Laboratory at Gros-Lichterfelde found the variations in atmospheric humidity to produce such a decided effect on the results of physical tests of paper, that it was necessary to make all tests under constant relative humidity conditions.[3] About 1890, they accordingly adopted 65 per cent relative humidity for all physical testing of paper. It is not made clear why 65 per cent relative humidity was selected, but it appears to have been taken because of the fact that, since the average outdoor relative humidity is more than 65 per cent and the indoor humidity somewhat lower, it was easier to add moisture to the air than to remove it.

This condition has been generally accepted in this country, apparently without investigation. Since the average yearly indoor humidity in this country is, according to the data available, but 35 to 40 per cent, it does not seem rational to test paper at a relative humidity rarely obtained indoors. The testing should be done under humidity conditions more nearly like those under which the paper is used. It is doubtful, however, if it would be advisable to set the relative humidity for such work as low as 40 per cent or even 45 per cent, since for about five months of the year it will be necessary to dehumidify to secure these percentages. A relative humidity of 50 per cent is probably as low as can be maintained throughout the year without elaborate equipment. Even at this percentage it will be necessary to dehumidify the greater part of the time during the months of July, August and September.

Not only has humidity a marked effect on the results of physical tests, but also on the handling and use of paper. The printer, engraver, stationer, librarian and others using large quantities should standardize their working and storing conditions to secure the best and most satisfactory results at all times of the year. The most suitable humidity conditions for their respective purposes should be determined by investigation and means should then be taken to maintain these conditions throughout the year. The paper maker and consumer would undoubtedly profit by the maintenance of uniform humidity conditions most satisfactory for their purposes. Suggestions from the Bureau of Chemistry have led to the elimination of a number of difficulties in printing and engraving establishments of the government caused by variations in atmospheric humidity.

In most texts on paper testing it is suggested that certain definite humidity conditions may be had by placing the samples in small containers, in which the definite temperature and humidity required are maintained for 12 to 24 hours, then removing from the containers and testing under the atmospheric conditions prevailing in the room. Accurate results cannot be obtained in this way, especially with the folding endurance tester. As will be seen from Table II, results made with this machine are valueless unless made under uniform humidity conditions. Nor has it been found possible to apply accurately a formula for correction where the tests have been conducted at a different humidity than 65 per cent as no two kinds of paper or even runs of the same kind of paper will necessarily permit the application of the same correction factors —a fact that is clearly shown by comparing the results in Table II, Columns 2 and 3 with Columns 6 and 7, respectively.

The results in Table II show that the physical qualities of the paper change very rapidly with changes in

[1] "Atmospheric Moisture and Artificial Heating," Proceedings of the Convention of Weather Bureau Officers, 1898.

[2] "Some Results of the First Year's Work of the New York State Commission on Ventilation," *Am. J. Pub. Health*, No. 2, 5, p. 85.

[3] *Mittheilungen a. d. K. Technischen Versuchungsanstalten*, 7 (1889), 2 8 (1890), 8 to 19.

TABLE II—RESULTS SHOWING RAPIDITY WITH WHICH THE FOLDING ENDURANCE IS AFFECTED BY HUMIDITY

Samples of Uncoated Blue-Print Paper. Results Given are Averages of 10 Tests Each

EXPOSURE	12 hrs., 71° F. and 30% rel. hum.		Exposed 71° F. and 30% rel. hum.		12 hrs., 65° F. and 65% rel. hum.		Exposed 65° F. and 65% rel. hum.	
TESTING	71° F. and 30% rel. hum.		Immediately at 65° F. and 65% rel. hum.		65° F. and 65% rel. hum.		Immediately at 74° F. and 25% rel. hum.	
Paper No.	*Double Folds* Long.	Trans.	*Double Folds* Long.	Trans.	*Double Folds* Long.	Trans.	*Double Folds* Long.	Trans.
28541	316	411	852	804	1431	1298	468	347
28538	104	186	229	269	843	416	329	214
28519	305	296	373	440	1561	641	Not tested	

the relative humidity of the air. They show that papers should not be exposed to a certain humidity condition and tested under other conditions even though the tests are made at once. They indicate further that paper loses moisture faster in passing to a lower relative humidity than it gains moisture in passing to a higher relative humidity. The length of time for which it is necessary to expose a paper to a certain humidity condition before it reaches equilibrium can be definitely determined by means of the

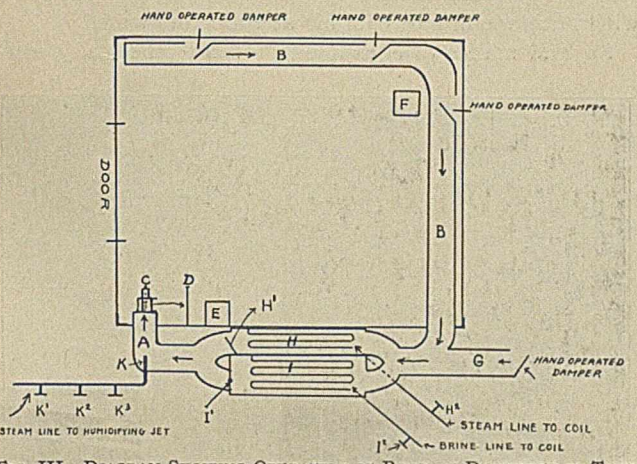


FIG. III—DIAGRAM SHOWING OPERATION OF ROOM AS DESCRIBED IN TEXT

folding endurance tester as well as by weighing the paper. Articles dealing with the effects of humidity on paper are in preparation and will be published in the near future.

DESCRIPTION OF THE BUREAU OF CHEMISTRY CONSTANT TEMPERATURE AND HUMIDITY ROOM

For general testing work this room has been operated up to the present at 70° F. and 65 per cent relative humidity. The temperature was at first set at 65° F. with 65 per cent relative humidity. At 65° F., the men were decidedly uncomfortable and developed frequent colds. It was, therefore, deemed advisable to adopt 70° F. as the standard temperature with the relative humidity at 65 per cent. The room can be operated automatically at any relative humidity from 20 to 85 per cent and any temperature from 40 to 95° F. Investigational work has been carried on at different humidities and temperatures to show the effects on paper and on tests made with various testing machines.

The room is 10 ft. 6 in. × 14 ft. 3 in. × 9 ft. 3 in. high and contains 1410 cu. ft. It was constructed in connection with the refrigeration plant of the Bureau. The walls and ceiling of the room are 8 in. thick and consist of an outside sheathing, 4 in. of ground cork, a thin partition and two layers of sheet cork, each $1^1/_2$ in. in thickness, the inner layer finished on the inside with cement, which is painted to prevent absorption of moisture. The floor is insulated in the same manner, cemented and covered with linoleum. The door is of the regular cold storage type. The insulation of the room is such that when the automatic controls are turned off the temperature will remain constant for several hours.

Air is drawn into the room by means of a sirocco fan (Fig. III, *C*), from the intake flue *A*, through which the tempered air and moisture are supplied. It is delivered into one corner of the room near the ceiling, against a slotted baffle plate, *D*. Two fans, *E* and *F*, are located within the room to keep the air uniform throughout; *E* is placed in front of the baffle plate where the air enters, and *F* on the floor in the diagonally opposite corner. These fans are essential in order to prevent the air from stratifying. The outlet flue *B* is located near the ceiling along the two sides of the room opposite the intake, and has three openings, each with an adjustable hand damper, through which air is removed from various parts of the room. This flue is connected with a fresh air flue, *G*, outside of the room, which supplies air to the tempering coil chambers *H* and *I*. The sirocco fan located in the intake flue maintains the air circulation, drawing air into the room and forcing it out through the outlet flue. Careful experiment shows that the two fans as placed within the room insure even humidity throughout the room.

The tempering coils, steam and refrigerated brine are located in well insulated chambers on the outside of the room and are connected both with the inlet and outlet flues. All air supplied to the room is drawn over one or the other of these coils as the demands of the room may require. The steam coil *H* contains approximately 28 sq. ft. of heating surface, and the brine coil *I* approximately 113 sq. ft. of cooling surface. They have been found ample at all seasons of the year for maintaining any temperature within the range of the controlling thermostat, 40 to 95° F. In order to obtain maximum efficiency it is necessary to keep the brine coil free from ice, and this is accomplished by opening the chamber once every two or three weeks and allowing the ice to melt off.

The automatic operation of the plant is obtained by means of air pressure and automatic air pumps maintain a pressure of approximately 12 lbs. The operating valves and dampers are worked by diaphragms. Automatic diaphragm-operated valves are located on the pipe lines leading to each of these coils; the brine valve I^1 opens when air pressure is supplied to the diaphragm operating it and the steam valve H^1 when the air pressure is released from the operating diaphragm. Each coil chamber is fitted with an automatic diaphragm-operated damper, I^2 and H^2, leading into the main flue to the room. These dampers work by means of their respective diaphragms at the same

time as the corresponding brine and steam valves on the coils. The automatic operation of these valves and dampers is controlled by a thermostat within the room to be described later. The two valve diaphragms and the two damper diaphragms are all on the same air-pipe line, the air pressure of the line being controlled by the thermostat within the room, which makes and breaks the circuit of air.

Moisture for humidifying is supplied by means of a steam jet, K, located immediately outside of the room in the intake flue. This steam jet consists of a brass pipe about 8 in. in length, perforated and wrapped with cotton wicking, which removes any water which may be in the steam. This produces a finely divided steam vapor, which has been found the most satisfactory method of humidifying. Two automatic diaphragm-operated valves, K^1 and K^2, are located on the steam line leading to this humidifier; K^1 is operated by the hygrostat within the room and opens

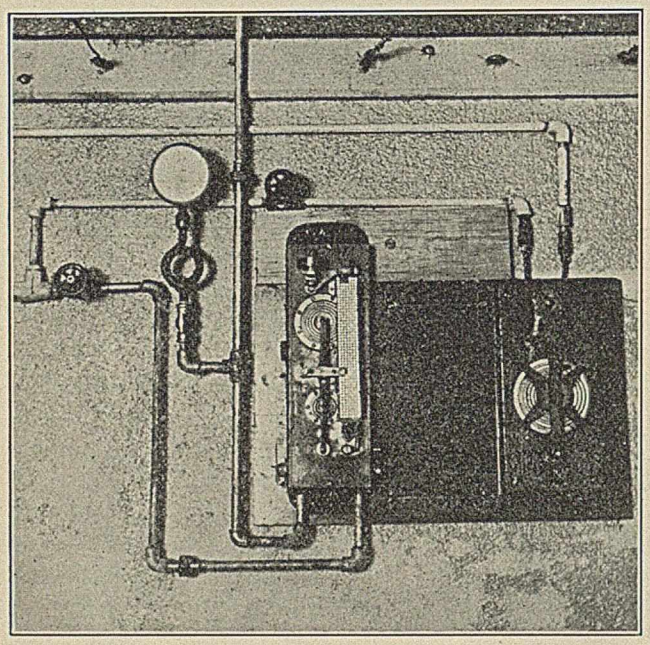


Fig. IV—View of Temperature and Humidity Controlling Instruments Located within the Room
Thermostat on the Right; Hygrostat on the Left

when the hygrostat releases the air pressure on the diaphragm; K^2 is a safety valve which closes with the release of the air pressure to its diaphragm and is connected with the main air-supply line of the system. Since the valve controlled by the hygrostat opens with the release of air pressure, in case of a break in the main air-supply line of the plant this valve would not close and an excessive amount of steam would be supplied to the room. The safety valve is to prevent an accident of this kind. The supply of steam to the humidifying jet is controlled by a needle valve, K^3. It is important that the supply to the jet be regulated according to the capacity of the room so as not to furnish an excessive amount nor an insufficient amount of moisture for the room. A steam trap for removing the water in the steam is placed in the line in front of the valves.

AUTOMATIC CONTROLS

The room is automatically operated by two separate controls, one for maintaining temperature and the other humidity. Both controls are located within the room itself.

The temperature control was installed at the time the room was constucted and has given entire satisfaction. The temperature in the room varies less than 1° F. This thermostat operates the valves on the brine and steam coils and the dampers leading from these coil chambers into the room, previously described. When the room requires warm air, the thermostat releases the air pressure and the valve on the steam line and the damper to the steam coil chamber are opened, while at the same time the valve on the brine line and the damper to the brine coil chamber are closed. When cool air is required the above operations are reversed, the thermostat permitting the air pressure to be on the operating diaphragms. The above describes the principle of operation of the equipment. As a matter of fact the action of the thermostat is gradual, allowing the room to be supplied with both warm and cool air at the same time.

Several makes of equipment for automatically con-

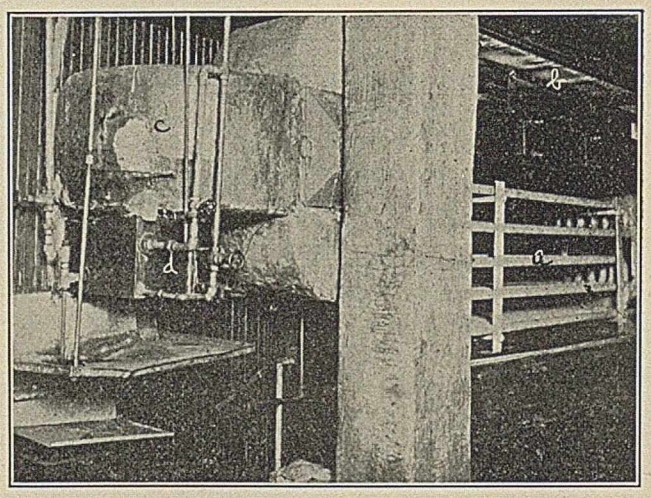


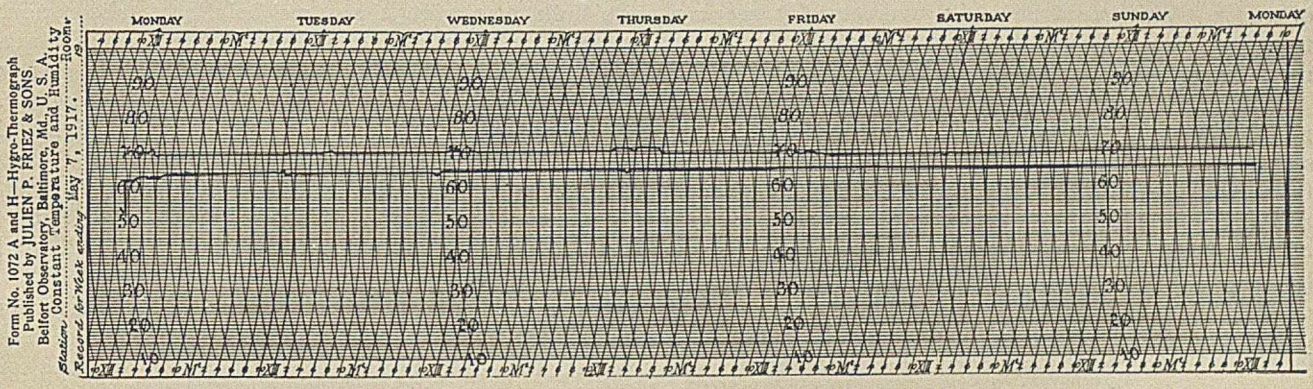
Fig. V—View Outside of the Room Showing Brine (*a*), and Steam Coils and Chambers (*b*), the Intake Flue (*c*) and the Humidity Supply Line (*d*).

trolling the humidity of the room have been tried. The hygrostat now used controls the relative humidity within less than 2 per cent variation. The room has been operated fairly well by means of other controls, but none, so far used, has proved as reliable as the instrument now in use in giving uniform and accurate automatic control at all seasons of the year. The instrument is a Type F hygrostat, in which the actuating material is silk fiber. This instrument operates the diaphragm-operated valve K^1 on steam line to the humidifying jet. When the need of more moisture is indicated by contraction of the silk fiber the air pressure to the diaphragm is released, opening the valve and admitting steam to the jet, until the set humidity is reached, whereupon the valve is closed with the expansion of the silk fiber.

Previous to the installation of the present humidity

controller the room was operated by passing all air from the tempering coils over a vaporizing pan, in which a constant temperature was automatically maintained. This system usually gave fairly satisfactory results, but when sudden changes in the outdoor temperature or humidity occurred these were not automatically taken care of within the room. The vaporizing pan was 12 × 18 in. and built immediately outside the room in the intake flue. The pan contained 2 in. of water in which was located a thermostat connected with an automatic diaphragm-operated valve, placed in the steam line, to an open coil in the pan for heating the water. By this method moisture was uniformly and continually added to all air passing into the room. It was impracticable to take much fresh air into the room under these conditions and consequently the same air was continually recirculated, which facilitated maintaining very constant conditions but did not permit proper ventilation. The thermostat regulating the temperature of the vaporizing pan required frequent attention to allow for the changing outdoor conditions of temperature and humidity. In summer the temperature of the water in the vaporizing pan was held at 120 to 160° F. and in winter 160 to 185° F. in order to maintain 65 per cent relative humidity within the room. With the present system it is possible to take all air directly from outdoors or to add any amount of fresh air to that exhausted from and to be returned to the room without seasonal resetting of the controlling instrument.

As has been previously stated the room has been uniformly maintained at the desired temperature and humidity with only regular inspection to insure the proper mechanical condition of the operating equipment. It is not unusual for both temperature and relative humidity to be maintained constant for several weeks at a time as shown by the accompanying copies of the autographic records, which by the way are confirmed several times each day by wet and dry bulb readings.



RECORD OF TEMPERATURE AND HUMIDITY FOR ONE WEEK BY THERMO-HYGROGRAPH RECORDING INSTRUMENT
TOP LINE—TEMPERATURE. BOTTOM LINE—HUMIDITY

CONCLUSION AND SUGGESTIONS

Seven and a half years' experience with and in developing a constant temperature and humidity room has led to the following conclusions and suggestions:

I—Owing to the intimate relation between temperature and humidity, both should be controlled, especially where exact testing conditions are desired. It is much easier to maintain uniform humidity conditions, when the temperature remains constant.

II—The source of the humidity supply should not be located within the humidity room. Experience shows that steam vapor is more satisfactory than water spray for increasing the humidity. If water spray vapor is used, mechanical moisture is likely to be deposited on the walls of the room, on the apparatus and on the materials to be tested. A steam jet or vaporizing pan has been found to be satisfactory for supplying the steam. If a water spray is used it must be installed outside of the room and the humidified air passed through a series of baffle plates to remove all excess of mechanical moisture before entering the room.

III—Uniform conditions within a room can be maintained only by the use of a number of properly located small fans. Without these the air will be stratified.

IV—Humidity may be controlled within limits in almost any room or building. It is unnecessary, even for testing laboratories, to construct such an elaborately insulated room as has been described, although a well insulated room is a great advantage. However, the best results will be obtained when the room has no outdoor exposure or windows. It is believed that a room constructed within another, leaving an air space of at least 12 inches between the walls, can be maintained at constant temperature and humidity by the control system described herein. The walls of the room may be of $^7/_8$ in. lumber and should be practically air-tight.

V—Humidity and temperature systems must be controlled more closely in paper and textile testing laboratories than in most factories, and for laboratories more or less difficulty may be experienced with many automatic systems, which are entirely satisfactory for commercial and manufacturing plants. It is, therefore, advisable to submit any installation to a thorough trial before reaching a conclusion as to its efficiency. As temperature and humidity are so closely related, a temperature effect on the actuating material of a humidity control instrument must be properly compensated for. Naturally if a humidity control is installed in a room in which the temperature is closely

controlled this practically eliminates the effect of room temperature on the humidity controller. All materials used for humidity controls are subject to temperature changes to a greater or lesser degree.

VI—Not only is the control of humidity of importance in the testing of materials, but also in many industrial lines as well. Many of the troubles and complaints of the pressman and engraver are due to humidity effects on paper and could be remedied by maintaining more uniform humidity conditions in the press and storage rooms. Low indoor humidity in winter is the cause of much inconvenience in printing, causing the paper to curl and shrink and thus interfering greatly with the work of the presses. Paper is more flexible at high humidity. This fact is of direct importance to the manufacturer of envelopes and in the folding of paper, the humidity of the room determining whether the folding is smooth or cracked. The humidity of the drying loft and the calendering end of a paper machine undoubtedly plays an important part in the finishing of paper. The expansion and contraction of the sheet caused by variations in atmospheric humidity are of controlling importance in map and chart making and in certain special uses of paper. This could be easily overcome by keeping the paper at a uniform humidity from the time it is received until the work is finished.

VII—There are many other industries in which the maintenance of uniform humidity is absolutely necessary. Among these are the manufacture of textiles, fuses for munitions, motion picture films, tobacco and many others. Humidity control is being applied to the ripening of fruit, curing of cheeses, drying of lumber, manufacture of leather goods and to many other important industries.

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A METHOD FOR DETERMINING THE ABSORBENCY OF PAPER

By E. O. REED

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The serviceability of blotting paper, paper towels, filter paper and copying paper is largely dependent on their absorptive properties for the measuring of which several methods have been used. Since blotting is the most important of absorptive papers, the methods proposed have been especially adapted to the testing of this class of paper.

Absorption is most commonly determined by measuring the rate at which distilled water rises in a vertically suspended strip usually 15 mm. in width, the lower end of which dips beneath the surface of water contained in a trough. Either the time which it takes the water to rise to a given height or the height to which the water rises in a given time, is noted. The latter is the more common method. Apparatus for conducting this test, which is known as the "mounting test," has been designed by Klemm[1] and by Stevens.[2] Specifications for this quality in blotting paper usually require that absorption shall be not less than a certain number of millimeters in 10 min. The absorption in each minute can also be noted, though specifications generally state only the total absorption in 10 min.

There are several disadvantages in the use of the mounting test for determining the absorptive properties of a blotting paper. The strips are suspended vertically while the blotting paper is always used flat. The use of ink in this test is not practicable, due to the large surface exposed to evaporation in making the test and since most writing inks contain a colloidal precipitate, the blotter will tend to absorb only the liquid portion. There is considerable difference in the absorption of water and of ink by blotting paper. To get the true ink absorptive value, ink must be employed in the test. The chief drawback of the mounting test, however, is that it is unaffected by the bulk or weight of the paper which necessarily has a relation to serviceability. In this procedure an unlimited quantity of water is in contact with a variable thickness or bulk of paper for a definite time and the height to which the liquid rises in this definite time is recorded. Neither the width, thickness nor weight of the strip affects the results. Two papers of different bulk may give the same height of absorption, but the lighter will undoubtedly not absorb as much water as the heavier nor as rapidly. This is clearly shown in Table III, which will be discussed later. Bromley[1] suggests determining the actual weight of water absorbed. This procedure shows clearly that the mounting test does not take into consideration the bulk of the blotter, which is one of the chief factors determining the amount of water absorbed in a specified time.

Other methods have been suggested for indicating the absorbency of blotting papers. Sindall[2] describes a test for determining the absorptive qualities of blotting paper, which consists of noting the time required to absorb 0.5 cc. of ink delivered drop by drop, allowing each drop to be absorbed before another falls. Methods somewhat similar but differing in details of manipulation are described by Cross and Bevan,[3] and by Stevens.[4] The size and character of the zones formed are also noted. The thickness or bulk of the paper unquestionably plays an important part in determining the size and character of the zones. It has also been suggested that the absorptive capacity and the loss of absorbent qualities of blotting paper on repeated use can be determined by soaking it in ink, allowing to dry, and then noting the time required for the absorption of a definite quantity of ink dropped upon it.[5]

The same criticism—failure to include the effect of thickness or bulk of the paper on the quantity of ink or water absorbed in a given time—applies also to the methods suggested by Favier[6] and by Fromm.[7]

[1] "Handbuch der Papierkunde," p. 318.
[2] "Paper Mill Chemist," p. 229.

[1] "Notes on the Requirements of Certain Special Classes of Paper," *Paper Maker and British Paper Trade Journal*, **52**, 59.
[2] "Elementary Manual of Paper Technology," p. 119.
[3] "Paper Making," 4th Ed., p. 389.
[4] "Paper Mill Chemist," p. 231.
[5] *Ibid.*, p. 233.
[6] *La Papetérie*, **1894**.
[7] *Wochbl. Papierfabr.*, **1909**, 4172.

In both of these methods absorption is measured with the paper in a horizontal position. By Favier's method the time required to saturate a square decimeter of the paper under a uniform pressure of water is noted. The absorption value is calculated by dividing the amount of water absorbed by the time required to saturate the paper. By Fromm's method five circular pieces of blotting paper are floated together on a trough of water and the time required to saturate the top piece is noted.

Though each of the methods referred to above is faulty in some particular, the results obtained with them, while varying with the procedure employed, are serviceable in judging the quality of blotting paper, if the limitations of the methods are kept in mind. It has long been felt, however, that none of the methods for indicating absorption give a true measure of the serviceability of absorbent papers, especially of blotting papers.

Investigations of the several procedures for the testing of absorbency indicate that by a modification and standardization of the procedures described by Sindall, Cross and Bevan and by Stevens, more accurate information as to absorptive qualities may be obtained than by the mounting test or the other methods mentioned. The procedure finally adopted consists in noting the time required for the absorption of one cc. of a specified standard ink or of distilled water under definitely prescribed conditions.

PROCEDURE

Place a 4-in. square of blotting paper over a beaker or tumbler and arrange a support in such a manner that a 1-cc. pipette is held in a vertical position with the delivering tip $^1/_2$ in. above the center of the surface of the paper. A suitable apparatus may be made by boring a hole in a cork through which the stem of the pipette will pass freely. Clamp it in a ring stand, so that the pipette when placed in position has the tip at the correct distance above the surface of the paper. Select a pipette with a delivery time for distilled water at 70° F. temperature of approximately 4 sec. Fill the pipette with distilled water or standard ink at 70° F. temperature. Place it in position in the support and permit the contents to flow upon the surface of the paper and record by means of a stop-watch the time required for the complete absorption of the liquid. Triplicate determinations should be made and the results averaged to secure the absorption time of the paper.

A 4-in. square of blotting paper is sufficiently large and it should be placed over a beaker or tumbler having a diameter somewhat greater than the blot made by the liquid, in order that the edge of the blot may not extend to where the paper rests upon the glass, as this may affect the time of absorption. It is important in placing the square of blotting paper upon the tumbler to dish it slightly, so that the water or ink will be received in one pool and thereby prevent buckling of the paper. If the paper is allowed to buckle, uneven distribution of the liquid will be caused and the time of absorption considerably affected, thereby rendering the test valueless. Check tests with this method in most cases differ but 2 or 3 sec. on papers absorbing the ink in less than 25 sec., and from 5 to 10 sec. on papers absorbing the ink in from 50 to 100 sec.

The results obtained using a specified standard ink are more indicative in the case of blotting paper than when water is employed. It is impossible to depend upon ink purchased on the market for use in a standard test of this character. It is therefore absolutely essential for the analyst to prepare the standard testing ink in accordance with a definite standard formula. For this purpose the formula for U. S. Government Standard[1] blue-black writing ink has been adopted. This formula is as follows:

	Grams
Pure dry tannic acid	23.4
Gallic acid, in crystals	7.7
Ferrous sulfate	30.0
Dilute hydrochloric acid (U. S. P.)	25.0
Carbolic acid	1.0
Dye, Bavarian blue (D. S. F), Schultz and Julius No. 478	2.2

Make to a volume of 1,000 cc. at 60° F. with distilled water. All of these chemicals should be of U. S. P. quality and in addition the purity of the tannin should be determined by the hide powder method.

Dissolve the tannic and gallic acids together in about 50 cc. of warm water and allow to cool; dissolve the ferrous sulfate in about 150 cc. cold water. Add the hydrochloric acid to the ferrous sulfate and immediately mix the solutions. Add the dye dissolved in water and the carbolic acid and make up with distilled water to 1000 cc. Mix thoroughly and allow to stand for at least 4 days at room temperature. When ink is to be used for tests, draw out without shaking the bottle. Formulas for standard inks are also given in Bureau of Chemistry *Bulletin* **109**, revised, page 43, and Bureau of Standards *Bulletin* on "Some Technical Methods of Testing Miscellaneous Supplies," page 43. These formulas differ slightly from the one adopted in that gum arabic is added and the soluble dye is not included. The formula adopted gives an ink closely agreeing in composition with the normal commercial inks furnished under the above quoted formula.

To prevent oxidation and evaporation of the ink when not being used, it is essential that the ink be poured into 50-cc. dark bottles, tightly corked and stored in a dark, cool place. The use of 1 cc. of water or ink gives a sufficiently wide range in the absorption results between different papers. In the case of filter paper, copying paper and very light-weight blotting paper, a smaller amount of water or ink (0.5 cc.) should be employed.

There are several factors which affect the results, namely, the temperature of the liquid, the delivery time of the pipette, the distance of the tip above the surface of the blotting paper and the amount of liquid used. These should be standardized, if accurate and comparable results are desired. In most cases there is little difference between tests made with either the felt or wire side of the blotter up. It is advisable, however, always to place the same side of the paper up, preferably the wire side, as on that side the absorption is more uniform.

Table I shows the effect of the time of delivery

[1] "General Schedule of Supplies, 1917–1918," General Supply Committee, Item 1128, p. 60.

from the pipette on the time required for absorption of the water by the blotting paper. Ten 1-cc. pipettes were used. The pipettes were supported so that their tips were approximately 1/2 inch above the surface of the paper. The temperature of the distilled water was 70° F. and the wire sides of the papers were up.

TABLE I—RELATION BETWEEN SPEED OF DELIVERY AND TIME OF ABSORPTION OF WATER

Pipette No.	Time of delivery Sec.	Time Required for Absorption Sample 32286 Sec.	Sample 32751 Sec.	Sample 32288 Sec.
1	3	16	10	55
2	3 1/2	15	10	57
3	4	16	10	55
4	4	17	11	58
5	4	16	11	56
5	5	16	10	57
7	6	16	11	55
8	15	24	17	65
9	15	23	17	67
10	27	30	29	80

There is considerable difference in the results obtained with rapid and slow delivery pipettes. However, the results obtained with pipettes delivering the water in 3 to 6 sec. are practically the same. This is explained by the fact that with a slow delivery the rate of absorption of the fluid by the paper is nearly the same as or exceeds the rate of delivery from the pipette. Since the most uniform and accurate results are obtained with quick delivery, a pipette delivering 1 cc. in 4 sec. is regularly used in this test. The last drop delivered upon draining, unaided, is included in the test but not in noting the time of delivery.

Table II shows the effect upon the time of absorption of the distance of the point of delivery above the surface of the paper. The same pipette delivering in 4 sec. was used in all cases and the temperature of the distilled water was 70° F.

TABLE II—EFFECT ON THE TIME OF ABSORPTION OF DISTANCE OF POINT OF DELIVERY ABOVE THE PAPER

Distance of tip above surface In.	Time Required for Absorption Sample 32751 Sec.	Sample 32735 Sec.	Sample 32926 Sec.
4	8	19	35
2	9	20	37
1	10	24	37
1/2	10	26	38
3/8	10	26	39

The distance of point of delivery above the surface of the paper has very little effect on the time of absorption, though a slightly faster absorption with increasing distance is noted. Practically no difference, however, is observed in the average time of absorption when the tip of the pipette is from 3/8 to 1/2 inch from the paper. When the tip of the pipette is an inch or more above the surface of the paper, the liquid spatters, covering a larger area and the time of absorption is lessened. This difficulty is overcome when the tip of the pipette is placed approximately 1/2 inch above the paper.

In Table III there are given comparative results obtained by the mounting test and by the procedure outlined above, on a set of white blotting papers of the same composition and weighing 19, 32, 45, 58, 72, 96 and 140 lbs. per ream 19 × 24—500 sheets, respectively. The stock of these papers is all rag and the ash content varies only from 1.2 to 1.5 per cent. Distilled water at 70° F. temperature was used in both methods. The mounting test strips were all cut transversely of the sheet 15 mm. in width.

TABLE III—COMPARATIVE ABSORPTION TESTS, USING THE MOUNTING TEST AND THE 1 CC. ABSORPTION TEST

Sample No.	Ream Weight 19 × 24–500 Lbs.	Mounting Test 1 Min. Mm.	10 Min. Mm.	Time Required for Absorption of 1 cc. Sec.
32791(*)	19	20	54	111*
32792	32	20	54	100
32793	45	19	54	61
32794	58	19	53	58
32795	72	20	52	36
32796	96	18	50	37
32797	140	20	55	11

(*) This sample is very thin and allowed 4 drops of water to filter through, reducing the amount absorbed by that quantity.

The absorption values of these samples obtained by the mounting test are practically the same, though the weight of the paper varied from 19 to 140 lbs. per ream. These results are in harmony with the known fact that the rate of rise of water in the mounting test is independent of the weight of the paper. On the other hand, the speed of absorption in the cubic centimeter absorption method increases inversely with the weight of the paper. The effect of the weight or bulk of the blotter on the absorption value is clearly indicated by the time required for the absorption of 1 cc. of water in the horizontal position. This test shows that the speed of absorption increases with the increase in bulk of the paper and that the heavier the blotting paper the better its absorption properties.

In Table IV there are given the analyses and absorptive values of several typical samples of blotting paper measured by three different methods. Results are given by the mounting test, using distilled water, and by the 1 cc. absorption method, using distilled water and also U. S. Government Standard ink. The water and ink were used at 70° F. temperature.

The samples are arranged in the order of their absorptive values as indicated by the time required for the absorption of 1 cc. of standard ink. The order would be changed completely if the samples were arranged in the order indicated by the values obtained by the mounting test or by the absorption time for 1 cc. of distilled water. It will be noted throughout that the values by the mounting test do not give the same relative rating for absorptive qualities as those obtained by the 1 cc. time absorptive method using water or ink. It will be noted that here, too, the effect of weight is shown by the results obtained with the 1 cc. absorption method. By the 1 cc. absorption method the time varies from 9 to 203 sec., by the mounting test from 44 to 101 mm. Thus the possibility of differentiating between papers is much greater with the former than with the latter method. The results obtained by using 1 cc. of standard ink are undoubtedly of the most practical value. In this paper it is not the purpose to consider the factors in the manufacture of blotting paper which affect the absorption quality, as this will be fully dealt with in a later publication. However, the color, stock, and ash content of the paper, as well as the weight, will be found to explain the results in most cases.

If these samples are classified according to weight, that is, all samples grouped into 140, 120, 100, 80, or 60 lb. classes, the results by the several procedures still show difference in order of absorptive values, though the differences are not as marked.

The proposed method may also be used to give an

TABLE IV—ANALYSES OF TYPICAL SAMPLES OF BLOTTING PAPER WITH COMPARATIVE ABSORPTION VALUES
(All Physical Tests Made at 70° F. and 65 Per cent Relative Humidity)

Sample No.	Color	Weight 19 × 24 500 Lbs.	Stock Rag Per cent	Stock Soda Per cent	Ash Per cent	Thickness 1/10,000 Inch	Bursting Strength Av. Points	Time Required for Absorption of Ink Sec.	Time Required for Absorption of Water Sec.	Mounting Test Rise in 10 Min. Mm.
32960	White	139½	81	19	8.3	365	27.0	9	9	96
28018	White	125	100	..	1.0	340	34.0	10	16	65
32956	White	102	79	21	7.7	285	21.0	13	11	101
32959	Gray	118½	70	30	7.9	330	30.0	14	10	86
28020	Blue	123½	100	..	2.6	330	30.5	15	16	65
32925	White	139	71	29	5.2	345	38.0	15	21	60
28129	White	97½	80	20	2.3	290	21.0	15	16	80
32961	Gray	135½	59	41	5.5	360	31.0	19	19	65
32924	White	119½	72	28	5.5	320	35.0	19	24	56
32955	White	77½	84	16	7.4	230	19.0	19	19	97
32799	White	100	100	..	1.3	250	19.0	21	18	61
32968	White	139½	48	52	20.1	335	21.5	21	18	67
32758	White	133	22	78	27.0	320	16.5	23	17	69
32969	Gray	137	49	51	18.4	330	26.0	24	18	63
32965	Gray	95½	52	48	17.0	260	19.5	26	16	78
32966	White	124½	51	49	19.9	305	23.5	30	22	68
32927	Pink	82½	85	15	4.7	220	23.5	30	20	75
32929	Pink	124	68	32	5.1	310	38.0	30	28	48
28030	White	93½	81	19	5.8	230	28.0	31	25	63
28024	White	101½	61	39	14.5	245	23.5	32	33	64
32760	White	114	22	78	25.5	260	24.5	38	23	69
32976	Gray	139	35	65	19.1	305	23.5	40	25	57
32962	White	80	66	34	14.4	215	18.5	40	26	80
32926	Pink	62	85	15	4.4	170	15.0	42	42	60
33852	White	63½	68	32	13.1	170	16.0	45	27	86
32973	Gray	102	26	74	20.2	240	19.0	49	29	67
32974	White	120	32	68	25.6	270	18.5	57	38	57
32970	White	83	26	74	19.8	195	17.5	62	50	66
32963	Gray	77	51	49	16.9	200	19.0	65	33	71
32922	White	77	62	38	7.6	190	26.0	65	47	63
32921	White	65½	68	32	6.3	150	22.0	74	85	57
31748	Blue	99½	60	40	23.9	230	20.0	104	69	56
28136	Blue	102	44	56	27.9	215	14.5	147	98	49
32936	Pink	58	37	63	16.0	132	13.5	203	197	44

indication of the total absorptive capacity of a paper or the loss of absorptive qualities on repeated use. In using this method to secure an indication as to the capacity of a blotting paper, a piece of paper of definite size (2 in. square is a convenient size) must be used. The test may be carried out in two ways: The paper may be saturated by running upon its surface successive 1-cc. portions of standard ink until it is completely saturated and will absorb no more. Although completely saturated with liquid in this manner, upon thoroughly drying the paper will still absorb more ink. Another plan is to allow the blotting paper to thoroughly dry between each 1 cc. of ink. Considerable time is required in the procedure, but after a certain number of applications of ink the absorption begins to decrease rapidly until finally a point is reached when the paper will absorb no more. By either procedure the number of centimeters of ink used and time required for the absorption of each centimeter is noted. The results by the procedures outlined do not give the same relative results and it is believed that the last suggested is the most indicative of the total capacity of blotting paper under service conditions.

However, the life or capacity of a blotter is so largely dependent upon the treatment it receives in service, that the results obtained by such a determination are of but little practical value. If a blotter is saturated with ink and allowed to dry, although somewhat stiffened, it will still absorb satisfactorily in most cases. In fact, it has been found that many blotting papers may be repeatedly saturated with ink and dried without materially lowering their blotting qualities. But in service the surface of the paper becomes covered with a coating of dried ink, rubbed, compressed and filled with dust, which renders it useless long before it is completely saturated with ink and its absorptive capacity gone.

Results on speed of absorption will not give an indication of the total absorption capacity of a blotting paper. For example, in Table IV, Samples 32955, 32799 and 32968 show practically the same absorptive values by the 1 cc. time absorption method for ink. Tests indicate that rated for total capacity of absorption the order would be 32799, 32955 and 32968, or in this case inversely as their ash content.

CONCLUSION

As the rate of rise of a liquid in the mounting test is independent of the bulk, an accurate indication of the absorptive qualities of a paper cannot be obtained with this test. It is our experience that the measurement of the zones formed by blots of ink on a blotting paper does not afford a reliable test for rating absorption qualities of different papers since the area of the blot is greatly affected by the thickness or weight of the paper even though the same amount of ink be used with each.

By the 1 cc. time absorption method suggested in this paper, the results obtained are apparently more indicative of the true absorption value of paper than can be obtained by other known methods. The method also has two distinct advantages: the test is made with the paper in the horizontal position and it is possible to use ink in making the test. The use of ink, provided a standard ink be used in all cases, gives the most serviceable indication as to the absorption value of blotting paper. The absorption value as indicated with water is not always the same as with ink.

The method has also been used in determining the relative absorptive values of paper toweling with very satisfactory results. In the case of copying paper, filter paper and very light weight blotting paper only 0.5 cc. of water should be used.

The method is very simple and convenient, and a number of closely agreeing results can be obtained in a very short time.

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THE USE OF TEXTILE FIBERS IN MICROSCOPIC QUALITATIVE CHEMICAL ANALYSIS

By E. M. Chamot and H. I. Cole

Received September 28, 1917

III—THE DETECTION OF BORON BY MEANS OF TURMERIC VISCOSE SILK FIBERS[1]

The reaction of boric acid with turmeric paper, involving a color change from yellow to rose, was first described by Trömmsdorff[2] in 1815. Later investigators showed that this rose color was changed to blue or greenish black upon the addition of alkali.

In this reaction curcumine, the yellowish coloring matter in the turmeric root, is changed by the boric acid into another substance, rosocyanine, first described and named by Schlumberger[3] in 1866. It was so-called by him because of the fact that it forms rose colored solutions and blue colored metallic salts. Upon analysis he found that the rosocyanine contained no boron, though the latter was necessary to bring about the reaction.

Ivanow-Gajewski,[4] Ciamician and Silber,[5] Milobedzka,[6] and Jackson and Clarke[7] have since worked on this curious and interesting reaction and they found, as did Schlumberger, that rosocyanine does not contain boron. Here, then, is another of those curious chemical reactions where an element plays a mysterious rôle, for it is strange that boron alone among the elements should be able to induce a molecular rearrangement of curcumine into rosocyanine.

Emich[8] suggested that the blue color is due to a reaction of cellulose. Jackson and Clarke,[9] however, obtained the blue color when no cellulose was present and our results as given are in accordance with their findings.

In testing for boric acid in the usual manner with turmeric paper, addition of the alkali almost invariably yields a greenish black color when boron is present instead of the much more characteristic blue color. In applying this test microscopically, however, using individual fibers instead of strips of paper dyed with turmeric, it is always possible to obtain a distinct blue color. Having experienced difficulty with flax and cotton fibers impregnated with turmeric, it was thought worth while to test out the various controlling factors for the production of the best and most sensitive fiber.

After various methods of dyeing with turmeric were tested, the following one was selected as being the most satisfactory. A 50 per cent alcoholic, alkaline solution of turmeric is prepared by boiling approximately 20 g. of ground turmeric root with 50 cc. of alcohol and adding to the filtered solution an equal volume of water and $^1/_2$ to 1 cc. of dilute sodium hydroxide (10 per cent). The fibers are immersed in this solution which is then evaporated on a water bath to a syrupy consistency. The fibers are removed and immediately dipped in 95 per cent alcohol, pressed between filter paper, dipped in a dilute aqueous solution of sulfuric acid, washed with water and dried. The transference of the fibers from the hot dye to the alcohol must be done quickly as otherwise the turmeric adhering to the fibers is removed only with difficulty. Too long an immersion in the alcohol tends to remove the adsorbed dye as well as the excess dye.

If the fiber still appears to have any unadsorbed turmeric adhering to it (with viscose silk this is easily noted by the lack of luster) it can once more be dipped in alcohol and washed with water. Any unadsorbed turmeric interferes with the formation of the blue color in the boron test. This method as given yields a beautiful golden yellow product which was found to be eminently satisfactory.

Curcumine of different degrees of purity was also tested but since the delicacy of the reaction obtained by using the ordinary turmeric extract is exceedingly great, there is no necessity for other purification than that given in the above described method.

To determine the influence of the nature of the fiber on the delicacy of the reaction, the common textile fibers, flax, cotton, wool, mohair, raw silk, purified silk, viscose silk (cellulose xanthate), lustron silk (cellulose acetate) and coarse fibers of cupra-ammonium silk were dyed in turmeric solutions as stated above and then used for the boron test.

Flax, cotton, raw silk, purified silk and viscose silk dyed with turmeric give the typical boron test described below, while wool, mohair, lustron silk and cupra-ammonium silk more often give a green instead of the typical Prussian blue color upon addition of the alkali. Of the various fibers tested, viscose silk gives by far the best color reaction, flax being next best but less satisfactory in comparison. No preliminary treatment of the viscose silk to render it more adsorptive was found to be necessary.

Of the various methods tested for applying the turmeric fiber test for boron, the following procedure gives the most satisfactory results: Place a drop of the solution of the material to be tested upon an object slide and acidulate with dilute hydrochloric acid to decompose any borates that may be present. In this drop, place a turmeric fiber about 5 mm. long and allow to evaporate spontaneously, or by *gently* warming, to *complete* dryness. Cool and examine the fiber under the microscope. A rose or violet-rose color indicates boron. To confirm the test, place a drop of a 1 per cent solution of sodium hydroxide upon the rose colored fiber. The rose color immediately turns to a beautiful Prussian blue color which gradually changes to violet. Too high a temperature in the evaporation or failure to allow the fiber to go to complete dryness may lead to negative results. Too concentrated a solution of the alkali will interfere with the formation of the blue color. The fiber must be observed immediately upon addition of the alkali as the blue color is then most intense.

A mineral acid alone with a turmeric fiber on evaporation to dryness gives a yellow to brown color, not the rose or pink color obtained when boron is also present. Furthermore, addition of a drop of alkali yields, instead of a blue, a yellow color changing to the

[1] For Parts I and II see This Journal, 9 (1917), 967.
[2] *J. Pharm.*, **16** (1815), 96.
[3] *Bull. soc. chim.*, [2] **5**, (1866), 194.
[4] *Ber.*, **5** (1872), 1103.
[5] *Gazz. chim. ital.*, **27** (1897), 561.
[6] *Ber.*, **43** (1910), 2163.
[7] *Am. Chem. J.*, **39** (1908), 696; **45** (1914), 48.
[8] *Ann.*, **351** (1907), 429.
[9] *Am. Chem. J.*, **39** (1908), 696; **45** (1914), 48.

characteristic mahogany color produced by alkali on the turmeric fiber.

It must be remembered that a test for boron as sensitive as this one, must not be performed upon an object slide made from resistance glass containing boron as one of its ingredients. It follows also that apparatus made from such glasses cannot be used for solutions which are to be tested for the presence of boron.

The presence of hygroscopic salts is objectionable, since they prevent the complete drying of the fiber. However, when the solution to be tested contains more than traces of boron, a satisfactory test may be obtained even in the presence of large amounts of such salts.

Any strong bleaching agents, such as hydrogen peroxide or a hypochlorite, must be destroyed before the test can be applied.

Much free phosphoric or silicic acid render the detection of boron difficult though not impossible. In the turmeric paper test for boron as commonly applied, it has been pointed out that molybdenum, titanium, zirconium, columbium and tantalum may lead to error, because under certain conditions these elements give a color reaction somewhat similar to that obtained with boron when the alkali is added. This source of error has been carefully studied and we find that the presence of these elements leads to no misinterpretation of the color changes nor could we obtain with any of these elements the blue colored fiber, characteristic of boron, when no boron was present.

Boric acid can be distinguished from a simple borate in the following manner: Evaporate to dryness without the addition of a mineral acid. A rose-pink indicates boric acid; undecomposed borates yield no rose color. Add the alkali. Boric acid gives the characteristic blue color, borates do not. Commercial borates of ammonium, sodium, potassium, calcium, barium, iron, lead, nickel, copper and manganese tested as described, gave a boron test from aqueous solutions only after acidification with hydrochloric acid. Ferric borate, however, failed to give a positive test in very concentrated solution.

It must be remembered that in the presence of inorganic salts which have the power to decompose a borate, a test for boron may be obtained without the addition of an acid.

The sensitiveness of this reaction was tested according to the method already described.[1] A positive test can be obtained by means of turmeric viscose silk, in one drop of a $N/16{,}000$ solution of boric acid or of a borate, normality being computed with respect to the amount of boron present. The amount of boron actually present in a drop of a solution of this concentration is 0.000,025 mg.

SUMMARY

I—Viscose silk, dyed with turmeric, gives an exceedingly sensitive microscopic method for the detection of boron in boric acid or in borates.

II—It is possible by this method to differentiate between boron as boric acid and boron combined as borate, providing substances which will set free boric acid from borates are absent.

III—A drop of a solution containing 0.000,025 mg. of boron gives a positive test for boron by this method.

[1] *Loc. cit.*

IV— THE DETECTION OF THE HEAVY METALS BY MEANS OF ZINC SULFIDE WOOL FIBERS

The use of fibers impregnated with zinc sulfide, as a microscopic means of detecting the heavy metals, was suggested by Emich and Donau[1] in 1907. They used cotton and guncotton as the carriers for the zinc sulfide. In making these fibers, according to their method, we found that it was extremely difficult to impregnate the fiber with the zinc sulfide. In order to overcome this difficulty, we endeavored to make artificial fibers containing a zinc salt and ultimately to change this salt to zinc sulfide, as follows: An ether solution of zinc chloride was mixed with a solution of collodion or "parlodion." Artificial fibers were then made from this solution by forcing it through a fine capillary opening into a solution of sodium sulfide. The resulting fibers, while sensitive enough, were generally imperfectly formed and the manipulation necessary for their satisfactory production required such a great amount of skill and practice that the method, after many attempts, was abandoned as unreliable.

The following modification of this method was also tested. Finely divided and colloidal zinc sulfide was mixed with the collodion and then made into fibers, by extruding into a coagulating liquid, by dry spinning and by making thin films of the mixture and subsequently cutting them. Fibers made by this method also proved unreliable.

The common textile fibers were then tested as to their suitability. Fibers of cotton, true silk, viscose silk, lustron silk, flax, ramie, wool and mohair were immersed in solutions of zinc chloride for several hours, washed with water and placed in solutions of sodium sulfide for 2 hrs., then washed and dried. Of the fibers treated in this manner, in reagent solutions of different concentrations, wool and mohair alone adsorbed enough zinc sulfide to give a satisfactory color reaction with the heavy metals.

The preliminary treatment of the wool was found to be important. Fat-free and swelled fibers adsorb more of the zinc sulfide then the untreated fibers. The fat may be removed from the wool by a mixture of alcohol and ether. For swelling the fibers the best results were obtained by soaking the wool over night at room temperature in a 1 per cent solution of sodium hydroxide. This gives the maximum swelling with the minimum detriment to the fiber.

Various zinc salts and methods of impregnating the wool with the salts were tested. It was found that zinc acetate is adsorbed to a slightly greater extent than either zinc sulfate or zinc chloride. The following method for making zinc sulfide fibers was finally adopted: The defatted wool is swelled by soaking over night at room temperature, in a 1 per cent solution of sodium hydroxide. It is then washed and dipped 5 or 6 times alternately in solutions of 10 per cent zinc acetate and 10 per cent sodium sulfide, pressing out the

[1] *Ann.*, **351** (1907), 432.

excess solution but not washing between dippings. After the final dipping, the impregnated wool is washed and dried by pressing between filter paper. Zinc sulfide wool fibers made in this way are sensitive to 0.001 mg. of copper. The sodium sulfide solution should be freshly prepared by passing H_2S into a solution of NaOH until a portion removed fails to yield a precipitate with $MgCl_2$. The fibers thus prepared are employed as follows:

(*a*) Place a drop of the solution to be tested upon an object slide and add a drop of dilute HCl. Introduce into the drop a zinc sulfide wool fiber about 5 mm. long and examine under the microscope.

(*b*) Evaporate to dryness, add a drop of dilute ammonium hydroxide, examine the fiber again and introduce into the drop a new fiber to serve as a means of comparison, in order that slight changes in color may be better discerned. These color changes are yellow, orange, brown or black.

In acid solution the fiber is

Straw-yellow	Tin
Lemon-yellow	Arsenic, Cadmium
Orange	Antimony
Reddish brown	Bismuth
Brown or yellow-brown	Platinum, Copper, Mercuric Mercury, Antimony (sometimes Cobalt, Iron, Manganese, Nickel)
Black (brown in very dilute solutions	Silver, Lead, Gold, Mercurous Mercury

In acid solution no color, but in alkaline solution the fiber may turn *brown* or *yellow-brown* if cobalt, iron, manganese or nickel is present. These elements, however, rarely give good reactions with the fibers.

It must be remembered that the color of the fiber, as usually observed with transmitted light, varies with the amount of the metal present. For example, a yellow or orange color, if deep enough, may appear brown or even black. On the other hand, an element giving usually a brown or black color with the fiber may color it a light brown or yellow when only traces of the element are present.

SUMMARY

I—A reliable and sensitive method for the preparation of zinc sulfide fibers has been described.

II—Zinc sulfide wool offers a satisfactory test in minute quantities of materials for the presence or absence of metals yielding colored sulfides.

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A PROXIMATE QUANTITATIVE METHOD FOR THE DETERMINATION OF RUBIDIUM AND CAESIUM IN PLANT ASH

By W. O. Robinson

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This method is based on the removal of the major portion of potassium chloride by fractional precipitation with platinic chloride and, further, by precipitation with strong hydrochloric acid. The resulting solution containing all the rubidium and caesium chlorides and a large amount of potassium chloride is compared spectroscopically with a standard solution according to the method outlined by Gooch and Phinney.[1]

[1] *Am. J. Sci.*, **44** (1892), 392.

For the determination, 20 or more grams of the dry plant are carefully ashed in a muffle where the temperature does not exceed 525° C. The ash is dissolved in hydrochloric acid and the excess evaporated off. An excess of freshly slaked lime is added to precipitate the phosphoric acid, magnesium, etc. The solution and precipitate are boiled a few minutes and then filtered. The calcium in the filtrate is then precipitated with ammonia and ammonium carbonates and filtered. For the sake of precaution, a second precipitation of the calcium should be made. The combined filtrates are evaporated to dryness, and the ammonium salts expelled. This operation must be most carefully done, for the rare earth chlorides are extremely volatile. It is best done in a muffle kept just below redness. The remaining alkali chlorides are filtered off with hot water, a few drops of hydrochloric acid added and then about 0.05 g. of platinic chloride. The solution is stirred well and evaporated to pastiness. Meanwhile a small carbon filter is prepared by drawing out a hard glass tube of $^1/_2$ in. or less diameter. A perforated platinum foil serves to hold a small mat of asbestos. The unchanged chlorides of potassium and sodium are rapidly dissolved in the minimum amount of hot water and the chloroplatinates of the rare alkalies with some potassium chloroplatinates washed on to the asbestos pad with 80 per cent alcohol. Care must be taken not to use too large an amount of hot water to dissolve and wash the unchanged chlorides. The platinic chlorides of potassium, rubidium and caesium are then reduced by connecting the carbon filter to a hydrogen generator and heating gently with a Bunsen burner. The reduction takes place easily, becoming spontaneous when some platinum black is left on the pad from a previous determination and the pad is somewhat moist with alcohol. The chlorides of the alkalies are washed through the filter with hot water, the filtrate evaporated to pastiness in a very small, lipped, platinum dish. The mass is then taken up with four drops of strong hydrochloric acid and filtered through a tiny filter into a vial of about 2 to 3 cc. capacity. A number of these vials are graduated to hold the same volume. The rare alkali chlorides are taken up and filtered with two more portions of acid of four drops each, each successive portion being blown through the filter. The solution is made up to volume and is ready for comparison. Standards are made up by treating known amounts of caesium and rubidium chlorides and an excess of potassium chlorides with strong hydrochloric acid as above.

A Bunsen burner is used for the source of heat and it must be carefully screened from the observer. The chlorides are so volatile that the flame lasts only a few moments. Caesium is identified by the doublets 4215.6 and 4201.9, and rubidium by the double lines 4593.3 and 4555.4. These lines are difficult to see, and the observer must remain in the dark room for at least an hour before the eyes become sensitive enough.

The comparison is made by introducing a coil of platinum wire of sufficient size to withdraw a very

large drop.[1] The coil is carefully dried high above the flame or on a radiator, taking care to avoid spattering. The unknown solution is matched with standards by means of the brilliancy of the line. An accuracy of from 5 to 10 per cent is easily obtained by different observers.

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[1] A No. 27 wire B. & S. gauge, coiled seven times around a 3/32 rod, makes a good coil.

A QUICK METHOD FOR LIME CAKE ANALYSIS

By ALFRED N. CLARK

Received November 5, 1917

The usual procedure in lime cake analysis has been to weigh out 50 g. of the sample in a sugar weighing dish, add acetic acid, mix to a thin mud in the weighing dish, transfer the contents to a 200-cc. flask, add lead subacetate solution, and fill to the mark with water. All the textbooks describe a method similar to the above, and in which a flask is used. Such a procedure has four serious drawbacks which are avoided in the method described below. With the flask method, lime is liable to foam over the sides of the sugar dish when acid is added; it is difficult to thoroughly mix in such a small dish without spilling; there is danger of spilling when transferring from the weighing dish to the flask; and the whole procedure is a slow, disagreeable one.

The writer weighs the sample of lime cake in a counterbalanced, nickel-plated, copper beaker of about 300 cc. capacity, adds the calculated volume of acetic acid solution from a pipette, mixes with a small pestle, adds a charge of lead subacetate solution from a Sachs-LeDocte or a Kruger pipette, again mixes with a pestle, and pours onto a filter. The dish is large enough to avoid foaming over, and the mixture is not transferred from the weighing dish until ready to filter.

The following examples will explain the calculation required for adopting the Sachs-LeDocte or Kruger sugar pipettes to lime cake analysis:

A Sachs-LeDocte pipette delivers 177 cc. of lead solution and uses a normal weight of 26 g. Therefore, 200 cc. of solution must be added to the dry matter of the lime cake, and if it is assumed that the cake contains 50 per cent moisture, we have 13 + 10 + 177 = 200 cc. As it is necessary to add acetic acid or ammonium nitrate to decompose saccharates, the strength of acid is so adjusted that 10 cc. are required. When the filtered sample is polarized in a 200 mm. tube twice the scale reading is the per cent sugar in the cake.

With the Kruger automatic pipette the normal weight is adjusted to the size of the pipette; for instance, if the pipette delivers 123.6 cc., the normal weight is 41.2 g. for beets, and the same weight is used for lime cake. The amount of solution to add to the dry matter of the lime cake is 158.5 cc., and if the lime cake contains approximately 50 per cent of moisture the solution is made up of 20.6 + 14.3 + 123.6 = 158.5 cc. Here 14.3 cc. of acetic acid solution are used, and the polarization in a 200-mm. tube is the per cent sugar in the cake.

If the moisture content of the cake varies appreciably from 50 per cent the volume of acetic solution added is adjusted accordingly.

When "free" sugar is to be determined, water is added instead of acetic acid.

By the use of normal lead acetate solution in the place of subacetate solution, no acetic acid need be added, but in that instance a different weight of lime cake should be used in order to give the proper dilution.

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RECOVERY OF LIGHT OILS AND REFINING OF TOLUOL

Report prepared by the Bureau of Standards in response to numerous inquiries for information regarding recovery of light oils and the refining of toluol. This report was submitted to, and revised in accordance with suggestions of the committee, consisting of representatives of the Public Service Commissions, municipalities, manufacturers of gas, and makers of toluol recovery equipment, organized under the chairmanship of Dr. E. B. Rosa of the Bureau of Standards at the request of the conference which met at the Bureau July 31, August 1 and 2, 1917.

PART I—THE TECHNICAL RELATION OF THE GAS INDUSTRY TO THE MILITARY NEEDS OF THE NATION

1. HIGH EXPLOSIVES MANUFACTURED FROM GAS BY-PRODUCTS—The importance of high explosives in the present war has been amply demonstrated. While nearly all kinds of explosives are used in some way, those which are most in favor for filling high explosive shells are manufactured from benzol and toluol, which substances have their most important commercial source in manufactured gas of one kind or another. The gas industry thus becomes directly and vitally connected with the conduct of the war and a survey of the demands which will be made upon it, and its preparedness in a technical way to meet these demands, is very important at the present time.

2. CITY GAS PLANTS MUST SUPPLEMENT COKE-OVEN PRODUCTION—The constituents of illuminating and fuel gas which are important in the manufacture of explosives at the present time are benzol and toluol, especially the latter. The removal of these constituents from the gas which is a by-product of coke-oven plants has been practiced for some time. Plants manufacturing city gas, however, have not generally removed these substances from the gas since they contribute to its light- and heat-giving qualities and the substitution of other substances to maintain the gas quality up to prescribed standards has not usually been considered profitable. Even now, although several months have elapsed since the United States entered the war, comparatively few city plants are equipped to recover these materials, but the prospects are that in the near future they must do so if the requirements for high explosives are as great as is anticipated. Major Burns of the Ordnance Department at the conference held at the Bureau of Standards on August 1 stated that the Army is dependent upon toluol for the manufacture of T. N. T. for shell filler. The amount of toluol needed depends upon the number of men engaged and how engaged. The present estimates are that toluol for shell filler will be needed in the coming year for our own army, for the allies, and the navy at a rate considerably in excess of the present or anticipated supplies from works under construction. There is at the present time about 4 million pounds per month of T. N. T. nitrating capacity and sufficient toluol is not now available to utilize it; it is therefore now impossible to place more orders for T. N. T. primarily because more toluol is not available. It is probable that any and all explosives including the picrates will be necessary eventually.

3. MANUFACTURING PROCESSES IN USE IN THE UNITED STATES—The manufactured gas distributed in the United States is of three principal kinds: Coal gas, carbureted water gas, and oil gas.

The manufacture of water gas consists essentially of an intermittent process in which a bed of anthracite coal or coke is brought to a high temperature by an air blast and then steam under pressure is blown through the fuel, forming carbon monoxide, hydrogen and a small amount of carbon dioxide, by reaction with the carbon in the fuel. The resultant gas, called blue water gas, has a heating value of approximately 300 B. t. u. per cu. ft. and almost no luminosity when burned in an open flame; it is conducted into a fire-brick-lined chamber called the carbureter, which contains staggered rows of fire bricks, called checker brick, heated to incandescence during the blow period. Gas oil or fuel oil is sprayed into the carbureter while the gas is passing through, forming an oil gas which enriches the blue water gas to any desired heating value or candlepower. Another checker-brick-filler chamber, called the superheater, converts most of the oil gas vapors into permanent gases, which will not condense again upon cooling. During the formation of the oil gas certain portions of the hydrocarbons which compose the oil are changed in their composition to form benzol, toluol, and related hydrocarbons, called aromatic compounds. Considerable tar is formed at the same time. This is condensed, scrubbed, and washed out of the gas by various means, but usually at a temperature which permits most of the aromatics to go forward with the gas. The sulfur in the gas is removed by iron oxide purifiers and the gas is metered and leaves the plant at, or slightly above, atmospheric temperature.

The manufacture of coal gas is essentially different from that of water gas. In this process certain classes of bituminous coals are distilled in fireclay or silica retorts or ovens and the resulting gases are condensed, scrubbed, washed, and purified to remove water vapor, tar, ammonia, and sulfur. As in the water-gas process, certain of the hydrocarbons given off by the coal are transformed by the heat of the retort to aromatic compounds. A small part of these aromatics are washed out of the gas by the wash water and tar, but the larger part remains in the gas; in fact, the cooling of the gas is usually so regulated that most of these substances will remain in the gas to increase its heating value and candle power. Coal gas retorts take a variety of forms; among these are coke ovens, chamber ovens, horizontal D-shaped retorts, vertical retorts, inclined retorts, etc. Even those of a given class differ among themselves in details of construction. In most of them the distillation is an intermittent process, but some continuous methods are used. In all these processes the gas produced consists of the same constituents in somewhat different proportions. The form of apparatus used in a given case depends largely upon economic considerations or is governed by certain special qualities which are desired in one or more of the products produced. In all of these coal-gas processes, coke remains in the retort after distillation. In some of them, as for example in coke ovens, coke is the principal product; but in city gas plants, gas is the chief product. The operation is carried out in any case to give most satisfactory qualities to the principal product and at the same time obtain as high yields and good quality as possible of the secondary or by-products.

Mixed gas is usually understood to be a mixture of carbureted water gas and coal or coke-oven gas. It is supplied in many cities in the United States where the requirements permit of a mixed gas being supplied.

The manufacturing installation for mixed gas is practically two complete installations, one for coal gas and one for carbureted water gas, with their auxiliary scrubbing, condensing, purifying, and metering apparatus entirely independent and separate. The manufactured mixed gas, however, is stored in common holders and delivered through a single distribution system.

The coal and water gas thus supplement each other. The uniform, but more cumbersome coal-gas production furnishes coke as fuel for the water-gas plant; this in turn takes care of the irregularities of the output and where necessary increases the quality of the gas production, especially where a high candlepower standard is in force.

The oil-gas process is at present confined chiefly to the Pacific Coast states, where comparatively cheap oil and expensive coal make the coal- and water-gas processes less feasible. In oil-gas manufacture, oil alone is used as fuel for heating the checker bricks of the fixing chambers and oil is sprayed by steam into the chambers where in contact with the bricks, lampblack and permanent gases are formed. In this process also, aromatic compounds are included among the constituents of the gas.

4. AVERAGE CONTENT OF LIGHT OILS IN VARIOUS GASES—The amount of benzol and toluol formed in any one of these processes is by no means definite. It depends upon the operating conditions and the quality of the raw materials (coal or oil). It would therefore be impossible to predict exactly what the yield in a given case would be, but an extensive inquiry into the operation of several typical plants has given the following approximate figures for the various processes. These figures are averages of the results obtained in the several plants; individual results may vary widely from them in a particular case:

DATA FROM TWELVE PLANTS INVESTIGATED

APPROXIMATE YIELD OF CRUDE LIGHT OILS

Horizontal-retort coal gas	3 gal. per short ton coal carbonized
Coke-oven gas	2.6 gal. per short ton coal carbonized
Continuous-vertical retort coal gas[1]	1.8 gal. per short ton coal carbonized
Carbureted water gas	10 per cent of volume of gas oil used

COMPOSITION OF CRUDE LIGHT OILS[3]

	Benzol Per cent	Toluol Per cent	Solvent naphtha, wash oil, naphthalene, etc. Per cent	Paraffins
Horizontal-retort coal gas	38	16	46	Less than 2 per cent[4]
Coke-oven gas	55	14	31	Less than 2 per cent[4]
Continuous vertical-retort coal gas[1]	15	15	58	12 per cent
Carbureted water gas	42	25	33	Less than 2 per cent[4]

YIELD OF PURE PRODUCTS

	Benzol	Toluol
Horizontal-retort coal gas	1.32 gal. per short ton coal carbonized	0.45 gal. per short ton coal carbonized
Coke-oven gas	1.47 gal. per short ton coal carbonized	0.35 gal per short ton coal carbonized
Continuous vertical-retort coal gas[1]	0.27 gal. per short ton coal carbonized	0.26 gal. per short ton coal carbonized
Carbureted water gas[2]	0.15 gal. per 1000 cu. ft. of gas	0.07 gal. per 1000 cu. ft. of gas

[1] Results from only one continuous vertical installation included here.
[2] The yield of toluol is variable according to amount of oil used in manufacturing the gas, being equivalent to about 2.0 to 2.2 per cent of the gas oil used in the plants investigated, but perhaps only about 1.6 in many cases.
[3] Data obtained from various sources.
[4] This amount may be exceeded under some operating conditions, but paraffins can usually be kept down to this figure except in unusual conditions or with certain fuels.

No specific data are available for the amounts of toluol present in oil gas, though it is understood that the oil gas distributed on the Pacific Coast contains at least as much toluol as does coal gas.

Assuming that a ton of coal gives 10,000 cu. ft. of gas and that 3.5 to 4 gal. of gas oil are used per 1000 cu. ft. of carbureted water gas, it is evident from the table that the amount of toluol obtainable per 1000 cu. ft. of rich water gas is considerably greater than that obtainable from coal or coke-oven gas.

5. PROSPECTIVE TOLUOL SOURCES—It does not seem likely that it will become practicable in the near future for plants having outputs less than 100 million cu. ft. per year to recover light oils. A survey of plants of that size and larger indicates that there are about 112 plants having an aggregate annual gas output of about 135 billions cu. ft., of which about 97 billions are water gas, 25 billions coal gas, and 13 billions oil gas. What annual output of toluol could be expected from washing all this gas is problematical. It seems, however, that at least 0.05 gal. of toluol per 1000 cu. ft. of gas could be expected, which would give a prospective toluol recovery from all these companies of about 7,000,000 gal. per year. It seems likely that with an adjustment of standards the benzol production from the same amount of gas would be between three and four times as much as the toluol production, or approximately 18,000,000 gal. These yields are by no means the maximum obtainable, since the production in some existing plants is higher than 0.05 gallon of toluol per 1000 cu. ft. A few of the plants included in this estimate are already recovering part of their toluol and benzol, but by far the greater part of the available supplies are not yet recovered.

PART II—PRINCIPLES UNDERLYING BENZOL AND TOLUOL RECOVERY

1. RELATION TO GAS PLANT OPERATING CONDITIONS—Benzol, toluol, and the related hydrocarbons, which collectively will be designated as light oils, are present in city gas as condensable vapors and are associated with other hydrocarbons of the olefine and paraffin series which possess many physical properties similar to them. To separate some of these substances, especially the paraffins, from the light oil by commercial methods, is well-nigh impossible and therefore it is important so to control the conditions of gas manufacture that as little of these substances will be present in the light oils, as is possible. The

presence of more than 2 per cent of paraffin compounds in toluol is said to make it unfit for the manufacture of explosives. Only by careful attention to the temperatures and other operating conditions maintained in the gas making process and by the use of suitable raw materials can the gas manufacturer be certain that the toluol obtained from his light oils will be salable. For example, in the recovery of light oils from water gas not only the temperature, but the rate of oil injection, spacing of checker bricks, etc., affect results. Dirty checker bricks are said to be a very common cause of high paraffin content in the toluol produced. The favorable conditions can be determined only by trial in each particular case.

For the successful operation of plants in which partial or total rectification of the light oils is carried out, careful technical control seems to be a prime essential. In smaller plants where only light oil is recovered technical supervision should be available in starting the plant and for such a time afterwards as will enable the regular operators to become familiar with the fundamentals of operation and establish a routine. It might be feasible for several small plants within a certain district to retain the services of a technical man who would divide his time among them, and make the more elaborate tests which are occasionally required for successful operation.

2. REMOVAL OF LIGHT OILS FROM THE GAS—To recover light oils from the gas, the method now almost universally employed is to bring the gas into contact with an oil which has a solvent action upon the light oils. Oil washing of gas is accomplished by a variety of apparatus. In any case to obtain complete absorption it is necessary that an adequate amount of oil at a sufficiently low temperature be brought into contact with the gas. The temperature of the wash oil should not exceed 30° C. (86° F.). The temperatures obtainable in practice will, of course, depend upon the facilities available for cooling the oil. It is desirable to have the oil a little warmer than the gas to prevent condensation of water from the gas into the oil which gives trouble in the further stages of recovery. The amount of wash oil circulated through the washers will depend upon the amount of light oil vapors present in the gas, the temperature of the oil, the amount of gas to be washed, and the saturation of the wash oil which it is feasible to obtain. About 10 gal. of wash oil per 1000 cu. ft. of gas washed, seems to be an average figure.

The oil now usually employed for this purpose in this country is a petroleum distillate called from its color, "straw oil;" some plants use a creosote oil obtained from the distillation of coal tar. The choice seems to depend largely upon which is available in a given case. The qualifications which a wash oil should possess seem to be substantially as follows:

A creosote oil upon distillation should yield not to exceed 5 per cent up to 200° C., and not less than 90 per cent between 200 and 300° C. The oil should not contain more than 7 per cent naphthalene and should not show any marked increase in viscosity down to 4° C. The oil should be as fluid as possible under the working conditions and should have as small capacity for heat as possible.

The characteristics of a straw oil for this purpose, as obtained from some operators, are substantially as follows:

I—Specific gravity not less than 0.860 at 15.5° C.
II—Flash point in open cup tester not less than 135° C.
III—Viscosity in Saybolt viscosimeter at 37.7° C. not more than 70 seconds.
IV—The pour test shall not be over —1.1° C.
V—When 500 cc. of the oil are distilled with steam at atmospheric pressure, collecting 500 cc. of condensed water, not over 5 cc. of oil shall have distilled over.
VI—The oil remaining after the steam distillation shall be poured into a 500-cc. cylinder and shall show no permanent emulsion.
VII—The oil shall not lose more than 10 per cent by volume in washing with 2½ times its volume of 100 per cent sulfuric acid, when vigorously agitated with acid for 5 mins. and allowed to stand for 2 hrs.

Some operators claim to have successfully used ordinary gas oil or water-gas tar. It is claimed by other operators, however, that when gas oil is used the paraffin and olefine compounds in it are likely to contaminate the light oil and that on account of emulsification this oil soon becomes unfit for use. Water-gas tar, it is said, soon becomes too thick for use and soon leads to serious naphthalene deposits in the distribution system. The advantages claimed for these materials are their general availability and lower cost, and the fact that most gas companies already have adequate storage facilities for these materials.

3. STRIPPING WASH OIL—To separate the light oils from the wash oil in which they are dissolved, some form of still is employed; the difference in boiling points makes possible the separation. In large plants there are used continuous stills, in which steam comes in contact with the wash oil and boils off the light oils. The light oil vapors together with the uncondensed portion of the steam ascend upward through a series of chambers, which will be described more in detail later. In their ascent they come in contact with descending wash oil carrying light oils which they assist in freeing. The light oil vapors together with some steam, naphthalene, sulfur compounds, etc., pass away from the still and are condensed. Some of the wash oil is also carried along with the light oils, and has to be separated in the subsequent treatment. In small plants either continuous or intermittent stills may be used.

4. REFINING—To obtain from the light oils those constituents which are most in demand, a further separation by distillation and chemical treatment is necessary. The light oil is distilled in some form of a still, usually equipped with a rectifying column and dephlegmator or planer which will be described in more detail later. The latter apparatus acts as a partial condenser in which part of the vapor is condensed and falling downward through the rectifying column meets the ascending vapors and washes from them a portion of the high-boiling constituents. Only the light low-boiling constituents are able to pass the dephlegmator uncondensed. What vapors shall be allowed to pass on to the condensers depends upon the temperature maintained at the dephlegmator. This temperature is regulated according to the particular oil which it is desired to separate from the light oil mixture at any particular stage of the distillation. By the use of the dephlegmator and rectifying column it is possible to obtain much more definite separation of the benzol, toluol, and other aromatics than would otherwise be possible. In making the first distillation of the light oil, it is usual to collect the distillate in three successive portions or fractions, making the "cuts" at predetermined temperatures. The first fraction is collected in a containing vessel or receiver until the temperature at the top of the still is 100° C. This fraction is called crude benzol, since benzol is its chief constituent. The flow of distillate is then diverted into another receiver and collected until a temperature of 120° C. is reached. This fraction is termed crude toluol, from its chief component. The fraction collected above 120° C. is called crude solvent naphtha from the use to which it is put, as a solvent of various materials. The boiling point of pure benzol and pure toluol are 80° and 111° C., respectively. It will be noted that one of the changes of fractions or cuts is made midway between these boiling points while the boiling point of pure toluol is midway between the other cuts.

That the first separation is by no means complete is shown by the following analysis, which is typical of a crude toluol fraction:

	Per cent
Benzol	11.1
Toluol	64.4
Solvent	8.9
Residue, etc.	15.6
TOTAL	100.0

The above procedure is not universal. Some operators collect the crude benzol and toluol together and subsequently separate them. Some of the impurities present in the crude fractions have boiling points so close to those of benzol and toluol that they cannot be separated from them by distillation. To remove a certain class of these compounds, called olefines, the fractions are washed successively with strong sulfuric acid, caustic soda, and water. The olefines form a thick, tarry mass, which settles out by gravity upon standing and is drawn off. The fractions are then redistilled in stills with very high rectifying columns and fractions are finally obtained which boil within a single degree of the temperatures which have been determined as the boiling points of pure benzol, toluol, etc.

Some operators prefer to distil the toluol fraction from water-gas light oils in a still without a rectifying column, previous to final distillation in a column still. The vapors from the still in this case pass directly through a condenser coming out in liquid form. This liquid passes upward through a tank containing a solution of caustic soda. By this process any sulfonated olefines which remain in the toluol are removed. Otherwise they would be broken up in the column still and have a destructive action on the dephlegmator and condenser. The condenser coil and connections of this intermediate still should be made of lead.

The final distillates are considered as substantially pure materials if their specific gravities also agree with those which have been determined for the pure constituents. If, however, the specific gravity is lower than that of the pure benzol or toluol, it is an indication of the presence of paraffins, and to a certain extent the lowering is a measure of the amount of paraffins present.

It is understood that there is no commercially feasible way of separating these paraffins; and in the case of toluol, if the amount exceeds 2 per cent, the toluol is unfit for the manufacture of explosives. It is stated by some operators that by regulating the speed of distillation it is sometimes possible to make the paraffins distil into other than the toluol fraction, even when present in excess in the crude toluol; but the real remedy is to adjust the gas-making conditions so that the paraffins will not be produced. It is evident that special knowledge and skill are necessary from beginning to end of the recovery process.

5. EFFECT ON GAS QUALITY—(*a*) *Oil Washing.* As has been stated above, the removal of benzol and toluol from the gas reduces its heating value and candle power. The amount of reduction will depend on the original quality of the gas before washing, the thoroughness of washing, and the process of gas making employed.

Operators of benzol recovery plants differ considerably in their opinion as to just what the average reduction would be, but the general opinion seems to be that the complete removal of light oils from gas results in reduction of at least 50 per cent in the open-flame candlepower and from $1^1/_2$ to 8 per cent in the heating value (averaging about 5 per cent). Various operators have endeavored to establish ratios between light oil removal and heat reduction. One operator states that for every 0.1 of a gal. of light oil removed per 1000 cu. ft. of gas, the heating value will be reduced between 13 and 14 B. t. u. per cu. ft. and the candlepower between $2^1/_2$ and 3 candles. Another states that the reduction of heating value is 10 B. t. u. for every 0.1 gal. of liquor oil remained.

Mr. J. W. Shaeffer, manager of the Milwaukee Coke and Gas Co., who has made some studies of the subject, states that the following expression gives very closely the heating value of oil-washed coal gas:

$$\frac{a - 121827\,b}{1 - 35\,b}$$

in which (*a*) is the heating value of the gas before washing, (*b*) is the number of gallons of light oils removed per cubic foot of gas washed and 35 is the number of cubic feet of vapor per gallon of light oil. The constant 121827 is the product of 17567 (the heating value per lb. of the light oils), 7.3 (the weight per gallon of these oils) and 0.95 (a factor to correct for the amount of wash oils in the light oil, which is assumed to be 5 per cent). From calorimeter tests he concludes that the theoretical loss is practically the same as the actual loss.

(*b*) *Re-enrichment.* If it is desired to recover toluol and still maintain a fairly high standard of gas quality, various methods may be employed, as follows:

(1) The light oils may be entirely removed from the gas, fractionated, and the benzol fraction returned to the gas by some suitable method.

(2) The gas may be only partially washed of its light oils by the use of insufficient wash oil for complete removal of the light oils.

(3) All the light oils may be washed from the gas and no portion returned; the enrichment up to the desired quality being accomplished by the addition of volatile petroleum distillates.

The decision as to which method should be employed in a given case would depend upon several considerations. A partial scrubbing of the gas by Process 2 would be most convenient for plants which did not fractionate its light oils, but the possible toluol recovery would be considerably less than in Methods 1 and 3. Method 3 would require the purchase of petroleum distillates, the price of which might make the method unprofitable. It is stated by some operators that more distillates must be added to gas than the quantity of light oil removed to compensate for their removal, especially where a candlepower standard is in force, since petroleum distillates do not contribute to the open-flame candlepower to anything like the extent that benzol does. In order to have the re-enrichment effective the distillate would have to possess certain qualities. One operator states that it should volatilize completely below 150° C. and have a heating value of at least 23,000 B. t. u. per lb.

The gas quality standard in force in a given locality would also, to a considerable extent, determine the method of re-enrichment and the toluol yields obtainable. A company which is operating under a very high candlepower standard is forced to re-enrich heavily or to be satisfied with a small toluol recovery. A lower standard obviates this difficulty to a considerable extent. One operator in a large city which maintains a 22-candlepower standard, states that a plant now making gas of that quality could, if relieved of the candlepower requirement, still maintain over 600 B. t. u. with a recovery of 0.05 gal. toluol and 0.08 gal. benzol, even though no light oils were returned to the gas. In plants making other gas qualities, the yields of toluol and effect upon gas quality would, of course, be different.

Figures as to the value of the light oils in water gas from various plants indicate that for medium candlepower gas, *viz.*, 12 to 17 candles, 0.1 gal. of benzol per 1000 cu. ft. returned to the gas raises the candlepower about 2 candles. The effect on the heating value in these particular cases is not known, but it seems probable that Mr. Shaeffer's conclusions would also apply in these cases. This would give about 12.2 B. t. u. per cu. ft. as the increase in heating value due to the addition of 0.1 gal. of benzol per 1000 cu. ft. of gas.

PART III—CONCENTRATION AND OPERATION OF LIGHT-OIL RECOVERY PLANT

1. SCRUBBERS—The apparatus in which the gas is brought into contact with the washing oil is known as the "scrubber" or benzol washer. In different plants it assumes different forms; that is, it may be of the rotary type, some form of bubble type, the spray type, or the tower and hurdle type, this latter being in use in most of the plants at the present time.

(*a*) *Rotary Scrubbers.* A rotary scrubber may be constructed somewhat as follows: The shell is of cast-iron approximately cylindrical in shape, with the axis parallel to the floor. It is divided into a number of compartments by means of plates which are the full size of the cross section of the shell and which have circular openings at their centers; a second set of plates placed alternately with the first reach from the bottom up to the middle of the shell.

The shell is traversed lengthwise by a shaft, the axis of which coincides with the axis of the shell, and which is supported by suitable bearings on the end plates and on the second set of cross plates mentioned above. On the shaft are fastened gas baffles in the form of discs made up of wooden slats, there being one disc for each compartment of the shell, built up so that the gas can travel between the slats either from circumference of the shell to the center or *vice versa*, but not straight across the discs parallel to the shaft. The central openings of the discs are alternately closed and opened in such a manner in conjunction with the arrangement of the cross plates that, when the scrubber is filled with the washing medium to the proper level, the gas is forced to travel through the upper half of the discs from circumference to center and from center to circumference, alternately. A small engine, or some other motive power, is used to rotate the shaft and the attached discs.

The spaces between the slats are very narrow, and thus the gas in passing through the scrubber flows in thin streams over surfaces which are kept continually wet as the shaft rotates by dipping into the washing medium in the lower part of the shell. The washing medium is admitted to the end opposite that at which the gas enters, and is carried by suitable overflows from one compartment to the other until it finally leaves the scrubber at the gas-inlet end. In this way the gas most thoroughly washed, comes into contact with the freshest oil.

(*b*) *Bubble-Type Scrubbers.* A scrubber of the bubble type usually consists of a series of superimposed sections, one mounted upon the other, and constructed of cast iron. Each section has a circular opening raised above its bottom, and covered with a hood or bell, the edges of which are serrated, so that any gas flowing though the opening can pass out only under the edge of the hood, which edge is kept sealed with the washing medium. Likewise an overflow for the washing medium is provided for each section. The gas enters the bottom of the washer and, passing up, bubbles through the seal of wash oil in each section. Fresh wash oil is introduced at the top, and fills the top tray to the height of the overflow pipe through which it drains to the next section. The process is therefore so arranged that the gas most nearly washed is brought into contact with the freshest oil.

(*c*) *Spray-Type Scrubbers.* In the spray-type scrubber the wash oil enters the top section of a series of superimposed sections through a syphon and passes through a spraying cone from which it is hurled by centrifugal force out through the perforations in the cone in a very fine mist or spray, thus filling the entire gas space with a mist of wash oil. The oil flows into the next lower section through the gas ports and is again brought into contact with the gas in the same manner here, finally leaving the bottom of the washer in a saturated condition. The gas enters from the bottom and passes upward through the succes-

sive washing sections. Power is supplied to the centrifugal spraying cones by a small steam engine.

(*d*) *"Hurdle-Tower" Scrubbers.* The "hurdle-tower" scrubbers are the most common type used at the present time; they usually consist of cylindrical steel shells about 6 to 7 times as high as the diameter. Two such shells are shown as *A* and *A*1 on the diagram. These shells contain a great number of grids or trays, commonly called "hurdles," made of white-pine slats 5 or 6 in. high by 1 in. wide. Except for spaces at the bottom and top of the scrubber these grids are practically superimposed one upon the other, with the openings staggered, separated by small spacing strips.

At the top of the tower the wash oil is sprayed in from a number of nozzles; after passing through the interstices in the grids it collects at the bottom in a reservoir. The gas enters the tower at the bottom and rises through the interstices in the grids by this means coming into intimate contact with the washing medium. Thus the freshest wash oil, introduced at the top, comes into contact with the most nearly washed gas.

In one plant designed to scrub about 10,000,000 cu. ft. of gas per day in which the tower is about 75 ft. high and 11 ft. in diameter, there are 84 grids, arranged in 4 banks of 21 each. The space at the bottom of the tower is about 8 ft. high, that at the top is about 5 ft. Spaces of about 3 ft. separate the various sets of trays. In the top are 12 oil nozzles. The foundation of such a tower is constructed of concrete and extends down about 7 ft. The size of the washer is, of course, dependent upon the capacity of the plant; 30 cu. ft. of scrubber capacity per 1000 cu. ft. of gas washed per hr. is a figure given by some engineers.

In some plants, notably in those utilizing existing tanks or towers, the grids are replaced by trays on which coke is piled or by one tray set near the bottom of the tower on which coke is piled to nearly fill the tank.

The wash oil is pumped by a circulating oil pump from the oil storage tank *T*4 or circulating tank *T*3 to the nozzles in the top of the scrubber. From these nozzles the oil is sprayed into the scrubber at a temperature of 30° C. or lower. When several scrubbers are required they may be arranged either in series or in parallel. In the former case the wash oil which has passed through one scrubber is pumped to the top of the next scrubber and flows down through this scrubber also. The gas passes from the top of the first scrubber to the bottom of the second and up through the second scrubber in the same manner as previously described. In those plants in which the scrubbers are arranged in parallel, each scrubber acts as an individual unit. An additional oil pump is required for each tower scrubber which is being used.

2. HEAT EXCHANGERS—In order to utilize the heat which would ordinarily be wasted, several pieces of apparatus known as heat exchangers or interchangers may be used. One of these is known as the "vapor-to-oil" and the other as the "oil-to-oil" heat exchanger. Each of these may assume a different form in different plants, or the order of succession may be different; in some plants one or the other may be eliminated, and in very small plants, especially those which are home-made, both are frequently missing.

(*a*) *Vapor-to-Oil Heat Exchanger.* The wash oil containing the light oils is pumped from the bottom tank of the tower scrubber to the vapor-to-oil heat exchanger, shown as *E* on the diagram. This piece of apparatus usually consists of a cylindrical steel shell which contains a number of tubes. The outer shell may be twice as long as it is in diameter; in one plant designed to scrub 10,000,000 cu. ft. per day it is about 8 ft. long and 4 ft. in diameter, containing about 150 tubes 2 in. in diameter. The cold benzolized wash oil flows through the tubes, while hot vapors from the top of the continuous still (hereafter described) pass around the tubes, being directed by a series of baffle plates. At the outlet of this heat exchanger the temperature of the benzolized wash oil is about 72° C. A heavy covering of heat-insulating material aids in the conservation of the heat. It is understood that this apparatus is controlled by the patents of a single manufacturer of recovery apparatus.

(*b*) *Oil-to-Oil Heat Exchanger.* After leaving the vapor-to-oil heat exchanger, the benzolized wash oil passes to and through an oil-to-oil heat exchanger, shown as *C* on the diagram. In some plants this apparatus is an oblong box, in which the hot de-benzolized wash oil from the still passes through pipe coils, the benzolized oil passing around the outside of these coils. In other plants this apparatus is built up of a number of pipe sections, joined at the ends. Each pipe contains a number of smaller pipes. The hot de-benzolized oil from the base of the still passes through the smaller pipes, the benzolized oil passing around them. The larger pipes are arranged in several banks one above the other. The banks are connected together at each level, but the superimposed pipes are connected only in pairs.

In one plant of the size above mentioned this heat exchanger is constructed of 8 10-in. pipes, heavily covered with insulating material. Each of the large pipes contains 14 $^1/_2$-in. tubes. The overall length is about 26 ft., the height about 7 ft., and the width about 3 ft.

At the outlet of this heat exchanger the temperature of the benzolized wash oil is about 94° C. and that of the de-benzolized wash oil about 87° C.

3. SUPERHEATER—Passing from the oil-to-oil heat exchanger the benzolized wash oil enters a superheater, sometimes called a preheater, shown on the diagram as *F*. This piece of apparatus usually consists of a cylindrical tank made of steel, and is about twice as long as it is in diameter. Inside of the shell are a number of small tubes, and several baffle plates. The benzolized wash oil flows around, and steam passes through the tubes. In the plant above mentioned this superheater is about 10 ft. in length and 4 ft. in inside diameter; in this shell are about 160 2-inch tubes. The superheater is heavily insulated, and owing to great corrosive action a duplicate is usually provided. Likewise, the parts are so arranged as to be removable without great difficulty. A safety valve is placed on top of this piece of apparatus.

The temperature of the benzolized wash oil leaving the superheater is usually about 145° C., although this temperature varies in different plants.

4. CONTINUOUS STRIPPING STILLS—After the benzolized wash oil leaves the superheater, it passes into the continuous stripping still, in which the wash oil is freed from practically all of the entrained light oils. This still, shown as *D* on the diagram, is usually constructed in two main portions—each of which is built up of superimposed individual sections. The total height is usually about 4 to 5 times the diameter of the lower portion, while the diameter of the upper portion is usually three-fourths that of the lower. Each section is made of cast iron, and is from 12 to 14 in. in height. The upper portion of the still usually has about half as many sections as the lower, and acts as a partial rectifying column assisting in retaining some of the wash oil in the still, which might go over with the light-oil vapor.

In construction these sections are similar to those described under the "bubble" type of scrubbers, there being a number of openings arranged in a circular manner in each section. However, the edges of the sealing bells are not serrated.

The benzolized wash oil enters the still at the base of the upper portion and passes down through the large portion of the still, rapidly giving up the light oil which it contains. Steam is admitted at the bottom and passes up through the still, bubbling from under the sealing bells of each tray and carrying upward the light oil in the form of vapor from the wash oil which seals the bells. The steam and these vapors pass through each individual section of the still in the manner just described and mingle in the upper sections of the still with the vapor set free there.

In one plant designed for 10,000,000 cu. ft. of gas per day the still is about 27 ft. high. The lower portion is about 6 ft. in diameter and the upper about 4$^1/_2$ ft. in diameter. The lower portion consists of about 12 sections and the upper of about 6 sections.

The temperature of the light-oil vapor leaving the top of this still is about 104° C., while the wash oil, stripped of all light oils, leaves the bottom at a temperature of 130° C. In some types of light oil recovery plants, the light oil vapors after leaving the top of the still column pass through some type of dephlegmator or planer through which a regulated amount of cooling water flows so that while the light oils are permitted to pass uncondensed, the water vapors and any wash oil vapors present condense out and run into a collecting tank. From this tank the water is drawn off and the wash oil which contains some light oil is pumped again with the benzolized oil into the still, or, if too heavy to be handled by the stripping still, it is sometimes put into the light oil to be subsequently refined in the crude still.

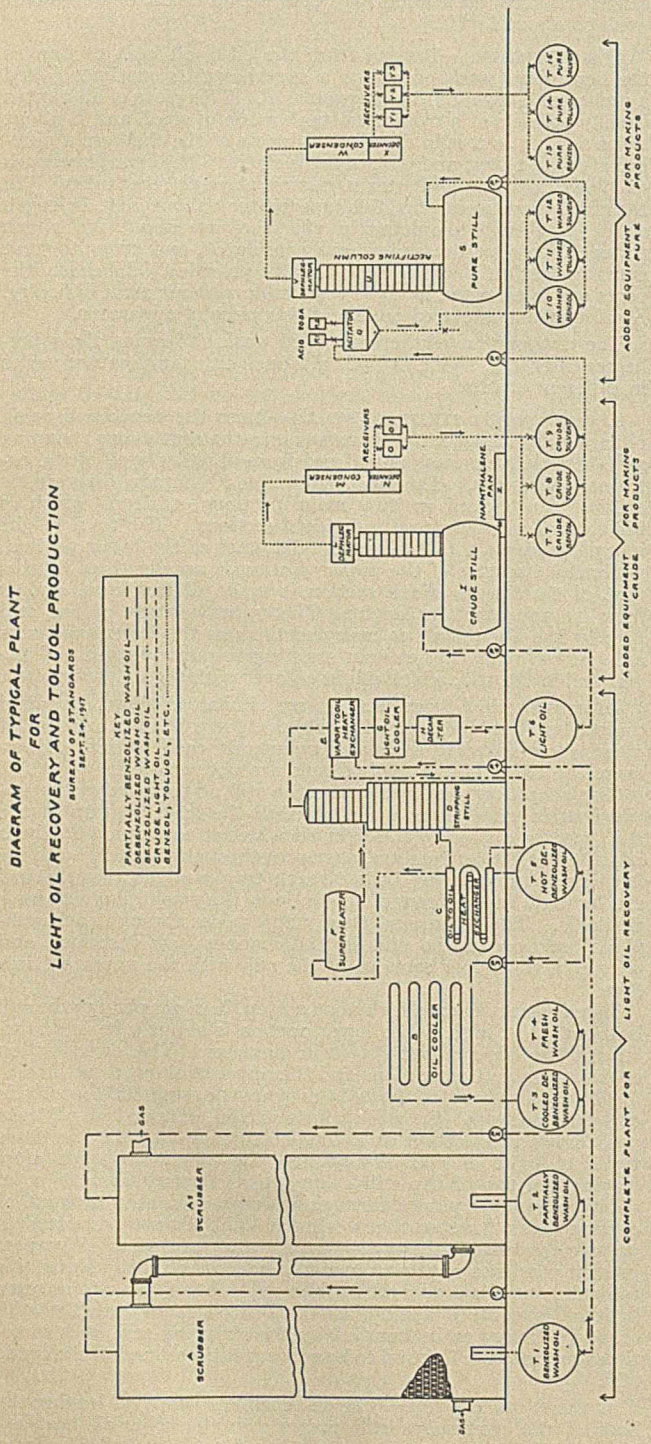
5. WASH-OIL COOLER.—The de-benzolized wash oil leaving the base of the continuous still passes into the oil-to-oil heat exchanger where its temperature is lowered to about 87° C. From this piece of apparatus the wash oil drains to a hot oil drain tank, *T*5, after which it is pumped through a wash-oil cooler, shown as *B* on the diagram. This consists of a number of pipe coils, the cooling water being showered upon the outside of the coils, while the wash oil flows through the inside.

In the plant above mentioned these coils are made up of 2-in. pipe with return bends at the ends, the whole being about

10 ft. high. At this plant there are 6 of the sets of coolers parallel to each other.

In some types of recovery plants the wash-oil cooler consists of pipe coils immersed in a tank of water. This apparatus is sometimes designated as the temperature regulator, since it determines the approximate temperature at which the oil is to enter the gas scrubbers.

From these coolers the wash oil passes to a wash-oil storage tank shown as $T3$, from which it is pumped to the top of the tower scrubber to again pass through the system.



In some plants the wash oil may be pumped directly from the oil-to-oil heat exchanger through the coolers, and into the wash-oil circulating tank.

6. CONDENSER AND SEPARATOR—The crude light-oil vapors leaving the top of the continuous still with a temperature of about 104° C. pass into the vapor-to-oil heat exchanger before described. From here they pass into a condenser, shown as G on the diagram. This condenser is usually of cylindrical shape, being about $2^1/_2$ times as long as it is in diameter. Inside of the outer shell are a number of tubes into which the vapors pass and in which they are condensed to liquid form by water passing around the tubes. The light oils leaving the condenser have a temperature of about 30° C. In the plant under discussion this condenser is about 9 ft. long and 4 ft. in diameter.

In many large plants it was found advantageous to install a pipe connection with a small blower or steam jet between the outlet of the light-oil condenser and the outlet of the last gas scrubber. By this means a considerable amount of non-condensable olefines leaving the stripping still may be returned to the gas, thereby re-enriching it to a considerable extent.

From this condenser the light oil enters a separator, or decanter, shown as H on the diagram. Here any water entrained in the light oil is decanted or separated, due to the difference in specific gravity. This piece of apparatus usually consists of a small cylindrical shell provided with 2 outlets, one for oil and one for water. The water connection extends down inside of the shell nearly to the bottom, the oil outlet being near the top. The water passes off to a sewer and the crude light oils pass either to a crude light-oil storage tank, shown as $T6$, or directly into the crude rectifying or "boiler" still, if the plant is so arranged as to do away with this tank.

7. CRUDE RECTIFYING STILLS—From the crude light-oil storage tanks, the crude light oil is pumped into the crude rectifying still, or boiler still. This still is composed of 3 parts, the boiler, shown as I on the diagram, the rectifying column, and the dephlegmator L.

The boiler still consists of a cylindrical shell having bumped heads, internally braced; it is designed to handle from 5000 to 12,000 gal. of crude light oil, according to the size of the plant. The shell is covered with insulating material in order to reduce heat losses. The distillation is carried out by the use of live steam, this being introduced into coils placed in the bottom of the still. There is also a perforated pipe in the bottom of the boiler so arranged that live steam can be utilized to aid in the distillation, although this latter is not frequently made use of. Vacuum connections are also provided so that the distillation may be aided in the latter part of the cycle.

In a plant designed to wash 10,000,000 cu. ft. of gas per day this still, designed to handle a charge of 5,000 gal. of crude light oil, is made of steel, 7 ft. 6 in. in diameter and 16 ft. long, overall. The steam coils are made of 2-in. pipe, and a ball and lever safety valve is attached to the shell.

The crude light oils are pumped into the boiler still until its capacity is reached, the distillation being carried out at the temperature previously described (see p. 53). The residue which remains in the still is known as the still residue, and consists of wash oil, naphthalene, etc. It is drained to the naphthalene pans which are described later.

After the charge is fractionated a fresh charge is placed in the still. The time required to complete a run varies; in some plants 40 hrs. are required while in others 24 hrs. are deemed sufficient.

The vapors from the still pass into the rectifying column, shown on the diagram, as they are distilled off. This column consists of a number of cast-iron sections, mounted one upon the other, each section being from 12 in. to 14 in. in thickness. It is mounted upon the top of the boiler still close to one end, and is usually about 3 times as high as it is in diameter, being heavily lagged with insulating material. In construction, each section is similar to those already described. There are six "up" openings in each section, the covering bells having their edges serrated. The vapors rise through the openings and bubble through a seal composed of the heavier portions of the descending oils, which are condensed in the dephlegmator and which drain back down the rectifying column.

In this plant this rectifying column is about 12 ft. 6 in. high and 4 ft. in diameter, and is built up of 10 sections.

Mounted on top of the rectifying column is the dephlegmator or planer shown as L on the diagram. Here the vapors rising from the rectifying column are cooled by a circulation of water. The heavier portions condense and drain back down the rectifying column as before described.

The dephlegmator usually consists of a box-shaped shell about two-thirds as high and wide as it is long, containing a number of water tubes. Baffles direct the course of the vapors through the dephlegmator. In this plant the dephlegmator is about 5 ft. 6 in. long and 3 ft. 6 in. high and wide, and it contains about 148 water tubes each $1^3/_4$ in. in diameter.

In another plant one rectifying column and dephlegmator is provided for two boiler stills. By this means a continuous flow of light-oil vapors is obtained.

In some cases the crude rectifying still and stripping still may be combined. In plants producing from 15 to 40 gal. of light oil per hour (about 1 to 3 million cu. ft. of gas per day) it may be found advantageous to have the stripping still of such size that it can strip in say 16 hrs. all the benzolized wash oil produced in 24 hrs. and to have such accessories to the still provided that it can be used as a crude rectifying still during the remaining 8 hrs. of the day. When a still is to serve both purposes it should usually be equipped with some form of dephlegmator, or planer, and with an auxiliary still base which can be valved off and used as a light-oil storage tank while the still column is stripping wash oil. This still base is equipped with closed steam coils and a live steam connection and is so connected with the still column that when in use rectifying light oil, it corresponds in effect to the boiler part of a regular rectifying still. In plants producing more than 40 gal. of light oil per hour it would probably be more practicable to have entirely separate rectifying and stripping stills. In plants producing less and probably in some producing more than 15 gal. of light oil per hour when advantageously situated, it would usually be impracticable to attempt fractionation of the light oil at all at the gas works.

8. NAPHTHALENE PANS—The still residue, containing wash oil, naphthalene, etc., is drained from the bottom of the boiler still into the naphthalene pans, shown as *Z* on the diagram. Here the naphthalene separates out on cooling in the form of crystals and the wash oil drains back to the circulating wash-oil tank. The naphthalene may be further dried by using a centrifugal machine.

In plants scrubbing the light oils from water gas, no naphthalene will usually be encountered.

9. CONDENSER AND SEPARATOR—The benzol, toluol, and solvent naphtha vapors leaving the dephlegmator enter a condenser, shown as *M* on the diagram. This is a cylindrical tank about 3 times as high as it is in diameter. Inside are a number of tubes through which water circulates; a series of baffle plates direct the flow of vapor around the coils. In this condenser the various light-oil vapors are condensed into liquid form.

In the plant above mentioned this equipment is about 8 ft. 6 in. high and 3 ft. in diameter, and contains about 90 tubes, each $1^1/_2$ in. in diameter.

From the condenser the benzol, toluol, etc., pass to a water separator, shown as *N*, which is similar to the one described above.

10. RECEIVERS OR SAMPLING TANKS—From the separator the benzol, toluol, etc., drains into one of two receivers, shown as *O* and *O*1 on the diagram. These are small graduated cylinders of about 100-gal. capacity, and are used as sampling tanks. One may be filling while a sample from the other is being tested to determine its character.

From these receivers the crude benzol, toluol, or solvent naphtha is drained into the proper one of the crude storage tanks, shown as *T*7, *T*8 and *T*9 on the diagram.

11. AGITATOR—If the plant is one which produces chemically pure products, the crude benzol, toluol, or solvent naphtha is pumped from the crude storage tanks into an agitator shown as *Q* on the diagram. This agitator consists of a large lead-lined, vertical, cylindrical, steel vessel nearly as high as it is in diameter. It has a conical bottom, and contains power-driven paddles. In one plant the agitator is about 8 ft. in diameter and 6 ft. high.

In the agitator the benzol, or toluol, etc., is washed with sulfuric acid, which is supplied from a small storage tank shown as *R*1. The paddles are located at a height which permits of discharging the acid in the bottom of the washer near the level of the benzol or toluol, and the distribution of it in such a manner as to obtain a thorough mixture. This mixing or washing is carried out for 30 to 90 min., after which the agitator is shut down and about 30 min. are allowed for the used acid to settle to the bottom of the agitator. The acid is used to separate the unsaturated hydrocarbons, principally olefines, which settle with the residue to the bottom of the agitator. The sludge is run off and the acid contained in it is regenerated for further use. The benzol or toluol is washed with water, after which a caustic soda solution is run into the agitator to neutralize any remaining traces of the acid in the benzol or toluol. This latter solution is stored in the tank shown as *R*2 on the diagram. After properly mixing with the light oil the soda is allowed to settle and is then drained off, the benzol or toluol being again washed with water to remove any traces of caustic soda. From the washer the washed benzol, toluol, or solvent naphtha drains into the washed-oil tanks, shown as *T*10, *T*11, and *T*12.

12. RECTIFYING STILL—From these tanks the washed benzol, toluol, or solvent naphtha is pumped into the pure rectifying still. This still consists of three parts: the boiler still, shown as *S* on the diagram, the rectifying column *U*, and the dephlegmator *V*. Each of these three parts fulfills the same function and is similar in construction to those described for the crude rectifying still. However, the rectifying column is usually about one-half again as high as that on the crude still, in order that closer fractionation can be accomplished. If benzol is introduced into the still, pure benzol is distilled over at a temperature between 80 and 81.5° C. If toluol is introduced into the still, pure toluol will distil over between 110 and 111.5° C. The time of distillation is usually about 5 times as long as in the crude still, and the size of the still is usually greater.

The residue is usually returned to the tanks containing the washed products while the vapors leaving the dephlegmator pass through a condenser, shown as *W* on the diagram, and then through a water separator, shown as *X*. These two pieces of apparatus are similar in all respects to those described above.

From the separator the "C. P." benzol, toluol, or solvent naphtha is run into one of three sampling tanks, shown as *Y*1, *Y*2, and *Y*3, similar to those marked *O* and *O*1, after which it passes to the pure tanks, shown as *T*13, *T*14, and *T*15.

13. LOCATION RELATIVE TO EXISTING PLANT—The relative position occupied by the light-oil recovery plant in reference to the remainder of the manufacturing plant varies in different localities. In some plants the washing of the gas takes place before the gas goes to the purifiers, while in others after the gas passes the purifiers. However, in any plant in which quantities of tar and ammonia are produced, the oil washing of the gas should take place after the tar and ammonia are removed.

The relative arrangement of the equipment depends largely upon the existing manufacturing plant. If possible, it should be close to the necessary steam and water supplies, and all of the parts should be so arranged that there would be only the minimum of all classes of piping required.

14. SPACE REQUIRED—Sufficient space is required for the necessary number of tower scrubbers, if the plant is to be of this type; for the building to house the stills, pumps, and other necessary accessories; and for the storage and circulating tanks and other outdoor equipment. The entire recovery plant should be in as compact form as possible, yet should not be too crowded.

The amount of floor space which is required for the building in which the stills are located, and in which some of the accessories must be placed, depends largely upon the products recovered and the daily capacity of the plant. Sufficient floor space must be provided for the stills, and the pumps should also be provided for, in estimating the amount of floor space required. It is possible to put much of the remaining apparatus at a higher level, thus economizing in floor space.

It is impossible to state with any degree of exactness the floor space requirements, but in several plants, from 2400 to 3000 sq. ft. of floor area are required for the recovery of "C. P." products. In another plant 1200 sq. ft. are required for the recovery of crude benzol, toluol, etc.

15. STORAGE OF MATERIALS—The question of storage of materials, *viz.*, wash oil, both benzolized and debenzolized, the crude light oil produced in the continuous stripping still, the crude benzol, toluol, solvent naphthas, etc., the refined products if plant carries the process to this extent, is one which must be considered carefully. Lack of adequate means of storage often means the discontinuance of the plant, unless it is possible to utilize some other equipment in the plant.

In all plants an extra supply of wash oil must be stored. It is advisable to have as a reserve from one-half to the full amount of wash oil circulated through the system in one day. This preferably should be stored in one tank, which should have a capacity at least equal to twice that of a tank car so that the unloading of incoming cars may be done promptly. It is also advisable to have sufficient tank capacity for all the wash oil being utilized in the system, one-half for the benzolized wash oil and one-half for the de-benzolized wash oil.

It is also necessary to provide a tank for the light oil recovered from the continuous still. This tank should have a capacity equal to that of the fractionating still unless there are two fractionating stills with one rectifying column, as is the case in some plants. If the plant is not equipped for fractionating the light oil, sufficient storage capacity to tide over any interruption of shipping facilities should be provided; it is suggested that capacity for a week's production should be available, but where practicable the capacity should be not less than twice that of an average tank car.

If the plant recovers crude benzol, toluol, etc., but does not further fractionate these, sufficient storage capacity should be provided to care for each of the crude fractions, so that no danger of a lack of storage will be met. In several plants the storage capacity for benzol is about twice that of the toluol, solvents, etc. It is suggested that capacity for a week's output of each of these liquids be provided. If the plant produces "C. P." products, sufficient storage capacity for each of the crude liquids should be provided, so that the pure still will be able to operate long enough to refine the preceding crude fractions.

The C. P. benzol, toluol, etc., likewise requires sufficient storage space so that if any interference with shipments occurs it will not be necessary to curtail the operation of the plant in any way. Here also the benzol storage should be about twice that for the toluol. In addition, in a C. P. plant storage must be provided for the sulfuric acid. As a summary, approximately the storage capacity indicated is required for the following materials:

When crude light oil only is recovered:
- Old wash oil de-benzolized
  - Equal to one-half the amount in circulation.
- Old wash oil benzolized
  - Equal to one-half the amount in circulation.
- New wash oil
  - From one-half to full amount in circulation, at least 2 car-loads.
- Crude light oil
  - Equal to capacity of crude still. If no fractionation, should be large enough to avoid difficulties caused by shipping delays, at least 2 car-loads.

When crude benzol, toluol, etc., are recovered:
- Same as above and
- Crude toluol
- Crude benzol
- Crude solvent naphthas
- Heavy naphtha
- Crude intermediates
  - Benzol storage about twice as great as other fractions.
  - If further refining is done, should be large enough to allow refining stills to work necessary time. If no refining, tanks should be large enough to avoid difficulties caused by shipping delays.

When C. P. products are recovered:
- Same as previously stated, and
- Washed benzol
- Washed toluol
- Washed solvent naphthas
  - Benzol about twice as great as other fractions.
  - Sufficient capacity to allow refining still to operate requisite length of time.
- Sulfuric acid
- Pure toluol
- Pure benzol
- Pure solvents
  - Benzol about twice as great as other fractions.
  - Large enough to avoid difficulties caused by shipping delays.
  - In addition, one or two spare tanks would be advisable.

The location of these tanks is largely dependent upon local conditions. In some plants they are placed underground, in other plants they are located in water-tight pits, while in still other plants part or all of the tanks are above the ground surface. They may be grouped together or they may be separated into different groups, largely depending on the amount of available space, or local fire regulations.

16. SAFETY IN OPERATION—The buildings for a light-oil recovery plant should be located as far as practicable from other plant structures; or if sufficient distance is not obtainable, owing to existing conditions, the building should be made an individual unit, by bricking up or otherwise closing all openings into adjacent buildings. Under any conditions, it is desirable that the still be located about 200 ft. from any source of flame, since the heavy benzol vapor is quite prone to travel along the ground for a considerable distance without dilution to a sufficient degree to prevent inflammability.

The buildings should be constructed of fireproof material throughout, and should be well ventilated and equipped with wire glass windows and metal fire doors. If practicable, it should be located away from railroad tracks or sidings, and the loading platform should be removed as far as practicable from the rest of the plant.

No open flames should be brought near any portion of a light-oil recovery plant, and only incandescent electric lamps, encased in vapor-proof globes with a protective wire casing around the globe, should be used around any portion of a light-oil plant. In case portable lights are required, small storage battery light should be used. All electric wiring throughout the plant should be encased in iron pipe conduits, and no extension cords should be used.

A sufficient number of fire extinguishers, of the type capable of extinguishing an oil fire, and buckets containing clean, dry sand should be conveniently placed not only inside of the building, but also outside. A plentiful supply of water, under high pressure, should also be readily accessible, and an efficient corps of men, trained in fire extinguishing, should be available at all times.

Smoking should not be permitted in or near the light-oil plant at any time.

All stills and superheaters should be equipped with a positive safety valve set to blow at about 10 lbs. pressure. Likewise all tank cars and tank wagons should be equipped with safety valves. All tanks should vent to the atmosphere, the vents being provided with a screen of fine wire in order to prevent the ignition of the vapors by sparks.

All joints in the piping, stills, tanks, or any other apparatus should be kept tight so that leaking vapors do not accumulate in the buildings or their vicinity. All condensers should be supplied with adequate cooling water to prevent the escape of vapor into the air.

When necessary to clean stills special precautions are necessary to prevent the workmen from being asphyxiated. No one should enter the stills until they have been thoroughly purged of all vapors and are cool. All connecting valves should be closed and locked, and if the valves are not tight, the piping should be disconnected. At least two openings should be maintained in the still to allow a circulation of air throughout. The man entering should be provided with a life belt and rope and another man should be stationed outside of the still to assist in case of necessity. He should obtain additional assistance before entering the still to aid the man overcome by the vapors in the still.

17. TECHNICAL CONTROL—In the operation of a light-oil recovery plant, in order to obtain efficient results and good quality of product, an adequate laboratory equipment must be maintained and at least one observer, skilled in making the necessary tests, must be employed. The extent of the tests in a given plant will depend upon the final products produced by the plant. Obviously a plant producing pure benzol, toluol, etc., will require much more elaborate tests than a plant selling unrefined light oil only.

The following is a list of tests usually required in the operation of a pure products plant as furnished by the Chief Chemist of a large operating company:

A—Tests of Gas
- (1) Heating value and candlepower of gas entering scrubber.
- (2) Determination of light oil in gas entering scrubbers.
- (3) Heating value and candlepower of gas leaving scrubber.
- (4) Determination of light oil in gas leaving scrubbers.

B—Tests for Wash-Oil Still Operation
- (1) Determination of light oil in benzolized wash oil.
- (2) Determination of light oil in de-benzolized wash oil.
- (3) Tests of the light oil.
  - *a.* Boiling point.
  - *b.* Determination of wash oil.

C—Tests for Crude Still Operation
- (1) Receiver tests; *i. e.*, boiling-point tests made to control fractionation.
- (2) Boiling-point tests of fractions (crude benzol, crude toluol, etc.) and residues sampled from their respective storage tanks.

D—Tests for Agitator Operation
- (1) Distillation and acid tests of washed benzols.
- (2) Tests for SO_2 in washed benzols.
- (3) Specific gravity of regenerated sulfuric acid.

E—Tests for Pure Still Operation
- (1) Receiver tests; *i. e.*, boiling-point tests made to control fractionation.
  - *a.* Boiling Point.
  - *b.* Acid Test.
- (2) Tests of pure products sampled from storage or running tanks or from shipments.
  - *a.* Boiling Point.
  - *b.* Acid test.
  - *c.* Specific Gravity.
  - *d.* Freezing Point (occasional in case of benzene).
- (3) Boiling-point tests of still residues.

F—Tests of Materials Used in Operation
- (1) Wash Oil.
  - *a.* Specific Gravity.
  - *b.* Viscosity.
  - *c.* Emulsification.
  - *d.* Cold Test.
  - *e.* Distillation.
  - *f.* Olefines.
- (2) Sulfuric Acid—Specific Gravity.
- (3) Soda—Na_2O.

It is evident that in a plant shipping light oil away for further refining, many of these tests could be omitted. In a very small plant, after the routine was established, occasional tests on gas before and after scrubbing and of the wash oil and light oil would probably suffice.

18. ADAPTATION OF LIGHT-OIL RECOVERY TO SMALL PLANTS—While the somewhat complicated system of heat exchangers and the careful design of stills, described in connection with the layout of a typical light-oil recovery plant, are very important in effecting economy of operation, they are not absolutely essential to the recovery of this material. The essential equipment of a small plant recovering only light oils consists of some form of scrubber to oil-wash the gas, a still for stripping the wash oil,

a condenser for condensing the light oils, and some tanks for the storage of the various materials. A plant which is so fortunate as to possess or to be able to obtain cheaply some old gas making or power-plant equipment might find it profitable to construct and operate a small plant. An old ammonia washer, water-gas scrubber, shavings scrubber, or even an old water-gas generating shell could be readily adapted for use as an oil washer by filling with wood grids, coke, or other materials which would furnish a large surface wet with the wash oil for contact with the gas. For a stripping still, an old boiler surmounted by a section of large diameter pipe filled with stones could be used and the process made an intermittent one. In this case tanks would, of course, be necessary so that a portion of the wash oil could be circulated while another portion was being de-benzolized and cooled. An old feed-water heater of the type in which the exhaust steam comes into direct contact with the cold water might be used as a continuous still, by connecting the top of it with a condenser of some kind and admitting the wash oil near the top and live steam near the bottom. For a condenser, a coil of pipe in a tank of water, an old closed coil-feed water heater, or similar apparatus, might be used. In such an improvised plant no fractionation of the light oil would probably be feasible. The light oil would be shipped to a larger plant or to a benzol refinery. In a simple plant of this kind the cool wash oil would be pumped from its storage tank to the top of the scrubber. From the bottom of the scrubber the benzolized oil would flow to a storage tank from which it could be pumped to the still. The hot de-benzolized oil from the still would be run into a storage tank to cool while another portion of benzolized oil was being distilled. After cooling, it would be again circulated through the scrubber. A fourth tank would be necessary for the storage of the condensed light oil. If sufficient old materials were available it might be possible to construct crude heat exchangers which would improve the economy of the plant. Whether or not a given small plant should attempt to make crude fractions would depend upon local conditions. In general, it does not seem practicable for a plant producing less than 1,800,000 cu. ft. of gas per day to do so.

It would hardly be expected that a simple plant of crude construction would recover the benzol as completely or economically as a large well-designed plant, but a large number of such plants would increase the total benzol and the toluol resources very materially.

In the small plant as well as in the large one all reasonable precautions should be taken to make the operation safe both to the operators and to the plant in general. The highly inflammable character of the materials handled and the explosiveness of the vapors when mixed with air should always be guarded against. The benzol plant should be located where in case of fire it will not endanger the rest of the plant. The fact that old equipment is used in the construction should put the operators on the outlook for leaks, which occur more or less frequently even in well-constructed plants.

19. TIME REQUIRED AND COST OF PLANT INSTALLATION—The time required for the construction of light-oil recovery plants seems to vary greatly. The two essentials to normal construction are sufficient labor to conduct the work in an expeditious manner, and the necessary material either at hand or arriving at a steady rate to carry on the work in logical sequence. In this period of shortage of efficient labor and of congestion of shops and railroads, the period of construction may be prolonged far beyond the normal period or it may perhaps even be halted. Of course the amount of construction and the clearing and preparing of the site necessary are large factors in the length of the construction period even in normal times.

If there is no difficulty in obtaining labor and material a plant to scrub about 10 million cu. ft. of gas per day should take approximately, 3 to 4 mo. to build. One such plant, recovering C. P. products, actually took 63 days to build. Another plant, recovering crude benzol, toluol, etc., took about 4 months to build. One plant of home-made construction throughout, and scrubbing about three-fourths of a million cu. ft. of gas per day, producing crude light oil only, took 35 days to construct and put into operation.

To present any definite figures as to the cost of installing a plant for the recovery of light oils is impossible. This is particularly true at the present time, when the price of labor and materials is steadily mounting. Each plant must be figured as a unit, and the cost is dependent upon a number of factors pertaining to each individual plant. If the plant is to be constructed of apparatus designed for the specific purpose, and practically no old equipment is utilized, it will, of course, cost more than such a plant utilizing existing equipment.

The capacity of the plant, the completeness of recovery, the available steam supply, and the available supply of condensing and cooling water are factors which must be given consideration in any estimate. The steam and water supply capacity especially should have very careful consideration since the requirements of a benzol recovery plant for steam and water are very considerable. Likewise, the location of the plant with reference to the source of material supply is of importance.

Among a number of plants visited no agreement as to cost was obtained. The figures were, in most cases, only approximate, and therefore no great reliance can be placed upon them. The year in which the plant was constructed also had a great bearing on its cost.

For example, one plant scrubbing about 11 million ft. of gas a day, and recovering C. P. products, is said to have cost about $200,000, while another plant scrubbing about the same amount of gas, but recovering only crude products, is said to have cost about $225,000. Still another plant scrubbing only $4^1/_4$ million cu. ft. of gas a day, and recovering C. P. products, is said to have cost about $200,000.

In one plant where some existing equipment was utilized 7 million cu. ft. of gas a day is scrubbed, light oil in the crude only being recovered; the cost is said to have been $25,000. Another plant, utilizing some old equipment, and scrubbing about one-half million cu. ft. of gas per day, producing only crude light oil, is said to have cost about $40,000. Another plant, made from odds and ends without heat exchangers or any other such devices, and with only a few pieces of apparatus bought, is said to have cost about $10,000. This plant scrubs about 650,000 cu. ft. of gas per day.

From the above examples it will be seen that it is impossible to draw any general conclusions as to the cost of a light-oil recovery plant. However, it will be seen that an efficient plant costs several hundred thousand dollars, but that the cost may range considerably lower for plants constructed from existing equipment, depending upon the amount of such equipment used.

20. ITEMS ENTERING INTO COST OF LIGHT-OIL RECOVERY—The Bureau is unable to give any estimate of the cost of light-oil recovery. This would necessarily vary greatly in different localities. We can only indicate some of the principal items which enter into the cost. These items are raw materials, steam, water, electric power, wages, overhead expenses, fire insurance, maintenance, depreciation, and in some cases cost of re-enriching the gas to the prescribed standard of quality.

The materials include wash oil, lubricating oils, packing and repair materials; and in plants producing pure products, sulfuric acid and soda are also needed. The wash oil consumption varies considerably in different plants, depending upon the kind of gas washed, the tightness of the circulating system and the method of operation. While wash oil does not enter into the final product, replacement is necessary at regular intervals, due to losses, depreciation of quality, etc. Some operators replace a certain percentage of wash oil each day while others replace the whole amount at stated intervals. The percentage of loss varies greatly. Operators claim a replacement of wash oil all the way from 2 to 10 per cent of the number of gallons of light oil recovered. Prices of wash oil at the present time range, according to information available, from $7^1/_2$ to 12 cents per gallon. These prices are continually changing, so no definite figure can be assigned.

In a pure product plant, sulfuric acid and soda are necessary for washing the distillates. The amounts used by various operators differ and are, of course, dependent upon the amount of the various constituents which must be washed out of the product. An average figure seems to be from 0.3 to 0.5 lb. of sulfuric acid per gallon of light oil produced, and about $^1/_{10}$ as much soda. Some operators give the amount of sulfuric acid required for washing the crude toluol as 0.8 pound per gallon of the toluol treated. The present price of acid was stated as about 4 cents per lb. and soda at about 8 cents per lb., making the cost of the materials about 1.6 cents and 0.3 cent, respectively, per gallon of light oil produced.

No figures are available as to the cost of lubricating oils for the numerous pumps, packing, gaskets, etc., but from the nature of the materials handled it seems likely that these expenses are rather heavy.

The consumption of steam, cooling water, and electric power, varying according to local conditions and the cost of the separate items are, of course, variable. The steam consumption for the stills and accessories alone is estimated by various operators as from 40 to 65 lbs., or even more in some cases, per gallon of light oil produced. The consumption depends largely upon the extent to which the heats of the still effluent and distillate are utilized to heat the incoming benzolized oil. One operator

who recovered crude fractions only from 14 million cu. ft. of lean by-product oven gas per day, stated that his steam consumption was about 65 lbs. per gallon of light oil, distributed as follows:

	Pounds
Stripping still	14.2
Superheater	48.8
Crude still	2.0
TOTAL	65.0

In this case there was no vapor-to-oil heat exchanger in use and the oil-to-oil exchanger was an improvised apparatus. The lower figure, 40 lbs. per gallon, was quoted by the operating superintendent of a chain of several plants as the requirement of the stills and accessories. No estimate could be obtained of the steam consumption of the various pumps in these plants. In many cases there seems to be no careful record kept of these items. In one plant washing about 12.5 millions cu. ft. of mixed gas per day, and producing pure products, it was stated that 250 boiler horse power was required for the entire recovery plant. As this plant produces about 3100 gallons of light oil per day, this would be equivalent to about 57 lbs. steam per gallon, assuming that the boiler horse power used was correctly estimated. One operator having several plants under his supervision gives 8 to 9 lbs. of steam per pound of pure products as an average figure in a plant having two heat exchangers. The question of installing elaborate heat exchangers in a given case to save steam must be decided by local conditions. If the cost of steam production in a plant is very low it may not be expedient to install all the equipment necessary for the fullest utilization of the waste heat. In a small plant, especially, it might not be feasible to install all this equipment and the use of steam could hardly be expected to be as low per gallon of product as in a larger plant.

The water used in a light-oil recovery plant for cooling purposes is also a very important item. In order to obtain efficient scrubbing of the gas the wash oil must be cooled to 30° C. or thereabouts, and the condensers and dephlegmators must have an adequate supply of cooling water or light-oil vapors will be lost. The amount of cooling water used will depend to a great extent upon the temperature of the water supply. A plant which is so fortunate as to have a supply of very cold water will be able to use considerably less than a plant in which the water is relatively warm. A requirement of about 60 gallons of cooling water per gallon of light oil produced seems to be an average amount. One operator of several plants gives 1.2 gallons of water per gallon of wash oil circulated as an approximate figure. A plant which is favorably laid out may find it possible to utilize a portion of the cooling water for other purposes after it has passed through the coolers; much water may also be saved in some cases by recirculating. The cost of cooling water will in all cases be a controlling factor and will determine how elaborate should be the layout with a view to saving water. Water can be used for cooling in many cases which would not be fit for boiler feed unless treated. In contemplating any light-oil recovery installations, especially in a small plant, one of the first considerations should be the adequacy of the existing steam and water supplies.

The labor expense in operating a benzol plant is a variable item for which only an approximation can be given. In starting a plant and establishing a routine a larger force is required than after the plant is under regular operating conditions. A superintendent who has general charge of the operation of s veral plants states that the regular operating force for a plant producing crude fractions consists of seven men during the 24 hrs. of the day, assuming that each man works an eight-hour shift. Of this force one man should be a technical man who understands the testing connected with the process. The actual operators are men of average attainments, usually of the same degree of skill as water-gas makers.

In some plants where very crude fractionations are made even a smaller force is sometimes employed, though whether a smaller force could carry on the process efficiently is questionable. In one coke-oven plant washing 14 million cu. ft. per day it was stated that the actual operation of the recovery plant required ordinarily only 2 hours of one man's time on each 12-hr. shift and about 6 hrs. of a chemist's time in 24 hrs. It was also stated that the operation of the recovery plant was much less troublesome than the operation of the ammonia equipment of the same plant.

No figures were obtainable which would permit even a rough estimate of the overhead expenses, fire insurance, maintenance, and depreciation of a light-oil recovery plant. Frederick H. Wagner, in his book entitled "Coal Gas Residuals," published in 1914, allows 10 per cent of the original cost of the plant to cover these items. We have no information to substantiate or disprove this estimate. In view of the uncertainty of the benzol and toluol market in the future and the fact that it might not be profitable for city gas companies to recover benzol and toluol without the exceptionally high prices for these products now prevailing, especially if re-enrichment of gas were necessary, it seems as though a value of 10 per cent would be much too low an estimate for a company to safely calculate upon.

ADDRESSES

CHEMICAL MICROSCOPY[1]

By E. M. Chamot

A speaker who has the temerity to address a joint meeting of two different technical societies always finds himself in an awkward predicament. He feels that he must present his subject from the viewpoint of each group of men, that he must lay equal emphasis upon all branches of the sciences represented by his audience. I find myself very much embarrassed, realizing this, and in doubt whether I am here in the guise of a microscopist or of a chemist.

This, gentlemen, is the introductory paragraph of the paper I had originally prepared. Since that time we have entered the great war and I know where I stand. I come to you as a chemist to make an appeal for a wider and more intelligent application of the microscope in every-day chemical practice.

If the talk appears rambling and fragmentary I trust you will bear with me, for with several momentous issues in the hands of my department I have had little opportunity to prepare a new paper and none to make new lantern slides. I will, however, attempt to stick to my text—Chemical Microscopy. To my mind there is no such thing as microchemistry as opposed to macrochemistry, and the term microchemical methods is a misnomer. A microchemical reaction or test may be one performed upon minute amounts of material without necessarily having recourse to the microscope.

Chemical Microscopy, on the other hand, requires that some type of magnifying optical instrument enters into the work. By chemical microscopy, therefore, we mean simply the application of microscopic methods to the solutions of problems arising in the chemical laboratory or in the chemical industries.

No instrument at our command can do so much or throw so much light upon obscure problems with so little an expenditure of time, labor and material. We chemists have been wasting golden hours and slaving over sloppy methods to accomplish ends which could have been reached easily and leisurely and with a degree of certainty unsurpassed by anything we have had at our command with test-tubes and beakers. Why spend hours upon a qualitative analysis that can be better done through the medium of the microscope in several minutes?

The time has come when we can no longer be satisfied with time-consuming operations. Industries must be speeded up, production increased, better inspection methods introduced, quality thereby raised and final cost in consequence reduced. I am simply preaching good conservation. If we fail in this war and disappear as a nation it will be because we have failed in our industries to produce the necessary material and the requisite quality. I cannot recall a single great industry to-day where microscopic methods intelligently applied will not lead to more or less marked improvements.

[1] Address delivered before a joint meeting of the Chicago Section of the American Chemical Society and the State Microscopical Socety of Illinois, at the City Club, Chicago, on April 20, 1917; Messrs. A. V. H. Mory, Chairman of the Chemical Society, and N. S. Amstutz, President of the Microscopical Society, presiding.

MICROSCOPIC METHODS NOT APPRECIATED

The causes of our failure to fully appreciate the value of microscopic methods are not hard to find. In the first place, in the educational system of our chemists no adequate training has been given in the multiplicity of uses of the microscope and its potential industrial applications. In the second place, too much emphasis has been laid upon biologic microscopy, so that the generally accepted view is that this instrument is intended for studies in biology or medicine. As a result, the development of the modern so-called high-grade microscope has followed strictly biological lines and has drifted farther and farther away from stands applicable for general work in the chemical laboratory. For example, the best of our present-day stands no longer have the mirror mounted upon a swinging bar capable of movements far to one side, or even above the stage for oblique illumination. In refractive index work, in the observation of melting points, in the study of fatigue failure in metals, in the general examination of alloys, cements, protective coatings, etc., and in the preparation of photomicrographs of certain preparations, this old device now abandoned is really essential, and it is necessary to remove the mirror from the stand and fasten it to a holder of some sort in order that it may be properly employed.

It is also unfortunate that the objectives of small angle, long available working distance and marked penetrating power are not obtainable save at second hand. The modern microscope objective is a marvel in its performance, yet it is limited to the study of mounted materials covered with a standard cover glass if over a moderate power is required for the examination; but, unfortunately, we chemists must work with uncovered preparations and we must sacrifice resolving power for penetrating power and for stereoscopic effects. We need instruments of moderate cost, substantially built, and which will withstand the corrosive atmosphere of most of our industrial laboratories. Thus the third reason for the backwardness of chemists to use the microscope has been the lack of suitable models and accessories. Even our good friends and near chemists, the petrographers, have never gone out of their narrow way to try and impress the chemist with the fact that the polarizing microscope is an indispensable adjunct of the research laboratory. The modern petrographic microscope is a measuring instrument of great precision. By its means alone a vast number of chemical compounds can be positively identified. The manufacturer of organic compounds, especially, cannot afford to ignore it as a means of increasing the ease of control work. In the hands of a skilled worker this type of instrument offers untold advantages.

The application of microscopic methods to analytical problems should appeal to every chemist. Not only can he perform qualitative chemical analyses easier, but he can measure refractive indices of both solids and liquids, determine melting and boiling points with exceptional accuracy and upon minute amounts of material which cannot be isolated, determine molecular weights and can study the structure of most of our commercial materials. Dr. Harvey W. Wiley, in one of his happy moods, once defined chemistry as "the astronomy of things infinitely small." Our telescope is the microscope. To make suitable progress we must, like astronomers, construct special instruments for special purposes, and like the astronomers we must become specialists in narrow fields within our vast science. We chemists must have analogues to the students of double stars, to the investigators of nebulae, to the seekers for comets, etc. When this day comes the results reported will be comparable to the discoveries of our astronomical friends. Americans make the finest telescopes in the world. Why not microscopes as well? Unfortunately the scientific world in the United States has been obsessed with the idea that no microscopes were worth using, unless made in Europe. We are all to blame for the present difficulties. Can you obtain an ultramicroscope, a luminescense microscope or even a polarization microscope in the United States this 20th day of April? Not one, nor can you obtain condensers, lenses and eye-pieces of quartz suitable for photography with ultra-violet rays, nor spectroscopic oculars; nor can we purchase a really satisfactory moderate priced metallograph, although in this line there is hope that instruments will soon be on the market.

AMERICANS MUST STAND BY AMERICAN-MADE INSTRUMENTS

If each one of us here to-night will agree hereafter to stand by American manufacturers and buy American-made instruments, we will soon have special microscopes and accessories ranking with the best obtainable. Our artisans have no superiors and few equals, but in order that we may persuade them to undertake the construction of the apparatus we require, it is essential that we must support them with advice and hard dollars and not with empty applause. It is easy to find fault and refuse to coöperate; but it takes time and tact to call attention to defects and suggest improvements.

If those using special microscopes would stop and consider the care and labor involved in their manufacture and would be a trifle more tolerant toward mistakes in construction, far greater progress would be made than at present. Let us all agree to try and stimulate the development of American types of microscopes which will do our work better and easier, and cease being mere copyists. Let us become "boosters" instead of "knockers."

I have already asserted this evening that the chemical microscope will do more for the chemist than any other instrument or group of instruments, and it behooves me to prove my contention. In the first place, microscopic methods are the simplest and shortest for the identification of a compound. Let us assume that the analyst has in his hands a crystalline salt, and by qualitative analysis in the usual manner he decides after about an hour's examination that it contains sodium and phosphoric acid—nothing else. It is manifestly a sodium phosphate, but which one? Mono, di or tri? This he can answer satisfactorily only by quantitative analysis, and actually only by a determination of Na and PO_4. If, however, he possesses a polarizing microscope, the problem is quite simple. The mono-sodium salt is orthorhombic, the di-sodium, monoclinic, while the tri-sodium phosphate is hexagonal. He can clinch his opinion with one or more simple optical measurements and prove his case by refractive index determinations by the immersion method. Why is it that the chemist never uses refractive index determinations by means of the microscope as an aid in qualitative analysis? It is inconceivable that we have had these methods used for years by mineralogists and petrographers, yet never had sense enough to apply them to our own ends and thereby save ourselves hours of time.

But to go back to our phosphate; had we made the qualitative analysis by microscopic means it would not have taken us an hour, but say not over half that time. We would have been seated comfortably at a table and would have satisfied ourselves in a very few minutes that the salt was di-sodium phosphate badly effloresced and of commercial, not C. P., quality. This case is actually a typical one and very simple. I have selected it because it illustrates quite clearly the way in which a simple salt may be identified. But I hear some of you say this requires a knowledge of crystallography. What of it? If this knowledge will save us time and labor let us by all means do a little reading.

EASE, CHEAPNESS AND QUICKNESS OF MICROSCOPIC QUALITATIVE ANALYSES

Of all the inorganic salts we will meet with in industrial work only a very few belong to the isometric system and have no effect upon polarized light. Very few are tetragonal and triclinic and fewer still hexagonal. There is rarely need for expert training to enable the analyst to properly place the compound under examination in one of these systems. Suppose again the analyst has an inorganic crystalline salt, and under the microscope it separates

from water in what appears to be large colorless octahedra which are isotropic. The salt must be an alum, or strontium, barium, or lead nitrate, or one of several chlorostannates. The addition of a tiny drop of nitron sulfate gives no crystalline precipitate, therefore it cannot be Sr, Ba or Pb, or other nitrate. A little calcium acetate gives crystals of calcium sulfate. The salt presumably, therefore, is an alum. A refractive index determination will show which alum, or we can go ahead and test qualitatively for the bases present.

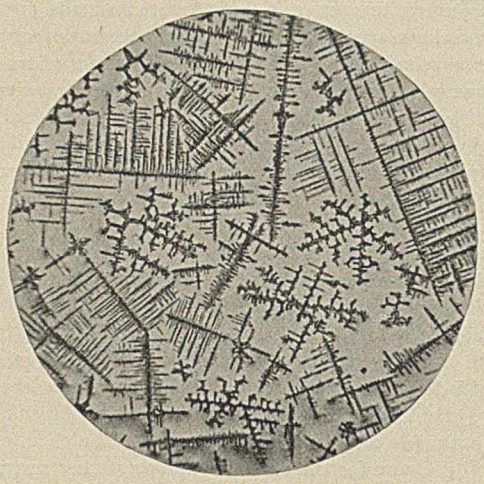


FIG. 1 × 50

The point I wish to emphasize is that in the identification of many substances a systematic time-consuming analysis is unnecessary. Note well also that all the work is done upon an object slide, that only low powers are employed and the amount of reagent required is negligible. Five grams of practically any reagent used should last an analyst, even in daily examination, almost a lifetime.

I find that the prevailing idea among chemists is that qualitative analysis, by means of the microscope, has for its purpose the detection of such infinitesimal traces of material that all

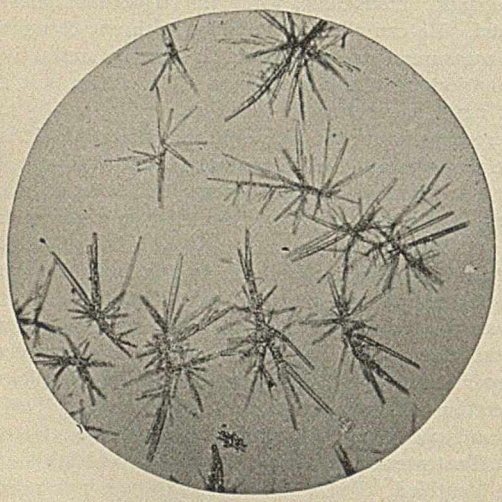


FIG. 3 × 50—$Co(CNS)_2.Hg(CNS)_2$

other methods fail. Although it is true that microscopic methods can be thus employed, by far the greatest points in their favor are the rapidity of obtaining results and the certainty of the reaction. Actually the relative proportion of material to solvent is very great; we are apt to be working with high concentrations. We take a fragment of the unknown material, not quite as large as a pin-head, and dissolve it in a minute drop of water or acid. The microscope enlarges this drop of solution until it appears to have the diameter of a ten-cent piece. This is almost equivalent to taking a handful of the unknown and dissolving it in a liter of solvent. The identity test is made by adding a reagent which will lead to the formation and separation of a crystalline phase.

VALUE OF MICROSCOPE IN ORGANIC ANALYSIS

It is in the field of organic analysis that the microscope stands without any possible competitor. Differentiation of isomeric compounds, recognition of different degrees of sulfonation, nitration, etc., is so simple in most cases as to be mere child's

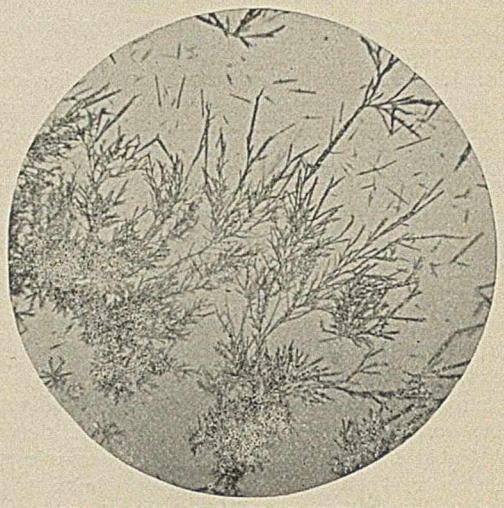


FIG. 2 × 50—$Cu(CNS)_2.Hg(CNS)_2.H_2O$

play. Take the case of the phenolsulfonic acids. Recognition of the different acids, mono or di, ortho, meta or para, or mixtures, was a stumbling block for years until Pratt showed that the barium salts were easily differentiated under the microscope. The di-acid salt forms stout monoclinic prisms, the mono-ortho acid long slender rods, and the para acid tufts of fine needles. Quite recently the microscope was called upon to aid a large plant in controlling the completion of a certain process. It was found that the manganese salt of a certain organic compound crystallized in plates with vivid polarization colors; the other

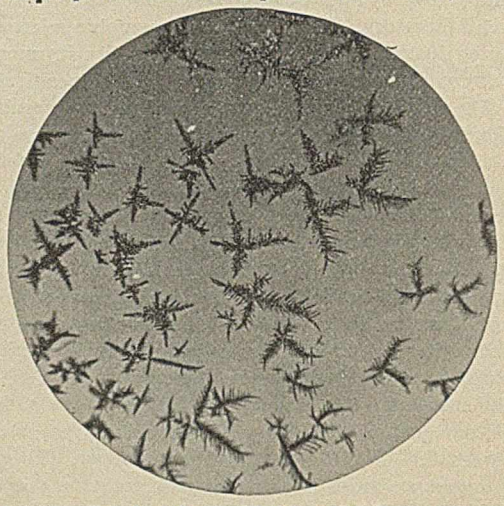


FIG. 4 × 50—$Zn(CNS)_2.Hg(CNS)$

product which it was desirable to eliminate crystallized only with difficulty in sphaero crystals polarizing feebly. A glance under the polarizing microscope showed at once the stage in the transformation of one form into the other. The older method of control took not less than twenty-four hours; the new not over twenty minutes.

By far the majority of organic compounds cannot be differentiated and identified without time-consuming quantitative determinations. Judicious application of the methods of what Lehmann years ago called crystal analysis yields the necessary information at once.

By means of an electrically heated stage not only can we determine melting points with greater ease than by the usual methods, but the accuracy of our observations is considerably increased. Amounts of material so small as to be practically invisible to the naked eye can be employed. A further advantage lies in the fact that the melting points of several different substances existing in a mixture may be ascertained without having recourse to long and arduous separations, involving loss of material and time.

Very reliable melting points of fats may also be obtained as well as the boiling and subliming points of small quantities of material.

MELTING-POINT DETERMINATIONS BY MICROSCOPE

The advantages of microscopic melting-point determinations will become more apparent when we recall that when we separate one compound from another at our laboratory work table, we so proceed that the final products stand upon our table a few inches apart in suitable containers. If we spread a small quantity of the original mixture upon a bit of cover glass and examine the preparation with a magnification of say 50 diameters, a decided space will be seen to exist between most of the different components. Gentle tapping will usually increase this space. To all intents and purposes the magnification has done exactly what we accomplished in our long chemical separation; *i. e.*, removed the components from apparent contact with one another, and interposed space between them. In most instances even very rapid crystallization of two or more salts upon a slide by quick evaporation of their solution will yield a preparation in which the salts will be found to have separated without intermixture, and with a sufficient space between them to allow a melting-point determination being made.

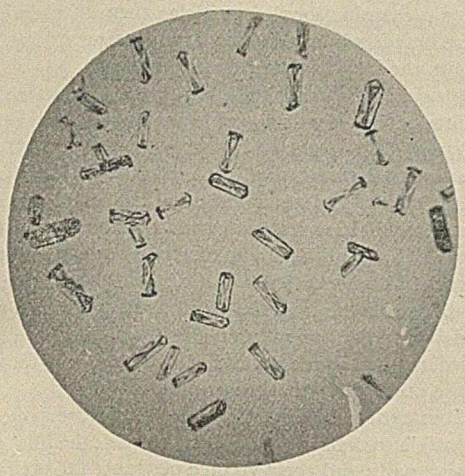


FIG. 5 × 50—$Cd(CNS)_2.Hg(CNS)_2$

This fact is clearly shown in Fig. 1. Evaporation has been pushed so fast as to force the salts to crystallize in dendritic forms, yet each group of dendrites is clear and distinct. Were such a preparation heated carefully and watched with the microscope, I think you will all agree that as one of the components begins to melt it will easily be discerned and will not interfere with the other. When, however, the temperature is raised to the melting point of the second component, the chances are that the two liquids will flow together. Nevertheless the moment of fusion is easily ascertained. If in melting-point observations, as I pointed out some years ago, we make use of the polarization microscope, the transition from a solid anisotropic body to a completely fused isotropic body is instantly recognized.

Doubtless that branch of chemical microscopy of greatest general applicability is in qualitative analysis. The addition of a suitable reagent induces the formation of a distinctive compound and its subsequent separation as a solid crystalline phase. These crystals are easily recognized and are so characteristic that there is little danger of mistaking those given by one element or compound for those of another. Add to the distinctive morphology the fact that color also enters into the identification scheme, and it will be even more apparent why microscopic methods offer such ready means of identification.

In a large number of cases one and the same reagent will cause distinctive crystal separations with a number of substances. One of the best examples of this is potassium (or sodium) mercuric sulfocyanate, $K_2Hg(CNS)_4$ [or $2KCNS.Hg(CNS)_2$] which gives characteristic crystals with copper, yellowish green (Fig. 2); cobalt, deep blue (Fig. 3); zinc, white (Fig. 4); cadmium, colorless (Fig. 5); lead, colorless (Fig. 6); manganese, colorless (Fig. 7); gold, yellow; silver colorless; and a red color with iron. Thus the addition of a single reagent will show at once the presence or absence of a number of elements, and at the same time produce an identity test for each, thereby saving an enormous amount of time and material. There are a number of such reagents available, and by carefully choosing them we can complete in a few minutes a qualitative analysis, intricate though it may be.

Time will not permit me to show slides[1] of more than one more of these multiple test reagents. I have selected cesium chloride, which gives us reactions for bismuth, antimony, tin, copper, silver and lead, and occasionally, aluminum and magnesium. You will note that the crystals obtained are just as different from each other and just as easily recognized as those formed by the mercuric sulfocyanates. Furthermore, in the characteristic reactions for the common acids the crystal forms are so different and so easily remembered that there can result no confusion when the tests are properly applied.

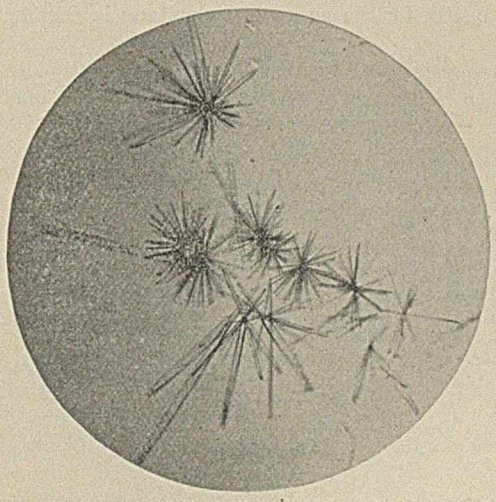


FIG. 6 × 50—$Pb(CNS)_2.Hg(CNS)_2$

SMALL AMOUNTS USED IN TESTS

The amount of material required for our tests is shown by the tiny fragment clinging to an ordinary No. 7 sewing needle (equivalent to a fragment whose diameter is approximately that of a period(.). The manner in which a test is performed I have tried to show in this lantern slide (Fig. 8.) An ordinary 3-in. × 1-in. object slide with the steps in the analysis of an alloy has been photographed natural size in order that the relative sizes of the drops may be better judged. The tiny black spot (0.8 mm. × 0.1 × 0.1 mm.) is a piece of the alloy of the exact size of that employed for the analysis. The large spot at the corner is the space occupied by the solution of the alloy after repeated evaporations with tiny drops of nitric acid to render insoluble any tin present. The nitric acid-soluble portion has been decanted to the second spot.

[1] Not shown here.

The residue has been tested and found to contain tin, antimony and copper. The nitric acid solution has been divided into three drops as seen in the slide: the first shows the dry residue after finding lead, copper and antimony present; the third spot is what remains on the slide after testing for other elements and finding zinc and iron in traces, in addition to those already found. The fourth spot has been used for testing for the remaining possible metals which were not disclosed in the other tests.

We have thus carried out upon an object slide the entire qualitative analysis of a bearing metal containing tin, antimony, lead, and a small amount of copper, and having traces of iron and zinc present. Actually it took little more time to perform the analysis than it has taken to tell it. The worker has been seated at a small table and has used less than five cents worth of reagents and gas. Instead of cutting off a small portion of the alloy we could just as well have rubbed it over a piece of ground glass or unglazed porcelain, dissolved off portions of the streak with acid and made our analysis as just outlined. The next lantern slide[1] shows this method together with the results obtained and the time required for the analysis. These cases are fair illustrations of what is possible in the saving of time, money and labor, through the employment of microscopic methods.

Other valuable applications of qualitative tests are those involving testing for the purity of precipitates in gravimetric an-

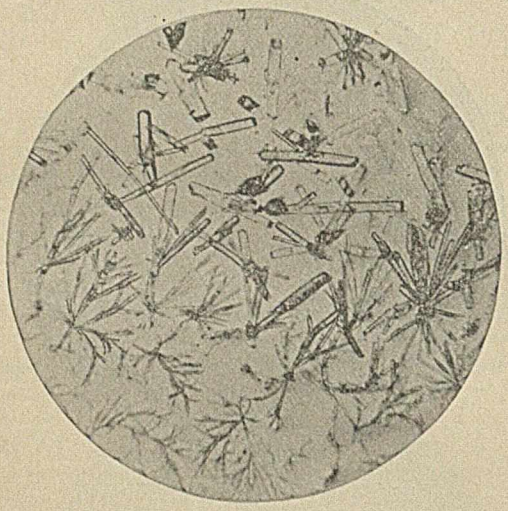


FIG. 7 × 50—$Mn(CNS)_2.Hg(CNS)_2$

alyses in order to avoid the time and trouble involved in resolution and reprecipitation, in testing for complete precipitation, especially in electrolytic analysis and also in testing for complete washing.

Another valuable application of microscopic chemical methods is in the analysis of the total solid residue in water analyses. We generally speak of the hypothetical combinations present. I do not wish to raise the question of reporting ions or combinations, but I do desire to lay emphasis upon the fact that it is possible and practicable, in most cases, to identify the salts present in the solid residue through their habit and optical properties, providing the work is properly done. I know of several instances where identification of the principal compounds present threw much light upon obscure problems. Traces or more of the heavy metals, such as lead, copper, etc., are far more readily detected by microscopic qualitative analysis methods than by any other means at our disposal.

Water analysts pay altogether too little attention to microscopic examinations of sediments and suspended matters, and to the deposits at the bottom of springs, wells and cisterns. Much valuable information is also to be derived from the examination of the muddy ooze at the bottom of streams, ponds and reservoirs, and from the study of the coated sands from rapid filter beds to learn the extent and character of the adsorption of aluminum hydroxide by the sand grains. When we speak of the "microscopy of drinking water," we generally mean researches upon the flora and fauna giving rise to disagreeable odors and tastes, but this is in reality only a very narrow portion of a huge field which is by no means restricted to biological problems or even to investigations made with the ordinary microscope, since it comprises problems soluble only by means of such specialized instruments as the ultramicroscope and the luminescence microscope.

[1] Not shown here.

EXAMPLES OF RANGE OF APPLICATIONS

The remaining lantern slides[1] have been chosen to illustrate the application of microscopic methods to the solution of problems in some of the great industries. I can do no more than touch upon them. Permit me, therefore, merely to outline the nature of the information given.

ABRASIVES—Proper grinding requires adequate speed without undue heating; cutting of uniform depth; wheels which wear well. In other words, the selection of the proper sort of wheel and speed for the specific purpose. There enters, in addition, the size of particles of abrasive and the nature of the bonding material giving a hard or soft wheel. Much of the manufacturing has been done upon a purely empirical basis and by rule of thumb methods.

Microscopic examinations of particles torn off show how the wheels have acted, while a similar examination of the abraded surface shows the character of the cutting done.

It is surprising how much information may be gained in this way, and how it may be used to guide one in making proper selections.

I will be able to demonstrate that a grinding wheel of a certain kind will tear off the surface of tool steel in such a manner as to heat the steel and draw its temper to such a degree that the particles you will see under the microscope have been fused into tiny spheres. Another wheel rotating with the same surface velocity will cut off the material in ribbons. You will note how few melted fragments are present as shown by the absence of tiny spherical masses. Such a wheel can be employed for purposes for which the other is obviously unsuited.

CEMENT, CONCRETE, CERAMICS, ETC.—By microscopic examination it is possible to determine the character of the final product, its component parts and their volume per cent; the prevalence of an undue proportion of air and water voids; the thoroughness of wetting of the cement mixtures, etc.

Not less important is the recognition of improper bonding and valuable information is obtainable as to the actual strength of the concrete or its liability to failure. There is here a huge field for the investigator offering untold possibilities.

The whole field of ceramics, both clay products and porcelains, needs intensive microscopic research. Even our ordinary bricks offer a most attractive subject for the investigator.

The thickness of glaze and the thoroughness of its bond with the body-making material can readily be determined. I have prepared slides of two high-grade porcelains; in one of these (Fig. 9) you will note the glaze is thick and between it and the porcelain are a vast number of tiny gas voids. In some cases these gas voids penetrate the glaze as infinitely fine capillary tubes. The other porcelain of far higher quality has a much thinner glaze and as you see (Fig. 10) has almost no gas voids—the bonding is almost perfect. Examinations of this sort, employed in the industry, go a long way to improve the products turned out.

FOODS AND BEVERAGES—Doubtless the earliest application of microscopic methods by the chemist was in the examination of foods, food accessories and drugs for adulteration or deterioration. Examinations of this sort are based largely upon vegetable and animal histology, and differ but little, if any, from the ordinary technique of histology. No other methods are available to ac-

[1] Only two figured.

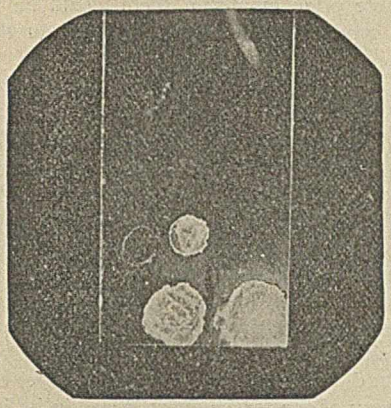


FIG. 8

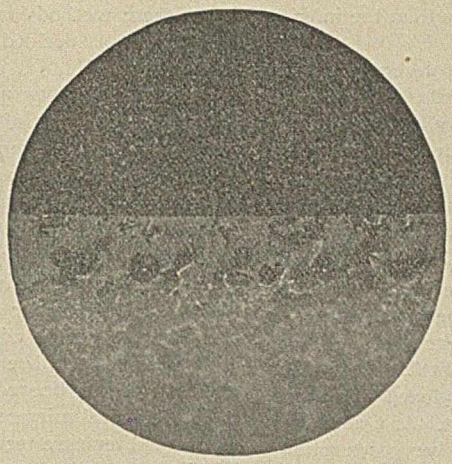


FIG. 9

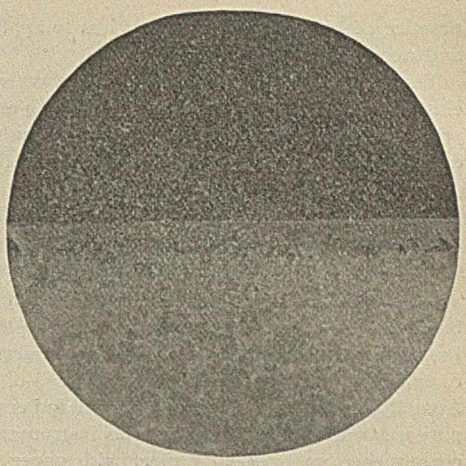


FIG. 10

complish the ends in view, and we can therefore assume that in this line at least the microscope is indispensable, training in the necessary technique imperative, and every food analyst and expert must perforce train himself to undertake studies of this sort.

This field of activity is so well understood and so firmly established that we can dismiss it without further comment. But there is in this whole question of the microscopy of foods and drugs, another phase, which chemists have greatly neglected—that of the amazing possibilities of microscopic qualitative and quantitative analysis. To even enumerate the list of substances whose detection becomes simpler, more certain and much more rapid than by our ordinary routine tests, would require more than the remaining time at my disposal. These "micro" tests are applicable to organic, as well as inorganic substances, as I have already pointed out. We have nothing better than microscopic methods for the detection of the poisonous metals, for the recognition of the organic acids, for the detection of preservatives, for the vegetable alkaloids, glucosides, and other active principles of plants; nor can we find other methods available for the quantitative analysis of starch mixtures and for similar analyses of mixed powders and meals of vegetable origin.

The recognition of our commercial synthetic drugs also is considerably simplified. In fact it is no exaggeration to say that proper analyses of this sort cannot be conducted unless the microscope is employed.

In the canning industry, especially that employing tin cans and other containers, the microscope gives information of untold value. Soldered and crimped joints yield up their secrets, as also the tinned surface or other protective coating which may have been applied to metal or paper surfaces. The possibilities are, in fact, without end.

METALLURGICAL INDUSTRIES—The microscopic study of metals and alloys has been so firmly established within the last few years, and the close relation between structure and physical properties so generally recognized and its importance proved in practice, that I need not spend time upon this question. Although these methods have been placed upon a firm foundation in the iron and steel industries, there is much work to be done in the great field of commercial alloys. We generally think of heat treatments in terms of steel only. As a matter of fact many alloys may be greatly improved by carefully conducted heat treatments. In order that such work may be properly done, microscopic studies of structure are imperative. This is well shown in the photographs of a copper-zinc, and of a copper-aluminum alloy.

Often the microscopic appearance of a roughly polished and etched specimen taken in conjunction with a hasty qualitative analysis will give the investigator all the information he may require to deduce the quantitative composition and to make a shrewd guess at the physical properties.

A most fruitful field leading to improved practices is the study of welds and brazes under the microscope. At least one expert in welding by means of oxyacetylene owes much of his remarkable success to microscopic studies of welded materials.

Not infrequently the microscope shows that a poor product is due to improper temperatures of casting or coating, and not to bad raw materials or wrong percentage composition. This is especially the case in babbitts and in tinned goods. In these photographs showing the great difference in the structure of a babbitt cast at too high a temperature and the same one poured just right, it is obvious that in the one case friction will be considerably greater than in the other, particularly if in a high-speed bearing.

PAINTS, PIGMENTS, PROTECTIVE COATINGS—The microscopic studies of materials falling in this group of commercial products may be classed under three heads: (1) The examination of the raw materials, (2) that of the coated surfaces and (3) studies of the methods and results of applying the coatings to the objects to be protected.

Briefly stated, the raw materials under the microscope (chiefly pigments, etc.) reveal their source and nature, often the process of manufacture and their suitability for the purposes for which they have been purchased. Take for example the mere question of size in the selection of the pigments for a mixed color paint. It is a simple matter to obtain a whole series of different shades by using, say two pigments and having them vary in the ultimate size of their particles, although the per cent by weight of each remains constant. The actual shape of the particles also probably seriously affects the length of time the paint really acts as an efficient protector, especially in paints containing silica, graphite, or both. The microscope also throws light upon the nature of the changes taking place in the pigments of paints exposed to air, light and the weather. A good illustration is to be found in the study of the cause of the darkening lithopones.

Examination of the weathered, coated objects, both of the surface and of sections cut through the thin films of coatings, not infrequently will permit the formation of an immediate opinion as to the quality of the paints or coatings, and the skill of the workmen who applied them.

Too little attention has been paid in the past to the study of sections. I believe all of you will be interested in the preparations[1] I have to show you. I have selected them because they exhibit in a striking manner the differences between good and bad paints, and between good and bad workmanship in their application. You will also note that the appearance under the microscope of these samples of japanned steel show very clearly the superiority of the one method of baking over the other; in actual

[1] Not shown here.

practice the superior surface costs less to apply than the inferior and wears longer and better.

The microscope in the hands of the chemist dealing with this class of commercial material enables him to evaluate rapidly the products handled by his firm, to improve faulty products and to determine whether the materials supplied to the trade are being properly applied.

Nor must we omit from mention the valuable information we may obtain from the microscopic study of woods to which fire- or decay-proofing substances have been applied.

PAPER—I have thus far failed to mention one great industry based largely upon microscopical control—the paper industry. Practically, an analysis of paper without reference to its ultimate composition as shown by the microscope is of little or no value. Actually, much paper is manufactured and employed for various purposes without studies under this instrument. As a necessary consequence we frequently meet with paper-fiber goods manufactured with little regard for the ends to be attained other than to sell at a profit. A fair criticism of our American paper products are that they are too good; that is to say, the quality is higher than need be, and the cost to the consumer is greater than it should be for many of the objects to be attained. By that I mean that a less expensive product would serve equally well and not infrequently better. This is poor business and poorer conservation. Let me cite a case in point:

A few years ago a firm manufacturing a product (which must be nameless, since the investigation was conducted in confidence) appealed to the laboratory for advice. Their product, and that of their competitors also, was failing to stand up under new conditions of use. In desperation the chemist of the firm wanted to know whether the microscope would reveal the source of the trouble. A day or two's critical study of new and failed material showed that changes made by the paper firms were probably the cause of the trouble. A commercially better grade of paper was being supplied. The matter was taken up with the paper firm. The answer was quick and to the point. The paper supplied was the highest grade that could be produced at that price and further they didn't propose to have any men, mere analysts, tell them their business. They had been manufacturing papers before the questioning men were born, etc., etc. In fact the same old story, and the same old trouble with many well-meaning American firms. All you industrial men have had similar experiences. I need not go further.

A small firm was prevailed upon to make a paper of the kind which, it was believed, would eliminate certain features which the microscope seemed to indicate to be the cause, or at least one of the causes of the trouble. This new paper was then treated in the proper manner and tested out. The results were so satisfactory that a contract was placed to take almost the entire output of the paper firm with specifications as to the kind of paper needed. The net result was that a product was obtained in which, not only were the old defects eliminated, but the cost of production was decreased, the final profit greatly increased, and the stability of this industry assured. But I am not sure that the paper firm which lost a large contract is even to-day convinced that the new methods of microscopic investigations are of value.

There is little doubt that similar conditions obtain in many of the other varied paper-fiber industries. Microscopic methods are the only ones which enable the analyst to identify the nature of the paper and to indicate its fitness and adaptability for the specific uses to which it will be put.

The technique for the recognition of the nature of the fibers present and for their quantitative determinations are fairly well established and are on the whole quite satisfactory. But a phase of microscopic investigation has been neglected, *viz.*, a study of the finished surface with references to the uses to which the paper is to be applied. A study of paper surfaces with vertical illuminator and with oblique light yields most interesting results. Were these methods more often employed there would be in many cases a decided modification in certain papers on the market.

THE TEXTILE INDUSTRIES—Like paper, the analyses of textiles and the recognition of the fibers of commerce are dependent entirely upon the proper application of microscopic methods. At the present time no other satisfactory methods are available for differentiating between the species of fibers employed, the specific treatment they have received, or the loom arrangement by which the yarns have been woven into fabrics. In not a few instances the information thus obtainable may go even further and disclose the nature of the method used in dyeing the yarn or the fabric. Uneven adsorption, variable penetration, etc., are easily recognized. The skilled investigator may go even further and discriminate between different qualities of the same species.

The technical microscopy of the textile fibers is still in its infancy: its literature teems with inaccuracies and contradictions. Too little attention has been devoted to the investigation of the reactions of reagents and the selection of proper differentiating stains, and the potential possibilities of dark field condensers having very oblique ray illumination (ultramicroscope) and of luminescence illumination (ultra-violet rays) have not yet received the attention they deserve.

By way of illustration of what the microscope reveals, I call your attention to several lantern slides[1] selected to show how neglect to employ this instrument led to the failure of a manufacturer to reproduce a fabric which the firm was called upon to manufacture because of war conditions. The reproduction involved producing a similar yarn from like fibers, a similar weave in the fabric, and a similar colored printed pattern. The slides show that in no case was he successful and that his different attempts were a waste of time, material and energy, since he apparently lacked the fundamental microscopic information necessary for success.

I trust that in these rambling remarks I may have converted some skeptics to a belief in the importance of chemical microscopy in our industries, and may stimulate a wider interest in a branch of chemical analysis whose value has been greatly underestimated and whose development has been sadly neglected.

DEPARTMENT OF CHEMISTRY
CORNELL UNIVERSITY, ITHACA, N. Y.

THE BUREAU OF MARKETS IN ITS RELATION TO THE CONSERVATION OF FOODS[2]

By CHARLES J. BRAND

Recently, I noted a peculiar typographical error in one of the western newspapers. An editorial, a half column in length, seriously discussed the need of food conservation, but through the carelessness of the typesetter the article was entitled "Food Conversation." Much of the matter that is going the rounds of the press in these days may be called not improperly "food conversation." Your section of the American Chemical Society and the Bureau of Markets are, I hope, not interested in, nor indulging in, careless and uninformed talk about food problems, but are taking serious steps to save the food of the country and to effect its more economical use.

Before proceeding to outline the relation of the Bureau of Markets to food conservation, let us first determine why the saving of food is so unusually important at this time. Roughly speaking, the diet of the average person in the United States is obtained from the following sources:

39 per cent Animal
31 per cent Cereal
25 per cent Fruits and Vegetables
5 per cent Sugar, Condiments, and Miscellaneous

[1] Not shown here.

[2] Presented before the Division of Agricultural and Food Chemistry, 55th Meeting of the American Chemical Society, Boston, September 10 to 13, 1917.

Therefore, if we examine into the world situation as to the consumptive requirement and supply of animal and grain food products, which total 70 per cent of the whole, the need of conservation will become apparent immediately.

As we have associated ourselves with the Allies across the water in a grim determination to win the war, we cannot think in terms of our own needs only, but must have in mind, in addition, those of our allies and those of deserving neutrals dependent upon us. The problem of the neutrals is intricate and delicate. Recent developments force the consideration seriously of a most severe extension of the embargoes on foodstuffs and other important materials.

As stated above, food animals and meats constitute 39 per cent of the average diet. On account of the inroads that war has made upon the herds and flocks of the world, it is estimated that there has been a decrease of over 115,000,000 head of cattle, hogs and sheep. Although our own animal production has been increasing slightly during recent years after a long period of serious decline, it has not kept pace with our increase in population, to say nothing of our growth in meat exports. The average exportation of American meats during the three years preceding the war was something over 493,000,000 lbs. During the war year extending from July 1, 1915, to June 30, 1916, the total exportation was almost 1,000,000,000 lbs. It is, of course, impossible to increase animal production quickly enough to produce this requirement, hence conservation must be called upon in order to provide what is needed.

In the case of the cereals, the crop situation in the allied countries, while fairly satisfactory in view of the vast amounts of labor diverted to war, still leaves an enormous total requirement that must be supplied largely by North America. The pre-war consumption and current import needs of wheat of Great Britain, France and Italy, our most important allies, expressed in terms of bushels, are as follows:

	Pre-war Consumption	Current Import Needs
Great Britain	268,000,000	203,280,000
France	360,000,000	118,400,000
Italy	236,000,000	59,800,000
TOTAL	864,000,000	381,480,000

The normal needs beyond their own production of the neutral nations dependent upon us are about 192,000,000 bu. Hence, the total import needs of our allies and the neutrals for wheat alone are in the neighborhood of 570,000,000 bu. On the basis of existing crop prospects, the United States, Canada, Argentine, Australia, North Africa, India and Russia will be able to supply about 500,000,000 bu. The long haul from Australia, requiring three times the tonnage that shipments from North America require, the uncertainty of being able to move any considerable quantities from India, and the almost impossible transportation situation in Russia, leave the burden upon the wheat fields of North and South America. The crop in the River Plate territory has not proven as large as usual, hence an added responsibility for us.

The normal consumption requirement of the United States is about 575,000,000 bu. The Bureau of Crop Estimates anticipates a crop this year of about 678,000,000 bu., hence our exportable surplus will be about 100,000,000 bu. By conservation it is of the highest importance that this quantity be increased to the greatest possible extent in order that the foreign deficit of 70,000,000 bu. may in some way be covered. The extent of this shortage will be more quickly grasped if we remember that it requires $4^1/_2$ bu. of wheat to make a barrel of flour, and that a barrel of flour under average conditions of efficiency in modern bakeries produces 275 loaves of bread. Our 70,000,000 bu. shortage, therefore, converted into barrels of flour would amount roughly to 15,500,000 bbls. or a shortage of over 4,000,000,000 loaves of bread. As there are about 103,000,000 people in the United States, this would represent a little less than 32 loaves for each person.

I have cited these two important food sources to indicate the amount and character of our needs.

In the case of two of our great food crops, the prospect is for a large increase. The corn crop will probably exceed 3,000,000,000 bu. as compared with a five-year average of 2,600,000,000. The potato prospect is for a crop of considerably over 400,000,000 bu. while last year's crop totaled only 285,000,000.

From this general review, let us proceed to a brief examination of what the Bureau of Markets is undertaking to do to improve conditions, not only as a war measure, but for peace times.

In the first place, we are trying to get the facts. An important desideratum in all work on food problems has been authoritative information regarding food habits, supplies, consumption, ownership, location and the like. This lack of authoritative information has been due primarily to lack of authority to obtain it. It seems incredible, but up to August 10 no branch of the Government had the legal power to force the divulging of information regarding food stocks held in any hands whatsoever.

On the recommendation of the Bureau of Markets, there was included in the so-called Food Production and Food Survey Bill (Public No. 40, 65th Congress) a section delegating quite comprehensive information-getting powers. This section, which is Section 2, and that part of Section 8 making appropriations are of sufficient interest in this connection to be read in their entirety:

SEC. 2. That the Secretary of Agriculture, with the approval of the President, is authorized to investigate and ascertain the demand for, the supply, consumption, costs, and prices of, and the basic facts relating to the ownership, production, transportation, manufacture, storage, and distribution of, foods, food materials, feeds, seeds, fertilizers, agricultural implements and machinery, and any article required in connection with the production, distribution, or utilization of food. It shall be the duty of any person, when requested by the Secretary of Agriculture, or any agent acting under his instructions, to answer correctly, to the best of his knowledge, under oath or otherwise, all questions touching his knowledge of any matter authorized to be investigated under this section, or to produce all books, letters, papers or documents in his possession, or under his control, relating to such matter. Any person who shall, within a reasonable time to be prescribed by the Secretary of Agriculture, not exceeding thirty days from the date of the receipt of the request, willfully fail or refuse to answer such questions or to produce such books, letters, papers, or documents, or who shall willfully give any answer that is false or misleading, shall be guilty of a misdemeanor, and upon conviction thereof, shall be punished by a fine not exceeding $1,000 or by imprisonment not exceeding one year, or both.

SEC. 8. * * * * * * For gathering authoritative information in connection with the demand for, and the production, supply, distribution, and utilization of food, and otherwise carrying out the purpose of section two of this Act; extending and enlarging the market news service; and preventing waste of food in storage, in transit, or held for sale; advise concerning the market movement or distribution of perishable products; for enabling the Secretary of Agriculture to investigate and certify to shippers the condition as to soundness of fruits, vegetables and other food products, when received at such important central markets as the Secretary of Agriculture may from time to time designate and under such rules and regulations as he may prescribe; PROVIDED, That certificates issued by the authorized agents of the department shall be received in all courts as prima facie evidence of the truth of the statements therein contained; and otherwise carrying out the purposes of this Act, $2,522,000; PROVIDED FURTHER, That the Secretary of Agriculture shall, so far as practicable, engage the services of women for the work herein provided for.

FOOD SURVEYS OF THE UNITED STATES

The plans which are now in operation contemplate a preliminary survey as of August 31, monthly reports on the important food commodities and a far more detailed survey about the first of December when all of the crops of the year have been gathered

and threshed. The preliminary inventory is now in progress and up to Monday noon 135,000 schedules had been returned from the enterprises called upon for reports. The August 31st survey requires the reporting of stocks on hand and in transit for eighteen of the most important commodities or classes of commodities. Included are the following:

1—Wheat
2—Corn
3—Beans, navy (pea beans), medium white and large white
4—Wheat flour, all kinds (bbls. of 196 lbs.)
5—Corn food-products
6—Rice, cleaned or milled
7—Rolled oats and oatmeal
8—Salted and cured beef
9—Cured hams, bacon, and shoulders
10—Other cured and salted pork
11—Lard, lard compounds, and lard substitutes
12—Salt fish, dry and in brine
13—Vegetable oils suitable for food, cottonseed, olive, peanut, etc.
14—Solid vegetable cooking fats (labels state whether vegetable or not)
15—Sugar, all kinds
16—Sirup and molasses, excluding any unsuitable for human food
17—Condensed and evaporated milk
18—Canned salmon.

Reports are also requested for purposes of comparison of stocks on hand one year ago on the same date. The eighteen items included in the preliminary survey will be used as the basis of the monthly reports already mentioned. Both the preliminary survey and the more comprehensive one to be made after the crops are harvested contemplate the obtaining of four classes of information:

I—Stocks on hand on farms.

II—Stocks in wholesale, jobbing, storing, manufacturing and other commercial establishments.

III—Stocks in retail establishments.

IV—Consumers' stocks, consumption records and dietary study.

I—STOCKS ON HAND ON FARMS

The determination of the quantities of the various classes of food products on farms, necessarily involving principally the quantity of cereals and the numbers of live stock and poultry, is being made by the Bureau of Crop Estimates through its existing machinery and usual methods. Their inquiry includes all of the grains, buckwheat, flaxseed, the sorghums, peanuts, beans of all kinds, peas, cottonseed, forage crops, milch cows, calves, beef cattle, sheep and lambs, swine, and poultry. The Bureau's figures for the total will, of course, be based on estimates, but the estimates will be somewhat more inclusive than those customarily made. Reports will be received for the preliminary survey from over 30,000 of the Bureau's regular township reporters. For the more comprehensive survey after the crops have been gathered, returns will be requested not only from the state, county and 30,000 regular township reporters, but also from 10 farmers in the vicinity of each such reporter.

II—STOCKS IN WHOLESALE, JOBBING, STORING, MANUFACTURING, AND OTHER COMMERCIAL ESTABLISHMENTS

Information regarding holdings in manufacturing, storing, jobbing, wholesale and other commercial establishments, is obtained by requesting from each such concern a statement of the exact amount, as nearly as possible, of each commodity on hand.

In the distribution of the schedules for the August 31st survey, there was included a list of the more than one hundred separate items upon which reports will be requested in the later inventory. Approximately, 384,000 schedules were sent out to the various food handling and distributing enterprises. As an indication of their character and number, I will cite some of the more important groups:

Grain elevators, mills, and wholesale dealers	38,000
Grain, flour and feed dealers and proprietary feed manufacturers	18,000
Breweries	1,200
Distilleries	800
Rice mills and storages	800
Canners of fruits, vegetables, meats and sea foods	6,500
Mills, refineries and exclusive dealers of edible oils	1,400
Sugar and sirup mills and refineries	1,300
Wholesale and retail bakers	32,000
Manufacturing and wholesale confectioners	1,800
Fish freezing plants, and dry and salt fish packers	1,040
Slaughters and meat packers	3,700
Lard compound and oleomargarine manufacturers	169
Wholesale poultry, butter, egg and cheese dealers	5,000
Poultry packing and fattening plants, and live poultry shippers	5,000
Wholesale fruit and vegetable dealers	1,500
Wholesale grocers and merchandise brokers with stocks	7,500
Creameries and milk condenseries (condenseries 393)	7,000
Cheese factories	5,000

III—STOCKS IN RETAIL ESTABLISHMENTS

On account of the great difficulty, in fact, practical impossibility of making a complete inventory of the stocks of the smaller retail concerns, the retail survey has been confined to retail grocers carrying stocks of $1000 and over and to general stores selling foodstuffs carrying total stocks of $3000 and up. In addition to this, the work already under way includes a detailed survey of the stocks of smaller retail concerns in a number of representative cities and rural districts. The figures thus secured will be used as a basis for estimating the total stocks for the entire country. In the general survey, schedules have been sent to 64,000 retail grocers, 63,000 retail meat markets, 60,000 general stores carrying foodstuffs, 100 chain store companies (a single chain store company operates as many as 3400 retail stores), 1200 department stores handling groceries, and 1200 hotels and restaurants.

For the purpose of estimating the stocks of the entire country the counties of the United States have been divided into groups according to the population of the largest city, town or village in each county. This classification includes as a separate class 44 large metropolitan districts. 43 counties have been selected for a detailed or intensive survey, which is being conducted by personal canvass. With the careful classification of all counties, and applying the returns obtained from the 43 counties selected, we hope to determine with a valuable degree of accuracy the retail holdings of the entire country.

A similar detailed canvass has been made of New York City with the coöperation of Dr. L. P. Brown, of the Bureau of Food and Drugs of the Department of Health and of the Police Department, New York City. The great importance of New York as a consuming center and the problem involved in supplying its foodstuffs from great distances give the canvass of that city especial importance.

IV—CONSUMERS' STOCKS, CONSUMPTION RECORDS AND DIETARY STUDY

For determining consumers' stocks a detailed survey has been made of the amounts held by a large number of representative families. 10,000 families in all parts of the United States were visited and a record was made of all food materials found in their possession. From this an estimate is to be made of the household stocks of the country. This is admittedly unsatisfactory but represented the best compromise which for the immediate purpose could be found between ignoring household stocks entirely or attempting to get returns from the 20,000,000 families in the United States, a manifest impossibility.

In passing, it should be said with reference to the preliminary survey as a whole that while it will yield information of unquestionable value, one of its greatest uses will be the organization of an efficient machine and the elaboration of satisfactory methods for making the more accurate survey in November or December.

In connection with the determination of consumers' stocks, a careful estimate of the weekly consumption of the more important

articles of food is being made among 3,500 typical families. A carefully prepared schedule for a week's consumption of 54 items of table food is being used and the coöperation of a suitable number of families has been enlisted in filling it out. Each was asked to keep a daily record of the food used by her family for 7 days. In case of food purchased, the cost was also recorded. If home-produced, that fact was set forth. All of these facts are, of course, held in confidence except so far as their use in general statements of totals and conditions are to be made.

A supplementary dietary study is being made in connection with the determination of consumers' stocks in which information was also collected as to the occupation, age, sex, health, racial stock, income and general economic condition of the families. While 3,500 families may seem a small number upon which to base any statement regarding the dietary of 100,000,000 people, it should be borne in mind that Atwater's American figures supplemented by some secured by Langworthy a number of years ago based upon a total of 400 families are the most satisfactory now available. In addition, it should be borne in mind that these figures have been used as the basis of the British Royal Commission's food supply investigations and in part also by Eltzbacher's commission which investigated Germany's food supply.

In the dietary study, all food on hand at the beginning, all procured during the course of the study, and all remaining at the end, are carefully weighed and recorded. Waste and refuse are taken into account, and from these figures the amounts actually used are determined. Over 400 institutions of learning scattered throughout all of the States are assisting through their teaching staffs and through their graduates in home economics. In addition, about 700 families, mostly members of the American Home Economics Association, are furnishing schedules either for their own homes or for families coöperating in the study[1].

When the comprehensive survey of the early winter has been finished it is believed that the food information of the United States will be more complete, detailed and accurate than any in the world.

In passing, may I say in correction of many statements that have run the course of the press that only $600,000 of the $2,500,000 appropriated for all marketing and distribution investigations are to be used in the conduct of the food surveys of the United States throughout the year.

I have described the food survey work in some slight detail as I believe it to be a subject of especial interest to your membership, whether engaged in physiological or other chemical lines. With thoroughgoing information, far more can be accomplished than without it. Nevertheless, we have in the past four years proceeded upon many lines of conservation work, which will be greatly emphasized during the coming year. A description of the chief lines with some examples of their operation and utility follows.[2]

The following titles describe to a degree those activities of the Bureau of Markets which most specifically relate to the conservation of foods.

(1)—The promotion of equitable distribution through the dissemination of market information by telegraph, telephone and mail.

(2)—Investigations and demonstrations in the conservation of food products in transportation and storage.

(3)—Market inspection of perishable foods.

(4)—City market service for the distribution and utilization of the home and commercial garden surplus.

(5)—Conservation of grain food supplies through the work in grain marketing, standardization and the supervision of grain inspection.

(6)—Reports on cold storage holdings of food products, available supply of space, and cold storage management.

(7)—Miscellaneous publicity activities designed to bring about consumption of products especially plentiful at certain seasons.

BUREAU OF MARKETS
WASHINGTON, D. C.

[1] As a working hypothesis, a daily requirement of from 90 to 100 g. of protein for a 150-pound man at full vigor with 3,000 calories of energy if he does a moderate amount of muscular work, has been generally adopted.

[2] On account of lack of space we are forced to omit this descriptive matter.—EDITOR.

THE CANNING INDUSTRY—SOME ACCOMPLISHMENTS AND OPPORTUNITIES ALONG TECHNICAL LINES[1]

By H. A. BAKER

There are produced in the United States at the present time about thirty-two million base boxes of tin plate per annum. About five million base boxes are exported, and approximately one-half the balance is used in making containers for canned food; that is, the equivalent of nearly five billion No. 2 or $1^1/_4$ lb. cans are being packed this year.

The canning industry is nothing more nor less than kitchen activity carried out on a large scale, with mechanical labor-saving devices. Food laws and evolved trade custom and ethics define canned food as natural products, with or without added salt and sugar, plus water when desirable or necessary, sterilized and preserved by heat alone. The point that naturally arises is, Why should any chemists be needed in an industry that is so simple as this? Some developments and work in this connection might therefore prove interesting, because more chemists are needed than are engaged in the industry at the present time.

Up to about nine years ago chemists exerted very little influence in the development of this industry. Of course, every one is familiar with the fact that the industry was founded on a basic scientific discovery, but it was developed largely by shrewd experimenters, usually without technical education. It is true that valuable assistance was rendered from time to time by technical men, usually associated with colleges, but the industry, until lately, did not have on its own pay-rolls men with technical training.

The Department of Agriculture gave some attention to canned foods, which was helpful, but for considerable time their help was along critical and not constructive lines, which is in sharp contrast to their present activities.

In 1912 the canning industry had become sufficiently progressive to have developed a strong national organization for self-development, education, dissemination of statistics, and activities along many lines other than marketing. It was then prepared to go one step further and establish a National Association Technical and Research Laboratory. This was accomplished through the assistance of generous donations from some of the allied industries. This development opened the opportunities for much experimental work on a large scale of a coöperative nature, that hitherto had been difficult, if not impossible. The Department of Agriculture has looked very favorably on the Association Laboratory, and has coöperated with it on several large investigations in connection with various industrial manufacturing concerns, supplying the tin plate, steel and cans for the trade. This machinery for coöperation is so complete and safeguarded from bias that investigations of national scope can be carried out and the results accepted, both by the trade and the technical men of the country.

It might be well at this point to give an outline of some of the problems that are studied, as well as those yet to be worked on. In doing this we will not attempt to make any individual mention of technical men or laboratories, the main point being to disclose somewhat the nature of the work, and the field for technical men in the canning and allied industries.

To begin with, we would point out that it has been found the work involves two sets of technical men: those who are straight technical men with superficial knowledge of the practical end of the work, and technical men with a broad and adequate knowledge of laboratory work, who are primarily business men with some executive ability. It will be readily seen that this arrangement is much more satisfactory than the usual one where purely practical and business men have the responsibility for the direction of technical activities. While

[1] Address presented before the New York Section of the American Chemical Society, November 9, 1917.

canning work is merely kitchen work on a large scale, it involves the use of high-speed machinery, concentrating and cooking devices, elimination of air and gas in the product, proper sealing temperatures and exhaust, proper closure, proper cooking temperature, as well as proper preparation of the food for canning.

Innumerable problems arise connected with spoilage, quality, appearance, discoloration, consistency, etc. Many of them can hardly be answered from the laboratory, and must be worked out by practical experimentation in a factory. For instance, a few parts per million of copper in canned corn from cooking utensils will turn it a dark gray. A very minute amount of copper will turn canned shrimp black. If evaporated milk does not receive the proper heat treatment after condensing, it will not stand sufficient processing to sterilize it without causing coagulation of casein and separation of cream. If condensed milk is not properly prepared in regard to the proportions of milk solids, sugar and water, and if the cans are not properly sterilized before filling, and aseptic methods of filling are not used, yellow discoloration of the product and spoilage will occur. If corn is not properly preheated before canning, the resultant product is watery, and separates. If string beans are not properly blanched, the product is either too tough, or is slimy. If red cherries are held in cold water too long, they will turn brown after canning. If cherries are packed in too heavy a syrup they will become very tough. If clam juice is extracted at too high a temperature it will turn black in the can. It will be seen that any of these problems, if carried to a consulting chemist outside of the industry, would cause him endless trouble, and could not be solved by analytical work.

A curious difficulty arose some time ago in connection with canned apples from a certain section of the country. These apples perforated tin containers very badly, spoilage was enormous, and there seemed no way of stopping the trouble. A peculiar thing was that these apples which caused trouble only contained about one-half as much acid as apples packed in neighboring states that caused no trouble. A certain chemist figured out from observing the drop in the water line of the cans that there must have been more air in these apples than in those that did not perforate. Actual tests showed this to be the case. It was found practicable to vacuumize these apples under water, in which case the exhausted air cells became filled with water when the vacuum was released, and it was found that apples packed after this treatment, on a large commercial scale, had not the slightest tendency to perforate the containers. Because of the urgency and extremely heavy losses, it was necessary to jump directly from a small laboratory experiment in glass to a factory installation capable of handling millions of pounds of apples in a season. Peculiarly enough, the installation worked perfectly from the outset.

About three-quarters of all the Hawaiian pineapple that is packed is vacuumized for quite another reason. It was found if the sliced pineapple was vacuumized that on the releasing of the vacuum the free juice on the outside of the slice, entering into the emptied air cells of the fruit, would change the color instantly from a rather unattractive white color to a rather standard yellowish color, which gives the appearance of perfectly ripened fruit.

For a long time the waste of the trimmings and the small pineapples was a dead loss. Some chemists went to work and now small pineapples and trimmings are crushed, the juice clarified, acid removed, and the syrup concentrated and used in canning in place of cane sugar. There is approximately a pound to a pound and one-half of cane sugar in one gallon of fresh pineapple juice. This is now being used, and has lowered the cost to the consumer of canned pineapple.

Great changes have taken place in the methods of meat packing in the last few years, and have saved over half the labor cost of canning. It was considered for a long time necessary to seal meat products in cans under vacuum on account of the sensitiveness of meat products to discoloration when cooked in the presence of air. It was pointed out and demonstrated by chemists that by changing the type of can, filling it so full that very little air space is left in it, and by merely steam-heating the product before sealing, that better results could be obtained than was possible with the vacuum system. The labor cost was cut in half, and an enormous saving resulted.

Cooking large cans of approximately gallon size had always been an expensive matter, and involved much loss on account of the internal strain on a can of large area. Extremely heavy weights of tin plate were demanded, and still buckles occurred, tin plate was broken, and spoilage resulted in cooking retorts when the surrounding counterbalancing steam pressure on the outside of the cans was released. Simple pressure cooling devices were evolved, which eliminate all trouble and loss on this score, besides reducing the cost of the container.

Methods of analyzing tin plate have been developed in a certain laboratory which designed a machine that enables four men in an 8-hr. day to turn out one thousand analyses of tin plate.

Much technical work has been done on tomato products. Sanitary methods of handling, sorting and cleansing have been devised so that it is possible to make tomato pulp, puree, ketchup, etc., with a minimum count of yeasts, mold and spores. Methods have been worked out that are simple enough to be applied by the average factory to control the finishing point, or density, of tomato concentrated products. Chaos previously reigned in this manufacture, and the loss and miscalculations were surprisingly large. Some canners boiled their product, allowed it to stand, drained off the liquor which settled at the bottom, little dreaming that in this way they were losing most of the sugar and flavor, and a very high percentage of solids. Much more profitable manufacture and elimination of waste resulted from concentrating the liquor as well as the pulp.

A great deal of work has been done on the cause of bacterial spoilage in canned food. This trouble is always occasioned by one of two things: either a minute defect in the can, or under-sterilization. All of the arts of the can maker, all the devices for testing, and the cunning of the bacteriologist is necessary in arriving at the cause of spoilage in many instances. It will be readily understood that successful work along these lines means the elimination of loss; that is, conservation of food materials and reduction in the cost of food to the consumer. It is not necessary to cite innumerable examples along these lines, for enough has been given to indicate the nature of the problem and possibilities of their solution. We should, however, mention two pieces of work that were done coöperatively through the organization previously described in connection with the National Canners Association Laboratory.

A general survey was made of the absorbed tin in all types of canned food in all types of containers, with various weights, or thicknesses of tin coating, both plain and enameled. It can be predicted at the present time approximately how many milligrams of tin per kilogram of food there will be in any tin can, with any product, in a given space of time, and whether or not the can should be plain or enameled.

Another extremely large experiment was carried out on determining the relative value of different weights of tin coatings on tin containers, and it was found that for all general purposes, except one, there was practically no difference in the protective value of tin coating running between one pound and two pounds of tin per base box. Approximately the same number of breaks, or minute defective spots, in tin coating is found, irrespective of the weight of tin coating, and if discoloration trouble develops, it cannot be taken care of by extra weight of tin coating. The

product itself must be so prepared and handled that it will not attack the container in such a way as to cause discoloration.

Consider for a moment the element of conservation involved in this. Supposing tin plate were to be manufactured which carried half a pound of tin coating more per base box than was of value, the industry would be carrying a burden of 20 to 25 cents per base box, which, of course, would be passed on to the consumer. On thirty million base boxes of tin plate this would be fifteen million pounds of tin a year, or approximately seven million dollars. Not only would there be the burden of unnecessary cost, but the actual waste of the world's mineral resources which should be conserved. The experiment itself cost only about fifty thousand dollars.

When one speaks of conservation in food industry the usual thought is merely the saving of some waste or by-product; the question narrows down in people's minds to some such question as taking care of potato peelings. Conservation on its broader side is mostly concerned with developing new and better ways of doing things, involving a saving of labor, money and materials, together with the enhancement of quality, and benefit to the public. It is true that there are plenty of waste products to work up in the canning industry, but it is also true that the more promising field is new developments. At the present time only 50 per cent of tomatoes delivered at the factory are turned out in the canned fruit product. Thousands of tons of pear peelings are wasted because they do not make a vinegar that tastes like vinegar. Thousands of tons of fish scrap, particularly on the Pacific Coast and Alaska, are wasted because easy and profitable methods of getting the values out of them have not been devised. Enormous quantities of green corn cobs are allowed to ferment and are used for fertilizer and cattle food, when it is well known that there is more sugar left in the cob than was taken off in the corn. Probably many kinds of bacteria which at present only destroy food could be made to do useful work, producing useful substances and chemicals, if they were thoroughly studied and put to work. Enormous quantities of sea food, which cost nothing to grow, are at present unused by the human family because no one has prepared them in a way that would make them palatable and attractive. Enormous quantities of shark and gray fish are not used because they happen to contain a small quantity of urea which in cooking turns into ammonia. The Department of Agriculture is giving this matter attention, and they, or other chemists, shall probably succeed in making this sea food as palatable and popular as Tuna fish, which for a long time was absolutely ignored. It was a huge, slimy, soft, unattractive looking fish that was so repulsive in its natural state that no housewife or cook would buy it and prepare it for the table. Somebody found out that if it was properly heated the soft flesh coagulated into firm flesh of attractive appearance. When it was cut up into small portions and canned, it became very popular, and millions of cases of this fish are now consumed.

It is not necessary to point out specifically a lot of things that lie waiting for chemists to do in the food industry and allied industries, because specific definitions tend to paralyze the imagination, and it is much better for individuals to hammer out their work along their own lines than to assign them definite and limited tasks.

It is of course proper to tell the American public that it should not neglect its chemists, and that if it will give the chemists a chance they will show how to save waste, reduce costs, and make life more comfortable and easy. This is one end of the problem, the other end being the chemist himself. He has to go out and dig up things for himself to do, and then act as salesman and sell himself to do them. After all, is that not fair, provided the chemist is fully warned and told by his teachers that that is what the game is, and that is the way he shall have to play it?

The canning field is broadening every day, and inviting some men of technical training to its assistance. Many other technical men should invite themselves because the work is there, and the results are to be obtained, and the public is waiting for the results.

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EDIBLE FATS, IN WAR AND LAW[1]

By David Wesson

With our country starting to take an active part in the World War, the food question becomes of vital importance. It is estimated at the present time that the United States has 1,600,000 men in its Army and Navy. Great Britain has nearly 7,000,000 and France 3,000,000. Our country is only beginning to build the Army which will be needed before the war is over.

No matter how well our Army is equipped with artillery, ammunition, and other tools of warfare, it will not be able to do its work properly unless it is well fed. We might as well expect the Empire State Express to make schedule time running on slack coal as to expect our armies and those of our allies to achieve great victories on improper or insufficient food.

The great advances made in the science of nutrition during the last 25 years have given us means to measure the amount of food required for men doing various kinds of work. When Atwater was making his painstaking investigations it did not seem probable to any of us that the results obtained with the calorimeter bomb were going to help decide the battle of today. Atwater has shown that persons engaged in very active work require far more food than when doing ordinary work. Some of his figures are very instructive. Without going too much into detail, the following will prove interesting as showing the different requirements:

	Calories
Rowing Clubs in New England	3,955
Bicyclists in New York	5,005
Football Teams, Connecticut and California	6,500
Prussian Machinists	4,270
Swedish Mechanics	4,500
Farmers' Families, United States	3,415
Mechanics' Families, United States	3,335
Laborers' Families, large cities	2,925
Lawyers, Teachers, etc., United States	3,220
College Clubs, United States	3,580

Judging from the intensive training our men are receiving in the several camps, and the active work they will have to perform on the battlefield in the cold, damp European climate, it is quite evident they belong in the football class, and will need about 6,000 calories per day per man.

Atwater gives in his table the following make-up of the football players' diet:

	Actually Eaten	Digested
Protein	226	208
Fat	354	336
Carbohydrates	634	615
Fuel Value, calories	...	6500

The fat in this diet would furnish 2,536 calories, or 39 per cent of the total, while in weight it amounts to one-third of the food elements.

When we consider the enormous demands on the world supply of fats by the warring nations, and the terrible curtailments which have taken place in production, due to the decrease in fat-yielding animals, the shortage of crops and the difficulties in transportation, it can readily be seen that the edible fat problem is a vital one, not only for the proper supply of our armies and those of our allies, but for the workers at home who have to supply the armies with fighting materials, and last but not least, the large civilian population.

[1] Address presented before the New York Section of the American Chemical Society, November 9, 1917.

No attempt can be made to go into statistics, which had better be left in the hands of our able food administrator, Mr. Hoover. It is sufficient to say that the edible fat supply in this country is now being greatly augmented by the increased production of peanut oil, which largely offsets the decrease in cotton-oil production due to the relatively small crops of the last two years. The country is also importing large quantities of copra and cocoanut oils, which formerly went to Europe. Soya beans and bean oil are also used in large quantities, but there is not enough to supply our needs here and those abroad, unless the strictest economy is enforced.

Attention need only be called in passing to the fact that large quantities of perfectly good edible oils are used in soapmaking and metal cutting, and also in mixing illuminating and signal oils. The use of edible oils should be rigidly controlled and substitutes prescribed for use in the arts, wherever possible. Waste should be cut down in the use of soap, which should be made of inedible materials to the greatest extent.

Where the housekeeper most feels the shortage of edible fat is in the high price of butter. Butter is high because it is scarce; substitutes, however, can be found to take its place, but because the manufacture and sale of them are so hampered by legal restrictions the public has but little opportunity to become acquainted with their merits.

You all remember the Bible story of how the children of Israel during the absence of Moses on Mount Sinai persuaded Aaron to make a golden calf, which they all fell down and worshiped, and when Moses came down with the ten commandments and saw what was happening he was so overcome with wrath that he broke all the commandments on the spot. Many of us engaged in the production of edible fat sympathize with Moses, because in the year 1886 our great American Congress, not to be outdone by the Israelites in worshiping a calf, deified the great American cow, and have been worshiping her ever since. I refer to the oleomargarine law which, with its amendments and regulations, covers over 90 pages of an octavo volume. It imposes a tax of $600 on every person who manufactures oleomargarine. It says expressly that any person who sells, vends, or furnishes oleomargarine for the use and consumption of others, except to his own family table without compensation, who shall add to or mix with such oleomargarine any artificial coloration that causes it to look like butter of any shade of yellow, shall also be held to be a manufacturer of oleomargarine within the meaning of the act.

Wholesale dealers are taxed $400 a year; retail dealers who sell less than 10 pounds at one time are taxed $6 a year. Anyone who manufactures oleomargarine without paying the tax is liable to a fine of not less than $1,000 nor more than $5,000, while wholesale dealers are subject to a fine of $500 to $2,000 and retailers from $50 to $500. The law provides for two kinds of oleomargarine: colored, paying a tax of 10 cents per pound; uncolored, paying 1/4 cent per pound. The law has worked out somewhat as follows:

For the fiscal year ending June 30, 1917, the tax receipts on oleomargarine were $1,995,720, of which $792,838 came from special taxes on dealers and manufacturers in addition to those on the product.

The quantities made were:

Colored.....	6,327,000 lbs., paying 10 cents per lb.
Uncolored.....	228,066,000 lbs., paying 1/4 cent per lb.
TOTAL.....	234,393,000 lbs.

The year previous the consumption was 152,124,000 lbs. The figures show the increased demand in spite of restrictions.

When the oleomargarine laws were passed in 1886 the only materials at the command of the manufacturers were oleo oil, neutral lard and imperfectly refined cottonseed oil, with small quantities of imported peanut and sesame oils.

At the present time, with improved refining methods, the whole field of vegetable oils is open to us, and several choice brands of vegetable oleomargarine are being made of cocoanut, peanut and other oils which are sold at about 30 cents per pound as against butter at 50 cents, and, except in the case of growing children, are every bit as satisfactory from a food standpoint as the more expensive products of the cow.

Under reasonable laws, the average consumption of oleomargarine in Great Britain is 8 lbs., against 17 lbs. of butter. Denmark, one of the greatest butter-making and consuming countries of the world, has an annual consumption of 43 lbs. of oleomargarine per inhabitant, Norway 33 1/2 lbs., and Holland 20 lbs. The United States consumed last year 2.34 lbs. of oleomargarine and 18 lbs. of butter per inhabitant.

While practically nearly all the oleomargarine in this country is sold uncolored, color is furnished with it and the consumer can color the material to suit his state.

Congress did so well with the oleomargarine law that in 1888 it tried to deify the hog in like manner by passing similar legislation against compound lard which, in those days, was a mixture of lard, oleostearine and cottonseed oil. Fortunately, the cottonseed oil product was able to present a better bill of health than the hog product and as a result the lard-compound industry grew.

Thanks to the chemist, a flavorless, odorless and almost colorless cotton oil was placed on the market in 1900, which, combined with oleostearine, made a lard substitute preferred by its users to the hog product.

Now with the hydrogenation process, lard substitutes, better than lard, are made without the use of any animal fat whatever. The lard supply of the country receives a much needed assistance, and the Southern farmer is obtaining about 8 times as much as he did for his cottonseed, at the time Congress tried to strangle the industry.

The oleomargarine law is not our only grievance against our statute books. About 1872, dairymen became very much concerned about the manufacture of cheese from skimmed milk and oleomargarine, which ten years later was superseded by the use of lard under patents issued in 1873 and 1881. The cheese was made by emulsifying skimmed milk with the melted fat, using two or three parts milk to one of fat, then treating the emulsion in the cheese factory in the usual way. Very good cheese was the result; it was not injurious to health, but it committed a sacrilege against the products of the sacred cow, whose high priests in Congress June 6, 1896, passed the filled cheese law promulgating regulations as onerous as those of the oleomargarine laws. Manufacturers are taxed $400 per annum; wholesale dealers $250; retailers $12, with fines and regulations galore, besides a tax of 1 cent a pound on the product. Naturally the industry languished, and though the bill was passed as a revenue measure, the last report of the Collector of Internal Revenue shows there is no longer any "filled" cheese made. If there was any good excuse for the passage of the bill at the time, there is none now. There is no reason why a compound cheese made from skimmed milk and carefully refined vegetable oils should not be perfectly wholesome as an article of diet, and with proper methods of manufacture be better than many of the cheeses now on the market. It would be infinitely better than skim-milk cheese, for example, which does not fall under the ban of the law.

When the war started I immediately commenced to look for available fat and protein. I knew the value of the various vegetable oils as food and realized that in order to utilize them to the best advantage they should be combined with protein. Such a combination spells cheese, one of our most concentrated forms of food, and skimmed milk at once suggested itself as the best available material. The first thing encountered in the

literature was the filled cheese law. This put a bar against experimenting on a suitable scale, otherwise I would have had some products here to-night. It will not, however, prevent us from contemplating some figures which in the present food crisis are worth considering.

The census of 1914 shows that the creamery production of butter in this country was 769,810,000 lbs., which would call for not much less than 20 times that much of skimmed milk and buttermilk, amounting in round numbers to say 15,400,000,000 lbs. of material containing about 3 per cent of casein, say, 460,000,000,000 lbs. If this were worked up into a standard cheese of 28 per cent casein and 36 per cent fat, it would produce 1,650,000,000 lbs. of cheese and require 594,000,000 lbs. of oil, equal to 1,485,000 bbls. This amount of cheese would furnish our present Army and Navy with 1,000 lbs. per man per year, or, if divided with the armies of Great Britain, France, England, and Italy, 13,000,000 men, each man would have 127 lbs. a year, or 0.35 lb. per day, furnishing 719 calories or about 12 per cent of his daily ration.

Even if only half the skimmed milk from the creameries could be worked up in this way, the figures are well worth considering.

When we think of the oleomargarine and filled cheese laws which allow any farmer working under unsanitary conditions to color the white butter from winter-fed cows and foist his product on the public as "golden June butter," and at the same time subject the makers and sellers of wholesome food products to more taxes, fines and restrictions than are imposed on whiskey dealers and saloon-keepers, we cannot help hoping that the day may soon come when the members of Congress will be guided by patriotism rather than politics and wipe these iniquitous laws from our statute books.

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CURRENT INDUSTRIAL NEWS

PERFUMERY FOR SIAM

Perfumery and cosmetics were imported into Siam during the year 1915–16 to the value of over $105,000, the United Kingdom being the chief supplier to the value of $30,000, followed by Japan with $26,000. Under this classification are included all kinds of perfumes and scented toilet waters, face powders, talc powders, tooth pastes and powders, shaving soaps and creams, cosmetics and lotions for the hair and face. American toilet requisites, according to the *Times Trade Supplement*, seem to be taking well on the market. The import duty on goods of this class is 3 per cent *ad valorem*.—A. McMillan.

DESULFURATION OF HYDROCARBONS

The removal of sulfur from petroleum is a problem of first importance and the following method adopted by La Fresnaye et Suchy and for which a patent has been taken, is of interest. The process hitherto adopted involving the use of ozone and sulfur dioxide is only effective up to a certain point.

According to a report in the *Chemical Trade Journal*, 61 (1917), 331, it has been found that the sulfur can be removed by a simple process of precipitation and without any decomposition, by treating the oils to be purified with a metallic compound under certain conditions after the addition of certain organic compounds, such as ether and phenol compounds, trioxybenzoic acid and trioxybenzole. The sulfur combines with the metal and may be removed by filtration. Suitable metallic compounds for this purpose are zinc carbonate, lead oxide and other compounds of the heavy metals having great affinity for sulfur. The amount of the metallic compound to be added depends, of course, on the percentage of sulfur in the oil, and it is advisable to use the metallic compound in excess.

One example of the process is as follows: 20 liters of oil having sulfur content of approximately 0.5 to 1 per cent are mixed with 300 cc. acetic ethyl ether in which are dissolved 5 to 7 g. trioxybenzoic acid or trioxybenzole. To this are added 50 to 70 g. lead carbonate or other suitable metallic compound, and the mixture heated to a few degrees above the boiling point using a reflux condenser or a closed vessel until a black precipitate is formed or until the liquid, at first turbid, becomes clear. If the end-point is too yellow, the liquid is ozonized to saturation and then washed with caustic soda until the pyrogallol is removed. An oil containing a high percentage of sulfur should be converted into a liquid oil by addition of ether and, if necessary, slightly heated before adding the metallic salts corresponding to the sulfur content. At the conclusion of the process the ether added is removed by distillation and the black residue is filtered off.—M.

LAMPBLACK MANUFACTURE

A process for the manufacture of lampblack from hydrocarbons is the subject of a recent German patent, says *Chemical Trade Journal*, 61 (1917), 348. According to this invention a vessel is charged with an inflammable mixture of gaseous hydrocarbons and oxygen under pressure, the bottom of the vessel containing a layer of liquid hydrocarbon in which a slow tension arc is set up between two electrodes and decomposes the liquid with the formation of lampblack, while at the same time the overlying mixture is ignited. A tension of 200 volts is generally used and must not in any case exceed 1,000 volts. By modifying the composition of the mixture, the decomposition can be retarded so as to prevent excessive pressure and temperature. As an example, a vessel with a capacity of 2 cm. is charged with $^2/_3$ gas and $^1/_3$ liquid hydrocarbon, the first-named constituent being acetylene and the hydrocarbon consisting of high fractions from the distillate of brown coal tar or crude petroleum. In addition to lampblack, hydrogen, methane, carbon monoxide, ethylene and heavy hydrocarbons are produced, the carbon remaining in the liquid while the gases pass into the acetylene mixture. Air is blown into the vessel and decomposes the acetylene, the resulting hydrocarbons splitting up into carbon and hydrogen. As the liquid charge thickens from the deposited carbon, it is drawn off, filtered and returned with a fresh portion of charge. Such of the carbon as is not deposited passes off with the effluent vapors and is collected in a second vessel.—M.

BORIC ACID AND BORAX

In the September issue of *La Science et la Vie*, an interesting account is given of the utilization of the natural steam from the volcanic area of Tuscany and of the manufacture of boric acid and borax. The highly saturated steam issues from the ground often at fairly high pressures, but, for purposes of conversion, it is utilized for heating a series of tubes containing water, the steam pressure in these tubes being two atmospheres (30 lbs. per sq. in.). The steam drives low-pressure turbines which, in turn, are coupled to alternators. The steam and water of these "soffioni," as they are termed, contain quantities of boric acid which is concentrated in a special apparatus and gives a product of about 99 per cent purity. The acid, treated with sodium carbonate, gives borax, which is produced in the form of crystals and powder. Ammonium carbonate is also manufactured, the carbonic acid necessary for the process being also obtained from the "soffioni." Investigation is also being carried out on the radioactivity of the gases of the "soffioni" and on the separation of the helium which is found to be present.—M.

POWER FROM REFUSE

In a circular illustrating some of their standard types of refuse destructors, Messrs. Meldrums, Manchester, state that, although with small amounts of refuse up to, say 1 or 2 cwt. daily, it is not usually worth while to use the heat produced for raising steam, a water heater can be combined even with the smallest destructor where a need for hot water exists, while with the larger sizes burning a ton an hour or more it almost invariably pays to install a boiler for purposes of steam raising, power, or heating. A portion of the steam is advantageously employed in providing forced draught for the destructor, since, in this way, the burning capacity is increased at least 50 per cent for a given grate area. Several typical examples of the utilization of refuse are given. At a large tannery in the Midlands a destructor, placed in front of a Lancashire boiler and dealing with 150 tons of spent tan a week, provides the whole of the steam required for drying without any other fuel. By means of a three-grate plant in conjunction with a Babcock and Wilcox water-tube boiler, all the steam required for running a textile mill at Rochdale is generated from shoddy waste.—M.

MINERAL PRODUCTION IN CANADA

The following statistics of the mineral production in Canada during 1916 are taken from the report recently issued by the Canadian Department of Mines.

	1916		1915	
	Quantity	Value	Quantity	Value
Nickel	82,958,564 lbs.	$29,035,497	68,308,657 lbs.	$20,492,397
Lead	41,593,680 lbs.	3,540,870	46,316,450 lbs.	2,593,721
Asbestos (1 ton = 2000 lbs.)	136,016 tons	5,133,332	111,142 tons	3,553,166
Natural Gas (1000 ft. unit)	25,238,568	3,924,632	20,124,162	3,706,035
Pyrites	309,411 tons	1,084,019	286,038 tons	985,190
Gypsum	341,618 tons	730,831	474,815 tons	854,929
Salt	124,033 tons	668,627	119,900 tons	600,226
Petroleum	198,123 bbls.	392,284	215,464 bbls.	300,572
Zinc (from zinc ores)	23,515,030 lbs.	3,010,864	.....	.....

According to the report of the British Columbian Minister of Mines, the output of zinc from the smelter at Trail in 1915 was approximately 1,500,000 lbs. At the beginning of 1917 the output of the smelter was from 25 to 30 tons per day.—M.

COPPER AMALGAM AS METAL CEMENT

The Vienna metal cement, which is sometimes mentioned in description of apparatus, is a copper amalgam. The *Giesserei Zeitung* recommends the following method for the preparation of this cement:

A strip of zinc is placed in a solution of copper sulfate and the powdery copper which is precipitated is put into a mortar and kneaded with mercurous nitrate, mercury and water into a plastic paste; three parts copper are used to seven parts mercury. When metals are to be cemented with this amalgam which is brought into the market in small cylinders, the parts are polished and heated up. The amalgam is heated up also to 80 or 90° C. and the parts are pressed together. The amalgam, itself can be hammered, rolled and put under a die; it takes a good polish. Placed in boiling water it softens sufficiently to use it as a material for taking casts. It is rolled into a thin strip which is applied to the heated object; the replica obtained is afterwards backed with type metal.—M.

JUTE SACKS FOR ARGENTINA

It is estimated that the stocks of jute sacks available in the Argentine Republic for carrying this season's crop of wheat, oats, and linseed amount to 50,000,000, which are sufficient to contain 3,000,000 tons of grain. As, however, the total crop is expected to be more than double that amount, a further 50,000,000 sacks or containers of some description will be wanted.—M.

JAPAN PEPPERMINT CULTIVATION

We hear, says the *Monthly Trade Journal*, that steps will soon be taken at Hokkaido, where the chief peppermint cultivation of Japan is carried on, to systematize the cultivation of the planting and the manufacture of menthol. In the past the sun-drying process especially has left much to be desired and, while the peppermint in the shape of crude oil has so far been shipped to Yokohama and Kobe where it is distilled in the factories, it is now proposed to erect factories in the chief farming districts on a coöperative basis.

Peppermint oil derived from the residue of oil after being properly refined is finding every year a larger demand abroad. Before the war the largest customer of Japanese menthol crystal was Germany, while to-day America is taking at least 88 per cent of the total output. The average price has been between $1 and $1.50 per lb., while several factories at the end of 1916 sent circulars to their chief customers announcing that, owing to circumstances, prices were likely to go up during 1917. This did not happen owing to improved factory conditions. During 1916 about 525,000 lbs., valued at $1,031,250, were produced.—M.

NON-INFLAMMABLE PLASTIC MATERIAL

A recent French patent, says the *Chemical Trade Journal*, 61 (1917), 365, describes a new plastic material which is non-inflammable and inodorous. The material is produced by transforming gelatines, glues and such substances of animal origin by suitable chemical reagents giving them plastic and malleable properties which allow them to be used industrially in a manner similar to natural products.

The gelatine or glues are first melted in a water bath at a temperature of 90° C. A decoction of hop-flowers is then prepared and mixed with dilute oxalic acid or any dibasic acid of that series and the solution is added to the melted gelatines or glues in varying proportions according to the quality of the materials used. The addition of this solution causes the gelatine to become more supple and also causes the impurities to deposit at the bottom of the vessel. When the gelatines are liquefied, they are poured out in the form of thin sheets or sticks of the desired thickness and left to dry in the cold air.

The coloring of the material is then proceeded with, natural or artificial dyes being employed. The sheets, when colored, are plunged into a bath of approximately the following composition: 25 to 35 per cent formaldehyde, 25 to 35 per cent water, 25 to 35 per cent alcohol and the rest composed of oxalic acid, tannin and glycerine. The oxalic acid may be replaced by any acid of that series. In the case of rich gelatines, a larger percentage of alcohol is used.

The substances may serve for the manufacture of combs, buttons, etc., and as imitation of tortoise, horn amber or ivory and is unlike cellulose products in being absolutely non-inflammable and odorless.—M.

ELECTRIC LAMP TRADE IN JAPAN

Japan, says the *Electrician*, appears likely to be a serious competitor in the incandescent lamp trade. In 1916, the Japanese exports of incandescent lamps were valued at $335,000 and in the first four months of the current year at $440,000 or at the rate of $1,250,000 per year. These figures are to be compared with no exports and with exports of the value of $150,000 in the year prior to the war. The one difficulty the Japanese lamp manufacturers have had, was in the supply of filaments, practically all of which used to be imported. Now, however, only a small fraction of the filaments used are imported. Large factories have been constructed and the Japanese manufacturers are now in a position to supply their own filaments.—M.

IMITATION LEATHER FOR SWITZERLAND

Supplies of imitation leather on the Swiss market and the scarcity of real leather have produced an exceptional demand in that country. French manufacturers are supplying an acceptable quality with a waterproof lining of rubber but are not now in a position to give good deliveries. Their total output comes far short of Switzerland's present needs in imitation leather.

Some of the uses to which imitation leather is put are drivers' seats and upholstering of motor cars, upholstering of furniture, cabinets and in making school satchels, while heavier qualities are employed in book-binding.

Manufacturers are recommended to equip agents with the necessary catalogs, price-lists and samples. Light but strong packing material is essential, this being important on account of tariff treatment. Motor-car upholsterers ask for antique or Moorish designs. A favorable dimension is 36 ft. long by 4 ft. to 4 ft. 9 in. wide. The price paid per piece varies from $2 to $8. It is not thought likely that the Swiss boot manufacturers will as yet adopt artificial leather.—M.

NEW MAGNESIUM ALLOY

The new magnesium alloy which the *Chemische Fabrik Griesham Elektron* is introducing under the name of Elektron Light Metal seems to be a war substitute only likely to subsist under war conditions. It is described as a silvery white metal, density 1.8, which melts at 620° C., and will burn only in shape of thin foil. It resists the action of caustic alkalies which would attack aluminum, and is said to be sufficiently strong and otherwise suitable to serve in the place of aluminum, copper and brass, also as an electric conductor. It is, however, acknowledged that the alloy is corroded by dilute acids and oxidizes in the air, though not superficially.—M.

ELECTRO-STEEL WORKS IN GERMANY

During the past two years, says *Engineering*, 104 (1917), 469, ten electro-steel works of the Lindenberg type have been built and put into operation in Germany and Austria, their aggregate capacity being 125,000 tons annually. Another eleven works are in course of construction with an aggregate capacity of 220,000 tons per annum and they will be started in the course of the next few months.

The Lindenberg Steel Works of Remscheid-Hasten showed a surplus for last year of $606,261 against $337,081 for the previous year. The dividend is given as 25 per cent in addition to a bonus of 10 per cent.

The German Electro-Steel Company has raised its capital to $200,000 and a further increase of $400,000 is contemplated, the domicile of the company being removed from Berlin to Saxony.—M.

FATS AND OILS

According to a recent German patent, the greases recovered from technical processes dealing with such substances as wool, leather, faeces, etc., by extraction, mostly contain saponifiable and unsaponifiable matters which can be separated by a treatment based on the fact that the latter can be volatilized by the vapors of inert liquids. For example, crude sewage fat is first saponified as completely as possible by the treatment with an alkaline earth or a metallic oxide, and the dry, anhydrous mass of soap is subjected to the action of superheated steam in a suitable still at a temperature above 200° C. The unsaponifiable oil passes over with the steam, leaving behind in the still a soap which, when decomposed with acid, yields fatty acids free from unsaponifiable fats and oils. The steam may be replaced by highly heated vapors of benzine, carbon tetrachloride, etc.—M.

NEW BRITISH DYE

The announcement has been made by the British Dyes, Ltd., Huddersfield, that they are now placing on the market two brands of a yellow vat dyestuff of the anthracene series under the name of chloranthrene yellow D. & G. This yellow, it is said, will be of great value to the textile trade as a self-color on account of its fastness to light, milling, washing and bleaching. It may also be used with great advantage in conjunction with chloranthrene blue for the production of various shades of fast green on vegetable fibers. The investigation of other dyes of the same class is being pursued successfully and these will shortly be available to the dyeing industry.—M.

WATER-PROOF GOODS FOR SOUTH AMERICA

Fully 70 per cent of the water-proof goods imported into Argentina are of British origin, but in some of the other states, such as Chile, Colombia and Venezuela, the last few years have witnessed a not inconsiderable increase of German and French made goods of this description. This market, says the *Times Trade Supplement*, is well worth attention and now that the competition from Germany is, for the moment, out of the way, it seems an opportune time for manufacturers to press their wares. The duty payable on water-proof coats—*ponchos*—large square-shaped sheets of water-proofed material provided with a hole in the centre for the reception of the head, with neck capes, etc., for men and women, is 42 per cent upon an arbitrary value of $6, and one-half of that rate for children's garments. The growth of the import trade has been notable, since in five years it has doubled itself. Thus, in 1909, the number of water-proof articles did not exceed 12,179, worth $70,377; while, by the end of 1913, the total was 24,328 articles valued at $137,313. Of these, the United Kingdom provided 70 per cent, Germany 10 per cent and France 15 per cent. Only the cheapest grades are manufactured locally. Silky materials are not much in demand, as the heavy rains of the country usually penetrate any but the thickest materials. Those with a proportion of wool are sometimes asked for.—M.

JAPANESE GLYCERINE

The British Commercial Attaché at Yokohama reports that the manufacture of glycerine was first commenced in Japan in 1916, when new plants were established by Government subsidies. The output of glycerine from these works is increasing, but is not sufficient for home demands, and refined glycerine is still imported from the United States. One Japanese company produces 70 tons glycerine monthly. The imports of glycerine to Japan in 1916 were 800,830 Kin (1 Kin = $1^1/_3$ lb.), compared with 1,712,912 Kin in 1914 and 1,430,922 Kin in 1913. Until recently Japanese fish oil was used as the basis for the manufacture of glycerine, but, with the expansion of the industry, animal fat from Australia and cocoanut oil from the South Seas are being used. The use of bean oil for this purpose is also under investigation, but the stability of the product for use as a constituent of dynamite has not yet been determined.—M.

WATER-PROOF AND DUST-PROOF FABRICS

The skin which forms on the surface of some oil paints and varnishes is practically air-tight. *Engineering*, 104 (1917), 340, quoting from a German contemporary, says that such a skin, which seems to be water-proof and dust-proof, can be formed on sacks of jute and on bags of cardboard, etc., for the transport of lime, chalk, cement and dextrine as well as for packing greasy and oily materials. The process is described as the Plüss-Stauffer process, but there are no further particulars. It is merely stated that the skin is pressed upon the material, which need not be a texture, by special machinery.—M.

RECOVERY OF PLATINUM METALS FROM CANADIAN NICKEL

The Report of the Royal Ontario Commission on Nickel, issued recently, states that although the presence of gold and silver and of metals of the platinum group in practically all nickeliferous pyrrhotites has long been known, their importance in connection with the Ontario nickel industry is not recognized except by those who recover and sell them. The nickel-copper ores of Sudbury are said to be capable of producing more palladium than the whole of the present world supply together with a large proportion of platinum, iridium and other metals of this group. The quantity of palladium present is much in excess of the platinum, but iridium, rhodium, ruthenium and osmium are also found. Although it is not possible to state exactly the actual quantity of the platinum metals present in the ores, the quantity recovered can be ascertained from the assay of the matte, provided the number of tons of ore smelted per ton of matte is known. In the year ending Dec. 31, 1916, the total ore smelted at Sudbury amounted to 1,521,689 tons with a production of 80,010 tons of matte. One company, which produced 63,567 tons of the total given above, states that the average content of precious metals per ton of matte for the three years ending 1915 was as follows: Gold, 0.050 oz. troy; silver, 1.75 oz. troy; platinum, 0.10 oz. troy; palladium, 0.15 oz. The report also discusses the advisability of utilizing the large quantity of sulfur at present expelled as sulfurous anhydride (SO_2) in roasting, it being estimated at not less than 300,000 tons of sulfur which would produce 1,000,000 tons sulfuric acid.—M.

GUTTA-PERCHA FROM THE SHEA BUTTER TREE

A supplement to the official *Nigeria Gazette* for August publishes a note to the effect that a trade in what is known locally as gutta-percha—a substance prepared from the latex of the Shea butter tree—has sprung up during the last two years in the Province of Bornu. The local price of the product at Nafada is 8 cents per lb. The method of collecting and preparing the product is given as follows: Small pieces of the bark are chipped out of the tree with a narrow native axe. The latex that slowly exudes from these cuts is scraped off as it contains impurities such as dirt, bark, etc. It is then boiled until the impurities float to the top when they are removed. The latex then coagulates and, in this form, is known as gutta-percha. It is not advisable to tap trees of less girth than 30 inches. The Shea butter tree is abundant in many parts of the Northern Provinces, and especially so in Meko, Shaki and Oyo districts of the Southern Provinces and in Ilorin. When collecting this product, the tappers could with advantage collect the Shea nuts and thus help to stimulate the trade in Shea butter.—M.

BRITISH PAPER EXPORTS

Since the war started, the export trade in paper from Britain has been seriously affected. The total quantity exported last year amounted to 2,556,621 cwt., a decline of 198,063 cwt. compared with 1915, 567,685 cwt. compared with 1914, 942,293 cwt. compared with 1913, and 772,840 cwt. compared with 1912. Of the year's total 72.70 per cent represented the shipments to British Possessions, and 27.3 per cent to foreign countries. Taking the figures for 1912, the trade with British Possessions represented 70.7 per cent of the total exports and that with foreign countries 29.3 per cent. Of course, some markets have suffered more than others in regard to reduced supplies, *e. g.*, a substantial shrinkage in shipments to India is shown, while the position of S. Africa and Australia appears to be favorable. France received more paper from Britain last year than in the pre-war period.—M.

LOW-GRADE ORE UTILIZATION

According to a report in *Stahl und Eisen* of July, 1917, we see that the war, the stopping of imports and the rise in prices have forced German metallurgists to make use of raw materials which were considered too poor in peace times. In several cases, sufficient success has been obtained by new methods to justify the working of low-grade ores even in normal times. Thus copper schists were hardly utilized when they contained only 2.5 per cent copper. Now ores of 1 per cent and even 0.7 per cent find utilization. As regards iron and steel, there has not been much change, but poor pyrites and phosphatic ores are no longer rejected. The vanadium for steel is found in sufficient bulk in slags which do not contain more than 0.7 per cent vanadium; the wolframite of old waste heaps is a raw material for tungsten; chrome ore of 24 per cent is welcome—half the percentage formerly deemed worth mining—and sources of nickel are worked if they contain 1.5 per cent of nickel; bauxite of 40 per cent aluminum is considered sufficiently rich. It is also stated that the aluminum can, after all, be got out of clay. There is no change as to arsenic and antimony. Sulfur, no longer obtainable as such, is gained from gypsum and anhydrite and phosphates of 20 per cent are converted into manure.—M.

SWEDISH INDUSTRIAL DEVELOPMENTS

The Helsungborg Copper Works, among other extensions, are about to begin the manufacture of electrolytic copper on a large scale. Detailed plans have been prepared and the work will be proceeded with as fast as the necessary raw materials can be obtained. One of the most important departures is the formation of a large chemical company with plenty of capital and excellent men at its back, in addition to which a large number of chemical engineers have been connected with the undertaking which will boast the largest laboratory in Sweden. The program is a very comprehensive one and is based not only upon home consumption but also to some degree at least upon exports. So far the preliminary labors have principally been confined to dyestuffs of which Sweden formerly imported 1,000 tons from Germany. Benzole is the principal raw material; but this, as well as most of the chemical substances required, can be produced within the country, as is also the case with most of the plants. The work is intended to commence in 1918.—M.

BRITISH BOARD OF TRADE

During the month of October, 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 might be able to give 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:
- Arsenious oxide, pure, snow-white
- Carbonate of lime, granulated
- Carbonate of sodium
- Sulfate of sodium
- Vanadate of lead or mottramite
- Borate of magnesium
- Tartaric acid substitute

Bone pitch (2 tons)
Composition fittings for glass syringes
Composition (with shellac base) for gramophone records
Davy thermometers
Ebony goods, toilet brushes, trays, mirrors
Hair-slides, metal fittings for
Jettoline asphaltum
Lawyers' bodkins and paper piercers
Leather, suede

MACHINERY AND PLANT FOR:
- Guillotine, 30 in. for cutting paper for dice cups
- Handling peat
- Glass grinding
- Producing small wire articles such as paper-clips
- Winding wood-wool cones

Metal book rests
Metal moulds for making small celluloid articles
Needles, bone or wood for mending fish-nets
Novelty charms
Opal glass jars for ointment
Perforators for punching papers for filing
Raphia wax
Scales for razor-hafts of synthetic resin or similar material
Stearine, best white saponified, solid
Studs and links, cheap, gilt carded
Tobacco pipes, cheap briar, plated mounts
Velvet horse leather
Watches, wristlet, cheap, for West Africa

—M.

SCIENTIFIC SOCIETIES

DECENNIAL INDEX PATRONS

In order to print the Decennial Index to *Chemical Abstracts* it became necessary to ask the friends of the American Chemical Society among the chemical corporations to assist in the work of donating $10,000 toward the fund required. This was done after $25,000 had been subscribed by members of the Society and others directly interested in purchasing the publication. The donations were asked for first through the local sections. The Philadelphia Section secured donations in the amount of $1,510.00; the Indiana Section, $50.00; the Pittsburgh Section, $50.00; the Detroit Section, $25.00; and the New York Section, $25.00, from local firms. A general request was then sent from the Secretary's office to the chemical industries of the country, asking for help on this important publication. The response was immediate. The Society desires to acknowledge with thanks the help of its friends listed below:

Alberene Stone Company	$ 10.00
Aluminum Castings Company	50.00
Aluminum Company of America	100.00
American Can Company	150.00
American Cotton Oil Company	50.00
American Glyco Metal Company	25.00
American High Explosives Company	25.00
American Smelting & Refining Company	250.00
American Zinc Lead & Smelting Company	100.00
Anaconda Copper Mining Company	250.00
Arlington Mills	100.00
Atlantic Refining Company	50.00
Ault & Wiborg Company	100.00
Badger & Sons, E. B	100.00
Baker & Company, Incorporated	100.00
Barrett Company, The	250.00
Bausch & Lomb Optical Company	100.00
Berlin Mills Company	100.00
Buffalo Foundry & Machine Company	100.00
Butterworth Judson Corporation	50.00
Castner Electrolytic Alkali Company	25.00
Celluloid Zapon Company	25.00
Columbia Chemical Company	25.00
Commonwealth Edison Company	100.00
Detroit Testing Laboratory	10.00
Devine Company, J. P	100.00
Digestive Ferments Company	5.00
Dow Chemical Company	50.00
Du Pont de Nemours Company, E. I	1,000.00
Duriron Castings Company	25.00
Eastern Manufacturing Company	100.00
Eastman Kodak Company	50.00
Edison, Thos. A., Inc	100.00
Eimer & Amend	100.00
Elyria Enameled Products Company	50.00
Fels & Company	25.00
Fisk Rubber Company	100.00
General Bakelite Company	100.00
General Chemical Company	500.00
General Electric Company	250.00
Grasselli Chemical Company	50.00
Harshaw Fuller-Goodwin Company	100.00
Heinz Company, H. J	100.00
Heyden Chemical Works	250.00
Hurlburt, E. B	25.00
Interocean Oil Company	25.00
Jeffery-Dewitt Company	25.00
Knight, Maurice A	100.00
Lennig Company, Charles	25.00
Lilly & Company, Eli	50.00
Lindsay Light Company	100.00
Mallinckrodt Chemical Works	50.00
Marden, Orth & Hastings	25.00
Mathieson Alkali Works	250.00
McElwain Company, W. H	100.00
Merck & Company	250.00
Monsanto Chemical Works	50.00
Morgan & Wright	25.00
National Aniline & Chemical Company	200.00
National Carbon Company	70.00
National Lamp Works of the General Electric Company	50.00
National Lead Company	100.00
Niagara Alkali Company	50.00
Norton Company	100.00
Oakland Chemical Company	50.00
Pacific Coast Borax Company	100.00
Pennsylvania Rubber Company	50.00
Pennsylvania Salt Company	100.00
Pfaudler Company	25.00
Philadelphia Quartz Company	15.00
Pittsburgh Plate Glass Company	100.00
Powers-Weightman-Rosengarten Company	50.00
Primos Chemical Company	25.00
Procter & Gamble Company, The	250.00
Raymond Bros. Impact Pulverizer Company	25.00
Republic Chemical Company, Inc	25.00
Roessler & Hasslacher Chemical Company	100.00
Rohm & Haas	25.00
Rome Soap Manufacturing Company	25.00
Rosenwald, Julius	100.00
Sargent & Company, E. H	100.00
Schaar & Company	10.00
Schoellkopf, J. F	200.00
Scoville Manufacturing Company	100.00
Sellner, Albert	5.00
Smith, Kline & French Company	20.00
Sowers Manufacturing Company	25.00
Sprague, Warner & Company	25.00
Squibb & Sons, E. R	50.00
Standard Oil Company of New Jersey	250.00
Swenson Evaporator Company	25.00
Textor, Oscar	5.00
Thomas, Arthur H., Company	100.00
Thorkildsen Mather Company	100.00
Toch Brothers	25.00
Union Oil Company of California	100.00
Union Sulfur Company	100.00
United Engineering & Foundry Company	25.00
United States Smelting & Refining Company	100.00
Victor Talking Machine Company	100.00
Virginia-Carolina Chemical Company	100.00
Washington Steel & Ordnance Company	100.00
Weston, Edward	100.00
Whitall Tatum Company	100.00
Anonymous	100.00

TENTH ANNUAL MEETING
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS
ST. LOUIS, MO., DECEMBER 5-8, 1917

The tenth annual meeting of the American Institute of Chemical Engineers was called to order at Hotel Statler, St. Louis, at 9.45 A.M., by President G. W. Thompson. As the local section of the American Chemical Society participated in the meeting, the Chairman of the Section, Mr. A. C. Boylston, assisted President Thompson in conducting this and other sessions of the meeting.

The address of welcome was delivered by Mr. Wm. T. Findly, representing Hon. Henry W. Kiel, Mayor of St. Louis. President Thompson responded to the address of welcome.

The ballots for officers were canvassed by a committee consisting of F. E. Dodge, R. S. Bicknell and S. F. Grove. The following officers were elected: G. W. Thompson, *President*, J. C. Olsen, *Secretary*, F. W. Frerichs, *Treasurer*, M. Toch, *Auditor*, and A. W. Smith, T. B. Wagner, D. Wesson, *Directors*.

The Council reported the appointment of a committee to consider the advisability of appointing a representative of the Institute on the joint committee of the Engineering Societies in coöperation with the United States Government in its war activities. The committee consists of: G. W. Thompson, *Chairman*, Chas. F. McKenna, M. H. Ittner, J. C. Olsen.

The Council has also authorized the purchase of $750.00 of Bonds of the second U. S. Liberty Loan.

The membership of the Institute at present is 283, consisting of 1 honorary member, 241 active and 41 junior members. The membership during the past six months has been increased by 12 active and 3 junior members. During the past year the increase has been 28 active and 5 junior members, making a net increase of 33 members, which is a larger increase than during any previous year.

The Secretary reported that six members had received commissions in the United States Government service as follows:

Edward Bartow, Major in Sanitary Corps in National Army.
Hardee Chambliss, Major, Ordnance Sec., Officers' Reserve Corps.
A. R. Chandler, Captain, Ordnance Dept., U. S. R., Rock Island Arsenal, Rock Island, Ill.
A. S. Cushman, Major, Ordnance Dept., U. S. R., Frankford Arsenal.
R. M. Gage, First Lieutenant, Sanitary Corps, U. S. Army.
A. H. White, Captain, Ordnance Dept., U. S. R.

The Treasurer reported a balance on hand of $1616.00.

The Committee on Meetings reported the following localities under consideration for the summer meeting to be held the latter part of June: Chicago, Ill., Syracuse, N. Y., Providence, R. I., and Newark, N. J. After some discussion the matter was referred to the Council for decision.

The first paper on the program was "The Relation between Efficiency of Refrigerating Plants and the Purity of Their Ammonia Charge," by Dr. F. W. Frerichs of St. Louis. In a preliminary statement Dr. Frerichs stated that a large amount of ammonium nitrate is required for the manufacture of explosives and that most of the ammonia obtained from the by-product coke-oven plants is in the form of ammonium sulfate.

There is only one plant in the United States, *viz.*, that of Herf and Frerichs in St. Louis in which aqua ammonia can be made from ammonium sulfate, and this plant is engaged in producing liquid ammonia for the refrigerating industry. Upon request of the Food Administration of the United States, the capacity of this plant is being increased 50 per cent in order to secure an ample supply of liquid ammonia for the cold-storage warehouses and the ice plants so as to conserve the food supply.

In order to obtain an adequate supply of aqua ammonia for the manufacture of ammonium nitrate, in the manufacture of explosives, Dr. Frerichs has been requested by the United States Government to erect eight new plants, the size of the St. Louis plant, at various points. Dr. Frerichs has generously offered the Government complete plans and specifications and the use of his patents for the duration of the war, the plants to be dismantled at the close of the war. In the paper presented, the results of tests made by the Bureau of Standards were given which showed that the ammonia made by Dr. Frerichs contained only one-thousandth of one per cent of organic impurities and that other samples of commercial liquid ammonia contained as high as 450 thousandths of one per cent of such impurities. Impurities of this kind produce permanent gases in ice machines which greatly reduce the efficiency of the process. This was shown in a practical test with two identical ice machines. With pure ammonia 57 tons of ice were made while with impure ammonia only 42–44 tons were made daily. During the entire test period 16,862 tons of ice were made in the first machine, while only 11,308 tons were made in the second. A very much greater amount of the impure ammonia was required so that the cost of ammonia per ton of ice using pure ammonia was only 1.27 cents per ton while the cost was 15.16 cents with impure ammonia. The coal consumption was one ton for eight tons of ice with pure ammonia, and only $5^1/_2$ tons of ice per ton of coal with impure ammonia.

Serious leaks due to corrosion were observed in the machine using impure ammonia, while there was no trouble of this kind in the machine using pure ammonia.

A paper by Wm. M. Booth of Syracuse, N. Y., on "Distilled Water" was then read. The author presented the results of many analyses of distilled water, rain and snow water, and also the requirements for purity in various industries. This was supplemented by a large number of letters from users and producers of distilled water. Various types of apparatus for the production of distilled water were then presented.

Wednesday afternoon members of the Institute and St. Louis Section of the American Chemical Society went by automobile to the very large ice plant of the Anheuser-Busch Brewing Association. This plant has a capacity of 1200 tons of ice per day and is the largest plant of its kind in the world.

The party then proceeded to the plant of the Herf and Frerichs Chemical Works. Construction work was here going on both on the extension of the ammonium sulfate plant and on a new plant designed to use ammonia liquors from gas works. Large circular reinforced concrete tanks were being constructed for the storage of ammonia gas liquors. To prevent leakage these tanks were placed within a larger rectangular concrete tank which is kept full of water.

The liquid anhydrous ammonia was being produced from ammonium sulfate. This salt is treated with lime and the gaseous ammonia absorbed in water. From this it is distilled, dried by lime and compressed to 250 lbs. The gas is washed by means of liquid ammonia, then cooled and charged into steel cylinders. The purity of the liquid ammonia is assured by testing a sample drawn from each cylinder.

The party then visited the By-Product Coking Plant of the Laclede Gas Light Company. The rich portion of the gas from the coke ovens is sold as illuminating gas, while the leaner portion is used for heating the by-product coke ovens. The illuminating gas for St. Louis is sold on the B. t. u. standard of 650 per 1000 cu. ft.

The gas is first cooled which removes the tar and about one-fifth of the ammonia, the remainder being absorbed in dilute sulfuric acid. The gas is then passed through a tower containing paraffine oil which removes the benzene and toluene. The light oil is distilled out of the paraffine oil which is used again for scrubbing the gas.

The party was very much interested in inspecting the stills in which the light oil is fractionated to separate the benzene from the toluene.

On Wednesday evening the members of the Institute and of the local section of the American Chemical Society took dinner at the St. Louis Club as the guests of Dr. F. W. Frerichs. The very handsome club house was much admired. The dinner was held in the spacious dining-room on the second floor, which was beautifully decorated with flags. Covers were spread for about eighty. After dinner, Dr. Frerichs gave a cordial welcome to his guests in a few well-chosen remarks. President Thompson and Mr. A. C. Boylston, chairman of the local section of the American Chemical Society, responded.

President Thompson then delivered an address on "Our Resources." Attention was called to not only the natural products in which the United States abounds but also to deficiencies, and suggestions were made as to measures which should be taken to render the United States independent of foreign sources of supply. The achievements of the American chemists during the war period were especially emphasized with reference to platinum supplies. President Thompson suggested that there were large quantities of platinum in the form of jewelry which should be made available for the war needs of our country.

The Secretary, Dr. J. C. Olsen, expressed the appreciation of the members of the Institute and of the American Chemical Society for the very delightful dinner which had been provided by Dr. Frerichs, affording such an opportunity for making the acquaintance of the local chemists; of Dr. Frerichs' courtesy in showing his ammonia plant, at which the purest ammonia made in the United States is manufactured; and of the patriotism of Dr. Frerichs, who, although born and educated in Germany, offered his services so freely to the Government. Vigorous applause indicated hearty endorsement of the sentiments expressed.

Mr. O. F. Soule, of the Merrill-Soule Co. of Syracuse, then explained briefly the process of evaporating milk by atomizing it under high pressure into a chamber, through which a current of warm air was passing. The entire process was illustrated by moving pictures. Samples were shown of evaporated skimmed milk, and also evaporated cream containing 74 per cent of butter fat. The remainder of the evening was spent in getting acquainted, the occasion being voted by all as a highly enjoyable one.

Thursday morning the party proceeded by automobile from Hotel Statler to the City Water Works. Mr. E. E. Wall, water commissioner of the City of St. Louis, explained the history of the development of water purification in St. Louis and gave an outline of the process employed for purifying water. This consists of pumping the water through a grit chamber where about 25 per cent of the solids, consisting mainly of sand, settles out. The water is then treated with lime which reduces the hardness from over 300 to slightly over 100 parts per million.

Sulfate of iron is then added which produces flocks of hydrate of iron which remove the finely suspended impurities. A charge of aluminum sulfate is also given to remove coloring matter. The water is then pumped into large settling basins where most of the sludge settles out. The remainder of the suspended matter is removed by filtering through sand filters, after which the water is treated with liquid chlorine to remove the remainder of the bacteria.

The party then inspected the plant. The washing of one of the sand filters was watched with the greatest of interest. The automatic devices for adding the lime, ferrous sulfate and aluminum sulfate were carefully examined. The lime is added as milk of lime, the ferrous sulfate automatically fed in powdered form, while the aluminum sulfate is added as a solution of standard strength. The excellent condition of the entire plant and its simple operation were greatly admired.

The party was then taken to the Riverside Club where luncheon was served in the spacious and beautifully decorated dancing pavilion of the Club.

After luncheon the party drove to Granite City where the plant of the National Enameling & Stamping Company was visited. Here the production of the enamel, grinding and dipping of the enamel ware were shown, as well as the furnaces in which the material is baked. The stamping machines were also inspected with great interest, as well as the electric welding of handles and other parts of the enamel ware.

On Thursday evening, a joint meeting with the local section was held at Hotel Statler. A paper by Gaston Du Bois of the local section on "Engineering and Chemical Works" was first read. Dr. Du Bois called attention to the deficiency of many chemists in knowledge of engineering problems met with in the construction or operation of chemical works, and pointed out the deficiency of the preparatory education of many chemists in this respect. A very lively discussion followed the paper as to the amount of chemical engineering training which should be given in the schools and the amount which could only be learned by experience in the chemical industry.

A paper on "Organization of Chemical Companies" was read by Mr. Frank Hemingway. The author showed that the lack of coöperation between the business interests and the technical staff of corporations lead to lack of efficiency and in many cases to failure of companies which otherwise had every prospect for success.

On Friday morning the members and their guests left the Hotel Statler by automobile for the plant of the Commercial Acid Company. At this plant the sulfuric acid chambers were inspected. Louisiana sulfur was used as the raw material. The capacity of the chamber plant was 240 tons of 66 Bé. acid. The nitric acid plant was then inspected, special interest being shown in the horizontal cast iron retorts and in the sewer pipe condensers. The manufacture of hydrochloric acid was then shown, shallow iron pans being used for the salt and acid. The phenol plant was also inspected. In this plant benzene is treated with sulfuric acid. The resulting product is neutralized with lime and sodium carbonate and is then added to fused caustic soda. After neutralization, the phenol is distilled off into iron drums.

Some of the members then visited the plant of the Laclede Christy Fire Clay Company.

During the forenoon, three papers were read on the general subject of Evaporation and Drying. Mr. Hugh K. Moore, of Berlin Mills, N. H., read the first paper on "Some General Aspects of Evaporation and Drying." Mr. Moore gave an outline of all methods of evaporation and drying which are possible or available, and he gave the conditions under which each method could be used to advantage. He discussed at greater length heat conductivity phenomena in evaporator tubes and more particularly forward and backward flow in multiple effect evaporation, and showed the great advantages to be derived from backward flow operation. This phase of his paper was discussed at considerable length.

Mr. F. M. deBeers read the paper on "Some Problems in Evaporation and Drying" presented by Mr. P. B. Sadtler and F. M. deBeers. Mr. deBeers presented the practical difficulties which are met with in designing evaporators and especially methods of overcoming such difficulties when very viscous liquids must be evaporated.

Mr. H. McCormack, of Chicago, read a paper on "Evaporation and Drying of Tannin Extracts by the Carden Process." In this process the tannin extract is atomized and the spray evaporated by a stream of warm air. The product produced is superior in every respect to the extract produced by other methods of evaporation.

Friday evening the subscription dinner was held at Hotel Statler. The attendance of sixty-three was about equally divided between members of the Institute and of the American Chemical Society. Music was furnished by Mr. F. W. Saltan, violinist and Miss Elsa Diemer soloist accompanied by Miss Mina Neaman.

President Thompson acted as toastmaster and presented Alex. S. Landsdorf, Professor of Electrical Engineering and Dean of the School of Engineering of Washington University. Professor Landsdorf described the work carried on by the University and exhibited a considerable number of lantern slides showing the buildings, grounds and laboratories of the University.

Dr. B. M. Duggar of Shaws Garden explained the founding of this remarkable botanical collection, and the work which is being done at present at the Garden.

Secretary Olsen gave a toast to the ladies, and pointed out that the attendance of the ladies at this meeting was the largest in the history of the organization and that much of the pleasure at the meeting was due to their presence.

Dr. Chas. E. Caspari, of the St. Louis College of Pharmacy, was introduced as the recently elected Chairman of the local section of the American Chemical Society, and spoke of the work being carried on by this section, and also of his high opinion of the influence of the American Institute of Chemical Engineers on the chemical profession.

On Saturday, the plant of the National Lead Company at Collinsville, Mo., was visited, the mechanical furnace being of special interest to those who made the trip.

A special program had been arranged by the local Ladies' Committee under the chairmanship of Mrs. A. A. L. Veillon for the entertainment of the visiting ladies. This program included on Wednesday a luncheon with members of the Institute at Hotel Statler; a sight-seeing trip of St. Louis by automobile; a dinner at the Hotel in the evening, followed by a theatre party. On Thursday the ladies accompanied the men during the visit and inspection of the City Water Works as well as at the complimentary luncheon at the Riverside Club. During the afternoon the ladies were entertained at tea by Mrs. Queeny at her residence, 3453 Hawthorne Boulevard. On Thursday evening the ladies attended a theatre party at the Jefferson Theatre. On Friday morning Mrs. Veillon gave a musicale at her residence, 4222 Flora Boulevard. During the afternoon, Shaws Garden was visited, and in the evening the subscription banquet was attended.

Although a considerable number of members could not attend the meeting on account of urgent war duties, the usual number were present at most of the meetings and functions, the attendance ranging from 50 to 100.

The St. Louis members proved to be very royal hosts, and the members of the Institute were interested to find so many important chemical industries in this locality.

COOPER UNION
December 15, 1917

J. C. OLSEN, *Secretary*

AMERICAN CHEMICAL SOCIETY PIN

Arrangements have been made for obtaining the Society pin at a cheaper price, one of 14 kt. gold of the same quality as the one now used, and one in rolled-gold which will have the same appearance, but will be cheaper. The pin will have a safety catch and will be of such length that the wearers will not be subject to being scratched. Members will please note the following:

1—The pins are ready for delivery.
2—The solid 14 kt. pin will be carried in stock at $3.00, plus 3 per cent war tax—totol, $3.09.
3—The rolled-gold pin will be carried in stock at $1.00, plus 3 per cent war tax—total, $1.03.
4—To obtain pins members must be in good standing and obtain an order from the Secretary of the Society, to whom no money should be sent.
5—Orders obtained from the Secretary should be sent or delivered to the C. G. Braxmar Company, 10 Maiden Lane, New York City, together with cash, check or money order in payment of the pin, whereupon the pin will be delivered post-free.

The pin adopted by the Society is an unusually attractive emblem, and the Society's colors, cobalt-blue and gold, are now being worn by many of our members. It serves as a means of introduction and will frequently enable you to meet fellow chemists whom you might not otherwise know are in the same profession. It is important that the members of the American Chemical Society wear this insignia as regularly as the members of the engineering societies display their distinguishing emblem. Show that you are proud of your Society and its work. Write to the Secretary for an order. CHAS. L. PARSONS, *Secretary*

THE NICHOLS MEDAL AWARD

The Nichols Medal for 1917 will be conferred on Dr. Treat B. Johnson of the Sheffield Scientific School of Yale University.

The Medal, founded by Dr. William H. Nichols in 1902, is awarded annually by the New York Section of the American Chemical Society on the merit of the original communications published in the journals of the Society.

The formal presentation to Dr. Johnson will be made on March 8, 1918, in Rumford Hall, Chemists' Club, New York City.

THE PERKIN MEDAL AWARD

The Perkin Medal for 1918 has been awarded to Dr. Auguste J. Rossi, Ph.D., of Niagara Falls, N. Y., for his work on titanium.

The Medal will be presented by Dr. W. H. Nichols at the regular meeting of the New York Section of the Society of Chemical Industry to be held at the Chemists' Club, January 18, 1918. Mr. F. A. J. FitzGerald, past-president of the American Electrochemical Society, will deliver an address on Dr. Rossi and his work. Owing to illness, Dr. C. F. Chandler will not be able to participate in the program.

WASHINGTON LETTER

By PAUL WOOTON, Metropolitan Bank Building, Washington, D. C.

Centralization of activities pertaining to chemicals, the lack of which has been so glaringly apparent for many months, is now being accomplished by the formation of a chemical section of the Raw Materials Division of the War Industries Board. This board, which consists of L. L. Summers, M. F. Chase, C. H. MacDowell and M. T. Bogert, is acting as a clearing house for all matters of chemical interest related to the war. This applies to the purchases of the allied governments as well as to domestic matters having a bearing on chemical supplies.

The chemical specialists attached to the War Industries Board are making no effort to occupy the anomalous position of representing the government and the industry at the same time. That such a plan is not feasible was shown in the collapse of the coöperative committee section of the Council of National Defense. Out of this experience, however, has grown the plan for war service committees representing each industry. These committees will form the point of contact with the government and will be representative of nearly 100 separate industries. The war service committees now are being formed through the medium of the Chamber of Commerce of the United States. Every effort is being made to complete their organization, as the War Industries Board now is working at a considerable disadvantage through the lack of a unit organized to act for an industry.

The formation of a chemical section of the War Industries Board will in no way effect the research activities of the National Research Council. Dr. Bogert continues at the head of its Committee on Chemistry and will divide his time between his duties with that committee and with the War Industries Board. Mr. MacDowell severed his connection with Armour and Company, where he was in charge of fertilizers and other by-products, to aid the government. Mr. MacDowell refers to himself as a "layman" chemist. For many years he has specialized in potash. He was closely in touch with the development of the alunite deposits at Marysvale, Utah. Prior to the war, he made a careful study of the German potash deposits.

Organizations of various industries interested in commodities which require import licenses have been called upon by the War Trade Board to select committees to coöperate with it in securing an equitable distribution of certain imported commodities. These committees are given no authority in the granting or refusing of import licenses or in determining who shall import the commodities requiring licenses. The representatives of the industry are to act as consignees and will release commodities as instructed by the War Trade Board. The committee is to obtain from importers such guarantees and agreements as the War Trade Board may require. Each committee will keep itself informed as to the use and disposition of the imports and will keep full records of all the shipments received. A few of these committees have been announced already, but the majority of them are still to be selected. Two of the most important committees will be those which will coöperate with the War Trade Board in the importation of manganese ores and iron pyrites. Other imports of chemical interest which require license are antimony, asbestos, chrome, cobalt, all ferro-alloys, iridium, molybdenum, emery, sodium, potassium and calcium nitrates, platinum, scheelite, titanium, tungsten and vanadium.

Exports of sulfuric acid during 1917 will not fall as far behind those of 1916 as had been anticipated earlier in the year. An increase of more than 1,000,000 lbs. took place in the exports of October. November figures are not available but even a more substantial gain is known to have taken place during that month. According to the Department of Commerce, there were exported in October 4,492,200 lbs. of sulfuric acid, as compared with 3,466,818 lbs. in October of 1916. During the first ten months of 1917, 53,487,786 lbs. of sulfuric acid were sent out of the country. This compares with 57,386,036 lbs. for the first ten months of 1916. That such a good showing is being made this year with the tremendous increase of domestic requirements is a source of much favorable comment among chemists here.

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Dr. C. L. Parsons, chief chemist of the Bureau of Mines, called together the chemical advisory committee of that bureau on December 17th and went carefully over the war work under his direction. Dr. Parsons, owing to the increased amount of war work being done by the Bureau of Mines, has been forced to turn over to others the direction of the work being done on other chemical matters. Dr. Parsons has submitted his report on the method used in the oxidation of ammonia which was developed at the Semet-Solvay plant at Syracuse, N. Y. This work was done under a coöperative agreement between the Semet-Solvay Company and the Bureau of Mines.

An important and timely report on the sulfuric acid situation has been prepared by A. E. Wells, of the Bureau of Mines staff. Mr. Wells is working in close coöperation with Dr. Parsons and M. F. Chase, of the War Industries Board, in his survey of the sulfuric acid situation.

Important developments in the manganese and pyrite situations, which will have a bearing on all imported minerals, are expected within the very near future. The point has been reached where unusual steps must be taken to stimulate domestic produc-

tion of manganese, pyrite and other products. Precedents will be broken, in all probability, in the legislation which will be proposed to provide means to secure increased domestic production, so as to save shipping.

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Changes which will alter permanently conditions of international competition in the chemical industries and which will have a direct bearing on the volume of foreign trade in chemicals are to be the subjects of a special investigation just begun by the United States Tariff Commission. The developments that have taken place in the chemical industries since the passage of the tariff act in 1913 are to be studied closely. The scope of the inquiry is set forth by the Tariff Commission as follows:

1—The manufacture within the United States of articles formerly unavailable or obtained exclusively by importation; for example, phosgene.

2—In the case of industries previously established in the United States, the erection of new plants or increase in capacity of existing plants; for example, the increase in capacity of existing plants for making caustic soda and chlorine and the installation of such plants at textile and paper mills.

3—The future of industries or establishments newly created, or in which productive capacity has been greatly increased to meet a direct war demand. How can these plants be utilized when the war demand disappears? For example, the acetone industry.

4—Any general or significant differences in the prevailing method of manufacture in the United States and abroad, such as the relatively small use of the carbureted water-gas process in England compared to its use in the United States.

5—Differences in the organization of the industry in the United States and abroad.

6—The development or invention in the United States or abroad of new or improved processes which are likely to influence the conditions of international competition; for example, the hydrogenation of fatty oils or the flotation process for concentrating ores.

7—Significant changes in the conditions of international competition caused by the recent law-making patents owned by citizens of enemy countries available to American manufacturers; for example, the patents on salvarsan.

8—Industries which have been seriously hampered in their normal operations or in their development by difficulty in securing materials or supplies formerly imported; for example, the lack of potash for fertilizer or glass. If these difficulties have been met by the introduction of substitutes, is it expected that there will be a return to the old materials and methods when foreign supplies again become available, or will the changes be permanent?

9—Developments or changes in other industries which have created a new or greatly increased demand for chemical products; for example, the manufacture of new varieties of glass in the United States.

10—The discovery of new uses of materials, creating a new demand or furnishing a market for materials formerly wasted; for example, the use of aniline as an accelerator in the vulcanization of rubber.

11—Any governmental hindrances in the United States or abroad, either in manufacture or commerce; such as the export duty on nitrate from Chile.

The Commission will publish only general statements or summaries, which will not reveal the operation or plans of individual companies.

The Tariff Commission is preparing for a systematic census of the production of the following coal-tar products: intermediates, dyes, medicinals, flavors, photographic chemicals and synthetic phenolic resins.

Issuance of licenses for the manufacture and sale of salvarsan has been begun by the Federal Trade Commission. It is expected that the price per dose will be lowered to $1.50, as a result of this action.

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Without the necessity of roll call, the House of Representatives on December 15th passed a joint resolution "for the purpose of promoting efficiency, for the utilization of the resources and industries of the United States, for lessening the expenses of the war, and restoring the loss caused by the war by providing for the employment of a discovery or invention called the 'Garabed,' claiming to make possible the utilization of free energy." It required a special rule to get the matter before the House but the Committee on Rules promptly supplied this deficiency. Practically the entire day was taken up in the discussion of cosmic forces and other matters related to the device of Garabed T. K. Giragossian, interspersed with parliamentary wrangles and squabbles over amendments. Despite the fact that Mr. Giragossian refused to show his device or its operation to any member of the Committee on Patents or to any committee that would be appointed by the House, most of the members of that body were dissuaded from voting against the resolution by the idea expressed in this question put by Representative Garrett: "Why is it that gentlemen so much fear to ascertain whether we really have some new blessing for mankind?"

PERSONAL NOTES

Mr. R. S. Banks, instructor in analytical chemistry at Iowa State College, has been appointed a member of the Inspecting Department of the Picatinny Arsenal, Dover, New Jersey.

Mr. L. A. Rumsey, former instructor in organic chemistry at Iowa State College, has been appointed head of the department of chemistry at Denison University, Granville, Ohio.

Mr. A. J. Wuertz, former research chemist of the Experiment Station of the agricultural and biological department of the University of Minnesota, is at present instructor in organic chemistry at Iowa State College.

Mr. William H. Kerr, assistant treasurer of the General Chemical Company, and manager of the Philadelphia offices of the company, has been elected a director to succeed Mr. Edward H. Rising, deceased.

Mr. Frederick Pope, of Moses, Pope and Messer, Inc., consulting engineers of New York, has been commissioned a captain in the Engineer Officers' Reserve Corps, Gas and Flame Division (Thirtieth Engineers).

Mr. A. Gordon Spencer, formerly chief chemist of the Canadian Inspection and Testing Laboratories of Montreal, has severed his connection with that company and is opening an office at 617 Transportation Building, Montreal, Canada, as a consulting chemist and metallurgist.

The United States Bureau of Mines has broadened the scope of its station at Urbana, Ill., to include work in coal and metal mining and the metallurgical industries of the Middle West. The present safety work will be continued and all work will be conducted under a coöperative agreement with the mining department of the University of Illinois. The Bureau staff is under the superintendence of E. A. Holbrook, supervising mining engineer and metallurgist. Other members are W. B. Plank, in charge of mine safety, and F. K. Ovitz, chemist.

Mr. Lester Yoder has been appointed as assistant chemist for the chemical section of the Agricultural Experiment Station at Iowa State College.

Mr. H. B. Underwood has severed his connection with the Buffalo Foundry and Machine Company and has identified himself with the Hewitt Rubber Company, Buffalo, N. Y.

Rensselaer Polytechnic Institute, in March, 1918, will start work on extensive additions to be made to the laboratories of the department of chemistry. Entirely new and complete laboratories will be constructed for quantitative analysis, organic chemistry, and physical chemistry. The food analysis and gas analysis laboratories will be materially enlarged, and new space will be assigned for lecture and recitation rooms. The great increase in the number of students entering for the course of chemical engineering has made these changes imperative.

Dr. J. Stieglitz has appointed the following Committee on the supply of organic chemicals for research during the war: E. Emmet Reid, *Chairman*, Roger Adams, H. L. Fisher, J. W. E. Glattfeld, W. J. Hale.

Mr. James H. Ellis, research associate in physical chemistry at Throop College of Technology, Pasadena, Cal., has become a member of the physics department of the college as instructor in electrical measurements.

Mr. Howard B. Bishop has severed his connection with the General Chemical Co., at Easton, to accept a position with the National Aniline and Chemical Co.

Mr. C. A. Mace has been appointed head of the textile department of Marden, Orth and Hastings Corporation, succeeding Mr. H. Gardner McKerrow. Mr. Mace has been for eight years with the Badische organization at the head of their Chicago offices. He is a graduate of the Massachusetts Institute of Technology.

Mr. R. J. Quinn has left the Wahl-Henius Institute and accepted a position with the Midland Chemical Company.

Dr. J. W. Turrentine is directing the work of the Government's experimental kelp-potash plant at Summerland, near Santa Barbara, Cal. The plant is in operation and is producing crude potash. Apparatus is now being installed which will make possible the production of refined potash and by-products, particularly iodine, for both of which chemicals there is a large demand for industrial and military purposes.

Professor Charles H. LaWall of the Philadelphia Section has been elected president of the American Pharmaceutical Association.

Major S. J. M. Auld, of the British Army, addressed the Northeastern Section of the A. C. S., at Boston, on December 8, on "Gas Warfare."

The United States Civil Service Commission announces an open competitive examination for junior chemist, for both men and women. Until further notice, applications will be received at any time. Salaries range from $1020 to $1800. There is special need of eligibles who are qualified as physical, biological or metallurgical chemists. The Commission also announces an examination for assistant petroleum chemist, for men only, to be held on January 15. Salaries range from $1680 to $1920. For further information apply for Form 1312, Civil Service Commission, Washington, D. C., stating the title of the examination desired.

Mr. Guy R. McDole, Assistant in Soils, in the University of Minnesota, and formerly Research Assistant in Agricultural Chemistry in the University of Nebraska, has enlisted in the Gas and Flame Regiment (Thirtieth Engineers).

Mr. H. Gardner McKerrow, for the last two years associated with the Marden, Orth and Hastings Corporation in the establishment and management of their textile department, is now connected with E. F. Drew and Co., Inc., 50 Broad Street, New York City. Mr. McKerrow will have the management of the textile department, and it is proposed to go into dyestuffs as well as the mill chemicals and industrial oils. Special attention will be given to American dyestuffs. Through the efforts of Mr. McKerrow and others a convention will be held in New York City, January 22 and 23 at the Chemists' Club, at which it is hoped all the manufacturers of American dyestuffs will be represented, for the consideration of a proper means of standardizing American colors. Mr. McKerrow will have associated with him, Mr. T. F. O'Keefe.

Mr. Carl F. Speh, secretary of the Turpentine and Rosin Producers Association, has been appointed on the sub-committee of the National Paint, Oil and Varnish Association to look after legislative matters of interest to naval stores, producers and manufacturers, and distributors of paints, oils and varnish.

Mr. Charles H. McDowel, president of the Armour Fertilizer Company of Chicago, has been called by the government to aid in chemical research work and development.

Dr. R. K. Strong, of the University of Chicago, has been engaged as professor of industrial chemistry at the Oregon Agricultural College.

Twenty-five members of the Southern California Section of the A. C. S. accepted the invitation to the Technical Societies of Los Angeles to inspect the wonderful one hundred inch reflector of the Mount Wilson Solar Observatory, on November 24 and 25. This was the first occasion in its history where the rigid schedule of the Observatory was broken for any reason.

The Michigan Smelting & Refining Co., announces that Charles T. Bragg takes the position of Works Manager of its Detroit plant, January 1, 1918. Mr. Bragg had been Chemical Engineer of The Ohio Brass Co. for six years and was for over four years Technical Director of Berry Bros. of Detroit.

Canada recently appointed Sir Henry Drayton royal commissioner to investigate exportation of Canadian Niagara power and controller of the distribution and production of electrical energy in Ontario.

The University of Illinois will give a Short Course in Ceramic Engineering January 7–19, 1917. The Course will be under the direction of Professor E. W. Washburn, Head of the Department of Ceramic Engineering, and Mr. A. V. Bleininger, Ceramic Chemist of the National Bureau of Standards, assisted by Professors C. W. Parmelee and R. K. Hursh, of Illinois, and a corps of lecturers on special topics. The two-weeks' course is intended to cover in an elementary and practical manner the scientific principles underlying the practice of clay-working. A common school education will suffice for the work of the course and no tuition fees will be charged. The course is open to all who are interested.

Prof. John Charles Clark, of James Millikin University, has been elected to the presidency of the Illinois Academy of Science.

The 276th meeting of the Washington Section of the A. C. S. was held on December 13 at the Cosmos Club. Mr. Atherton Seidell spoke on "Utilization of the Adsorptive Power of Fuller's Earth for Chemical Separations" and Mr. Oswald Schreiner spoke on "Potash Situation in Relation to Food Crops." A special meeting was held at the same place on December 18, at which time Prof. Wilder D. Bancroft of Cornell University spoke on the subject of "Contact Catalysis."

Mr. L. M. Larsen has accepted a position in the research laboratory of Ault and Wiborg of Cincinnati.

On Saturday, December 8, Professor Grignard and Lieut. Engel of the visiting French Commission gave addresses before the Robert Kennedy Duncan Club of the Mellon Institute of Industrial Research at Pittsburgh. Professor Grignard was made the first honorary member of the club. The two distinguished guests were entertained at the University Club at luncheon. After luncheon, Prof. Grignard gave a short informal address in French which was translated in substance by Lieut. Engel.

The 101st regular meeting of the California Section of the A. C. S. was held on December 15, in San Francisco, in conjunction with the annual banquet. Among the after-dinner speakers were Prof. Edmund O'Neill of the University of California, Prof. John M. Stillman of Stanford University, and Dr. Harry East Miller of the International Precipitation Company.

INDUSTRIAL NOTES

To help out in the use of sugar, Italian scientists have developed a process for obtaining a large yield of sugar resembling honey from grapes. This product is very suitable for preserving fruits and marmalades and for use in soda fountain syrups. If this industry attains any magnitude it will affect the trade in half refined tartar which is obtained from grapes, which will in its turn affect the woolen dyers who use this substance as one of the ingredients in the production of olive drab.

The Ideal Laboratories Company has been incorporated under the laws of Delaware with a capital stock of $2,000,000. Incorporators, T. W. Cole, Chicago, Ill.; K. S. Wilson and Marion Luce of Oak Park, Ill.

A shipment of platinum received December 12 at a Pacific Coast port from Russia was the cause of much satisfaction to Government officials. The shipment weighed 21,000 ounces and was valued at more than $2,000,000 It was consigned to the Secretary of Commerce who will supervise its distribution. Because of the internal conditions in Russia it is feared that the shipment will be the last exported from that country for some time to come.

Announcement has been made that the Consolidated Gas Company of New York has reached an agreement with Washington officials to manufacture toluol to help meet the shortage which exists in this war essential. The Government is to pay for the erection of the stills at the Company's plants and the Consolidated Gas Company is to furnish the labor for the actual manufacture of the toluol from its gas. The product is to be furnished the government at the actual cost of its manufacture. It is understood that contracts have already been let for the erection of some of the stills and that work has already been started at the Company's plant in Long Island City.

We learn from the *General Chemical Bulletin* that the discovery of platinum in Alaska has led the Government to assign experts to study the situation there and report whether the discoveries can replenish the platinum supply cut off by the cessation of activity in the Ural Mountain mines.

The T. N. T. plant of the Aetna Chemical Company at Heidelberg, a suburb of Pittsburgh, Pa., was damaged to the extent of $250,000 by an explosion on December 5, causing the death of eight men and seriously injuring many more.

American sulfur production will be augmented by the development of New Mexico deposits, which are claimed to be of high grade and extensive in quantity. To undertake this development the United Sulfur Development Company has been incorporated with $3,000,000 capital by J. J. and M. de Praslin of Lake Charles, La., and J. B. Bailey of Wilmington, Del.

Perchlorate Explosives Company of Poughkeepsie has been formed with a capital stock of $2,100,000. Incorporators: L. Bedell, C. W. H. Arnold, H. B. Vosburgh, Poughkeepsie.

The Amalgamated Dyestuff and Chemical Works of New York has increased its capital stock from $50,000 to $500,000.

Aluminum, antimony, arsenic, bismuth, magnesium, phosphorus and potassium are all found in the state of Queensland, Australia. Platinum is found but in small quantities.

Wyoming Sulfur and Refining Company, dealers in sulfur and chemical products, has been incorporated under the laws of Delaware with a capital stock of $2,000,000.

Exports of cinchona bark and alkaloids and their salts from the United Kingdom have been prohibited to all destinations, according to a cablegram from the American consulate at London.

Advices received from Havana, Cuba, state that planters in Cuba are turning their attention to the growing of castor beans. The shortage of castor beans in this country has turned attention towards the possibilities of bean cultivation in the island of Cuba. Plantings have been made and the reports from the growers are encouraging. Soil and climatic conditions are declared to be entirely adapted to the cultivation of the castor bean, and it seems assured that the new industry will be given a real test on the island.

The salicylic acid plant of E. I. duPont de Nemours and Co., at Newark, Delaware, was burned recently, entailing a loss of approximately $100,000. The fire apparently was the result of an explosion.

The Commonwealth Silica Co., Chicago, Ill., has been incorporated with a capital of $1,500,000, to mine silica, lime and other substances. The incorporators are L. L. and B. F. Cowan and P. Zak.

According to British Imperial Institute reports, a considerable amount of attention has been given in recent years to the recovery of wax from the waste produced in the extraction of sugar from the sugar-cane, and this industry has now been started on a small scale in Natal. Samples of the first consignment of Natal sugar-cane wax shipped to England have been examined at the Institute and have been found to be of good quality, quite equal to that of the first trial samples made and examined. Sugar-cane wax is now becoming better known on the market, and could be used as a substitute for the better-known carnauba wax in the manufacture of gramaphone records, polishes, candles, etc.

In a paper read before the New York Section of the American Chemical Society on November 23, E. D. Boyer called attention to a new use for Portland cement brought about by the war, namely, the construction of ships and barges of concrete. He states that ships of this character have recently been successfully built in Norway, and a 5000-ton ship is at present being constructed in San Francisco, while on November 21, a 250-ton ship was successfully launched at Montreal. The American Concrete Institute and the Portland Cement Association have organized committees who are making a study of the construction of vessels of this type, and these committees have designed a reinforced concrete barge of 2000-ton carrying capacity, with every reason to believe it will be successful.

The Federal Trade Commission has entered order for licenses to three firms to manufacture and sell the product heretofore known as "Salvarsan," "606," "Arsenobenzol," "Arsaminol," patent rights which have been held by German subjects. Hereafter this important drug will be manufactured and sold under the name of "Arsphenamine." The three firms designated are Dermatological Research Laboratories of Philadelphia, Takamine Laboratory, Inc., New York, and Farbwerke Hoechst Company (Herman A. Metz Laboratory), New York. The supply of the drug was heretofore almost exclusively obtained by importation from Germany. The enormous shortage of supply on this important product will immediately be relieved, and the article placed in the hands of the Government, the hospitals and the medical profession at a much lower price.

It is reported that the Spreckles interests of California have purchased extensive deposits of soda salts in southern Oregon and will start development work in the near future.

Further data have been received by the United States Bureau of Foreign and Domestic Commerce on the successful incombustible substitute for celluloid. Announcement of this invention by a professor in one of the Japanese universities was made about a year ago and aroused considerable interest in the United States. The new product has been given the trade name of "Satolite" derived from the name of the inventor, Prof. S. Sato, and a company for its manufacture has been started with a capital of $1,000,000. Satolite is a galolith made of the glucine of soya bean, coagulated by formaline. It is said to be produced much more cheaply than celluloid, and to have several advantages for industrial use not possessed by the latter. The factory is to be built in the Mukojima district in Tokyo, and the actual production will soon begin.

At the annual meeting of the National Academy of Sciences, held at the University of Pennsylvania, Philadelphia, November 20 and 21, Dr. Simon Flexner of the Rockefeller Institute, announced that two American physicians, Doctors Jacobs and Heidelberger, of the Rockefeller Institute, have evolved a new remedy to replace salvarsan. Dr. Flexner stated that it has many advantages over salvarsan, one being its cheapness. It is stated that it is less injurious to the human tissues and more readily manufactured than salvarsan. Like salvarsan it is an arsenic compound.

The cottonseed oil refinery being erected by Swift and Company in Houston Heights, Texas, is near completion. The approximate cost of the plant is about $250,000. The plant as a whole will include three buildings, the power house, packing house, in which the oil is refined and the acidulating building. Three large storage tanks have been built with a capacity of 27,000 barrels of cottonseed oil. This company is also planning the construction of a large fertilizer plant, to cost about $500,000, at Hammond, Ill.

The United States Industrial Chemical Company, which was chartered recently under the laws of Maryland with a capital stock of $24,000,000, is reported to have secured land for the erection of a plant near Curtis Bay to manufacture chemicals, fertilizers and hydrocarbons. It is also reported that the new company will take over the entire plant of the Curtis Bay Chemical Company, subsidiary of the United States Industrial Alcohol Company of New York. The new company's incorporators are Patrick H. Loftus and Francis C. Nickerson of Brooklyn and Stewart M. Seymour of New York. Directors for the first year are George S. Brewster, William R. Coe, Edward W. Harden, William S. Kies, Adrian H. Larkin, Percival J. McIntosh, Horatio S. Rubens, Richard P. Tinsley and Milton C. Whitaker.

Nineteen schools of technology are now maintained by the Japanese government at various sections of the island empire. So far as is possible each school is specialized to meet the general agricultural, mining and industrial needs of that portion of the country in which it is located. At Tokyo and Osaka, dyeing, bleaching and printing, the tanning of leather, industrial designing and the manufacture of oils, soaps, and colors are among the courses offered, and the faculty of the Tokyo school alone numbers eighty-eight, including two foreign instructors.

A training school for the higher technical education of women was recently opened in Lyons, France, the centre of the silk industry in that country. So severe a drain has been made on French manhood of all classes that it was deemed imperative that women should be offered an opportunity in the more important fields. The courses of study offered cover most of the technical courses hitherto confined to men.

A school of industrial chemistry, the first in Italy, is being organized at the University of Pavia.

Restrictions are being placed upon copra exports to France, apparently with a view of assuring a greater supply for the domestic production of edible cocoanut oil.

Platinum production in Colombia is increasing. Prospecting has shown that the metal occurs in the steam gravels and in the high gravels for long distances on the Arato and San Juan River.

A thorough and scientific investigation of the dyestuffs industry in the United States is being undertaken by the United States Tariff Commission for the purpose of ascertaining the need of further tariff protection and also in relation to the production of explosives.

Brazilian manganese is now being imported in large quantities by the United States, owing to the closing of other sources of supply.

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.

NATIONAL MUSEUM

Mineral Industries of the United States; Interpretation of Fertilizer Situation in the United States. J. E. Pogue. Bulletin 102. 22 pp. Issued October 10, 1917. Paper, 5 cents.

PUBLIC HEALTH SERVICE

Trinitrotoluol. Practical Points in its Safe Handling. J. W. Schereschewsky. Public Health Reports, 32, 1919–26 (November 16).

The Bacteriological Examination of Water. Comparative Studies of Media Used. H. E. Hasseltine. Public Health Reports, 32, 1878–87 (November 9). "The results of this work indicate that if the new Standard Methods (1917) be adhered to in the bacteriological examination of water, time, labor, and material will be unnecessarily expended and misleading results may be obtained."

GEOLOGICAL SURVEY

Chromite in 1916. J. S. Diller. Separate from Mineral Resources of the United States, 1916, Part I. 18 pp. Published October 26. "The greatly increased trade in steel and the consequently larger demand for ferrochrome have stimulated the search for chromite in the United States, as is shown by the fourteenfold increase in production in 1916 as compared with 1915. * * * * The total yield for the United States was 47,035 long tons, valued at $726,243.

"The price of chromite in California on the basis of a content of 40 per cent of chromic oxide ranged in 1916 from $14 a ton f. o. b. at points of shipment early in the season, to $20 toward the end of the year. To this must be added for the eastern buyer a freight rate for carload lots ranging from $10 a ton to Chicago to nearly $15 a ton to the eastern seaboard and making the California 40 per cent ore cost on the eastern seaboard from $29 to $35 a ton. A premium of 50 cents a unit for chromium oxide is usually allowed and a penalty of 50 cents a unit is exacted for chromium oxide under 40 per cent and silica over 6 per cent. At the Atlantic seaboard the ore from the Pacific coast meets the imported ore, which is sold on the basis of a content of 50 per cent of chromic oxide. Prices of imported high-grade ore are reported as ranging in 1916 from $35 to $45 a ton f. o. b. eastern seaports. Low-grade Canadian ore containing 30 to 40 per cent chromic oxide sold for $25 to $30 a ton f. o. b. at the same points. Twenty-five per cent ore sold as low as $18 a ton.

Embargoes were placed on the shipment of chrome ore from some of the principal sources, and it was feared that the supply for the United States would be cut off, but after the producers received a guaranty that the ore would not be reshipped to enemy belligerents the imports greatly increased, compared with 1914, especially those from Rhodesia, New Caledonia, and Canada, though imports from Greece have declined slightly and those from Turkey have entirely ceased.

Silver, Copper, Lead and Zinc in the Central States in 1916. Mines Report. J. P. Dunlop and B. S. Butler. Separate from Mineral Resources of the United States, 1916, Part I. 105 pp. Published October 27.

Bauxite and Aluminum in 1916. J. M. Hill. Separate from Mineral Resources of the United States, 1916, Part I. 12 pp. Published November 2. The production of bauxite in the United States in 1916 was 425,100 long tons, having a value at the mines of $2,296,400, an increase over the production in 1915 of 43 per cent in quantity and 52 per cent in value. The production from the Georgia, Alabama, and Tennessee field in 1916 was 49,190 long tons, an increase of about 74 per cent, and the Arkansas production of 375,910 long tons showed an increase of approximately 40 per cent.

Apparently the producers of aluminum consumed about 300,000 tons, makers of chemicals about 80,000 tons, and makers of abrasives and refractories about 45,000 tons of bauxite in 1916.

As will be seen by the tables, though the domestic consumption of bauxite in 1916 also increased 43 per cent over the consumption in 1915, domestic deposits were apparently able to supply the whole demand and still leave some bauxite for export. The larger exports were apparently to Canadian aluminum and abrasive makers.

The prices received for bauxite in 1916, as reported by producers, ranged from a low of $4.25 to a high of $6.25 a long ton, the average price for the whole production in 1916 being $5.40 a long ton. During the latter part of the year and early in 1917 higher prices were offered for good grade bauxite from the central Georgia field.

Owing to the freight embargoes placed by various railroads in the last half of 1916 and also to the shortage of cars the producers of bauxite had considerable difficulty in meeting their orders. The exceptionally wet winter was also a handicap to regular production and shipping and, at a few pits in the central Georgia field, work had to be stopped on account of difficult mining or hauling conditions.

"The value of primary aluminum produced in the United States in 1916 was $33,900,000, an increase of 108 per cent over the value of the output in 1915. This increase is, in part, due to the increased price, but is also due in a considerable degree to the greater output of primary aluminum in 1916 than in 1915. It will also be noticed, as shown in the tables, that the value of aluminum produced from scrap in the United States in 1916 increased more than 300 per cent over the value of the production in 1915, owing in part to the greatly increased price in the open market, but also to greater recoveries of aluminum from scrap. The value of the total domestic production of new metal and metal produced from scrap in 1916 was $57,330,200, as compared with $22,082,100 in 1915. The value of imports of aluminum has continued to decline, but the value of exports has increased greatly."

In the United States the quoted prices for primary or "virgin" aluminum ranged from a low of 55 cents a pound in January to a high of 65.12 cents a pound in November, the average for the year being 60.71 cents a pound, as compared with 33.98 cents in 1915. These prices are for small lots and immediate delivery, offered in the open market, and must not be taken to represent the price received by the single producer of primary aluminum in this country. It is reported, apparently on good authority, that the contract prices of the Aluminum Company of America to regular consumers ranged from 31 to 37 cents a pound in 1916, as compared with 20 to 31 cents a pound in 1915. The demand for aluminum was very large during 1916, particularly for war materials of various sorts, and it is highly probable that the demands in the near future will be increased considerably.

PRICES OF ALUMINUM, 1912–1916, IN CENTS PER POUND(a)

Year	Average Open Market Price Small Lots	Contract Price
1912	22.01	20–21
1913	23.64	(b)
1914	18.63	(b)
1915	33.98	20–31
1916	60.71	31–37

(a) *Eng. & Min. Jour.* quotations in annual review numbers.
(b) No figures published, but it seems reasonable to believe that contracts were made on approximately the same basis as for 1912.

Nearly 70 per cent of the domestic output of bauxite in 1916 went into aluminum, but manufacturers of aluminum salts used nearly 19 per cent; apparently 8 per cent was consumed in the manufacture of bauxite abrasives; and 3 per cent was used by makers of "high-alumina refractories," sometimes called bauxite brick.

The Palestine Salt Dome, Anderson County, Texas. The Brenham Dome, Washington and Austin Counties, Texas. O. B. HOPKINS. Bulletin 661-*G*, from Contributions to Economic Geology, 1917, Part II. 28 pp. Published October, 1917.

The highly folded, faulted, and eroded condition of the Palestine dome and the general absence of oil and gas as surface seepages and in shallow wells in this area detract from its oil prospects. The tilting and faulting of the rocks probably provided outlets for the escape of oil, and as no evidence of oil exists the conclusion is suggested that no large amount remains here, even if it ever accumulated. It is possible, however, that the soft and dominantly impervious nature of the formations involved in this fold closed up any possible lines of escape for the oil, as its absence at the surface may be interpreted to indicate. The eroded condition of the dome, as shown by the presence of Cretaceous rocks at the surface, and the presence of the salt core within 140 ft. of the surface over a large area are also unfavorable conditions, as they eliminate the possibility that oil may be found on the crest of the dome, which might otherwise be the most favorable area for its occurrence. Oil in commercial quantities has not yet been found in a salt dome so far removed from the coast as this one.

In the Brenham dome, as in most other salt domes, drilling is attended with many uncertainties and should not be undertaken without full knowledge of them. Failure to find oil in commercial quantities in the porous limestone, the "cap rock," and the sands overlying the crest of the dome makes deeper drilling necessary, with its increased costs and risks.

BUREAU OF MINES

Approved Electric Lamps for Miners. H. H. CLARK AND L. C. ILSLEY. Bulletin 131. 47 pp. Paper, 20 cents.

Yearbook of the Bureau of Mines, 1916. V. H. MANNING. Bulletin 141, 165 pp. Paper, 30 cents. This bulletin describes in some detail the more important work done by the Bureau of Mines during 1916 in efforts to increase safety and efficiency in the mineral industries. The purpose and organization of the bureau and a review of its work for each fiscal year are presented in the annual reports of the director. Those reports are necessarily summarized; they cannot give full details of noteworthy experiments nor describe at length new and improved equipment, apparatus, and devices that are being used by the bureau or have been devised by its engineers and chemists. This bulletin gives descriptions of some noteworthy safety devices and discusses in fuller detail than the annual reports the relation of the bureau's work to the general problems of safety and efficiency in the mineral industries and the significance of the results that the bureau has been able to achieve.

The Determination of Moisture in Coke. A. C. FIELDNER AND W. A. SELVIG. Technical Paper 148, 8 pp. Paper, 5 cents. "The experiments described in this paper were undertaken, in the course of fuel investigations made by the Bureau of Mines, with the purpose of ascertaining the most rapid and simple method for determining the moisture in coke with sufficient accuracy for use in specifications for the purchase of coke by the Government, by industrial concerns, or by private individuals.

"Moisture can be determined quickly and with adequate accuracy, ±0.5 per cent, by simply heating to constant weight a large sample of lump coke, in any convenient oven, or on a stove, hot plate, or steam coil at a temperature of 100 to 200° C.

"Because of its simplicity and flexibility this method may be used advantageously at points when coke shipments are sampled."

Effect of Low-Temperature Oxidation on the Hydrogen in Coal and the Change in Weight of Coal on Drying. S. H. KATZ AND H. C. PORTER. Technical Paper 98, 10 pp. Paper, 5 cents. In order to gain information regarding the possible changes of the hydrogen of the coal substance during the alteration of coal by the air, the work described in this paper was undertaken.

"The following conclusions are reached:

"1—There is a lack of agreement between the weight of water evolved by coal and the loss of weight when dried in an inert atmosphere. The excess weight of the coal may be due to absorption of gas.

"2—A study of the vapor tension of water in coal, as indicated by the water removed by a regulated current of dry nitrogen and air used alternately, shows no production of water by the oxidation of coal at ordinary temperatures.

BUREAU OF STANDARDS

Durability of Cement Draintile and Concrete in Alkali Soils (Containing Results of Third Year's Tests). R. J. WIG, G. M. WILLIAMS, A. N. FINN in coöperation with S. H. MCCRORY, Chief of Drainage Investigations of Department of Agriculture, E. C. BEBB, Engineer of U. S. Reclamation Service, and L. R. FERGUSON, Engineer, Portland Cement Association. Technologic Paper 95, 91 pp. Issued November 15.

Gas-Mantle Lighting Conditions in Ten Large Cities in the United States. R. S. MCBRIDE AND C. E. REINICKER. Technologic Paper 99, 35 pp. Published October 29. "From an inspection of about 4500 gas mantle lamps in service in 10 cities a summary of the condition of mantles, glassware, pilot light, and other particulars was made in order to determine to what extent the customer benefited through periodic maintenance service.

"By these observations it is found that a lamp not on regular maintenance is likely to be defective five and one-half times as frequently as a lamp which is regularly maintained. Also it is shown that on the average 1 in 3 of the lamps on regular maintenance was not in good condition, whereas the defects noted in the lamps not so maintained, average more than one for every lamp.

"One satisfactory system of estimating the expenses for maintenance work together with a set of unit costs is presented, based upon the analysis of the operation of 10 gas companies. A suggested table of costs for each type of unit is given."

Determination of Absolute Viscosity by Short-Tube Viscosimeters. W. H. HERSCHEL. Technologic Paper 100, 53 pp. Issued November 9. Paper, 10 cents. "The conclusions from this investigation for short tubes, such as are used in the Engler and the Saybolt Universal viscosimeters, are as follows:

"1—The value of the product of the velocity of flow and diameter of tube, divided by the kinematic viscosity, must not be greater than 800 if the flow is to be viscous rather than turbulent.

"2—Consequently water is not a suitable liquid for use in finding the relation between viscosity and time of discharge, and Ubbelohde's equation and all others based upon it are seriously in error.

"3—A small but positive amount must be added to the measured length of tube to get the effective length.

"4—Boussinesq's value of 1.12 for the coefficient of the kinetic-energy correction would be approximately applicable if the average head could be correctly determined.

"5—If the average head is determined by Meissner's formula, which is the best available, although unsatisfactory and far from accurate, a lower value must be used for the coefficient."

A Method for Testing Current Transformers. F. B. SILSBEE. Scientific Paper 309, 13 pp. Issued November 3. Paper, 5 cents.

Some Electrical Properties of Silver Sulfide. G. W. VINAL. Scientific Paper 310. 9 pp. "Silver sulfide may be prepared in the form of short wires or thin strips like a metal. The wire, which must be drawn hot, was found to conduct electricity like a metal of high specific resistance and approximately zero temperature coefficient. A strip of sulfide rolled at room temperature has a large temperature coefficient and shows both metallic and electrolytic conduction. It has a volt-ampere curve characteristic of a pyroelectric conductor. The strips are sensitive to small alternating currents, which increase the resistance enormously, while small direct currents have the opposite effect. The specific resistance has been measured and experiments made on the electrochemical decomposition."

Axial Aberrations of Lenses. E. D. TILLYER AND H. I. SHULTZ. Scientific Paper 311, 24 pp. Issued November 3. Paper, 5 cents.

COMMERCE REPORTS—OCTOBER, 1917

The **iron and steel** output of Japan is expanding greatly, especially in the shipbuilding, pipe and rail industries. (P. 10)

Among recently reported German discoveries or practice are the following: Formation of a viscous yellow **mineral oil** by treating coal with liquid sulfurous acid; production of **illuminating oil** by heating naphthalene with aluminum chloride; production of **ozokerite** from lignite; increase of 80 per cent in the output of atmospheric **nitrate** plants; use of new **lead and zinc alloys** to replace copper and brass; smelting of copper schists with 0.7 per cent copper and of low-grade lead-sandstone ores; production of **aluminum** from clay; smelting of low-grade **nickel** ores; new methods for regeneration of **rubber**; and increased use of nettles as a **cotton substitute.** (P. 50)

Steps are being taken to increase the production of **candelilla wax** in Mexico. (P. 55)

A new **petroleum refinery** is in operation in Venezuela. (P. 57)

Large areas of **mangrove** are found in the Philippines with 21 varieties, the bark of which contains from 12 to 35 per cent tannin. (P. 118)

Use of nettle fiber for **textiles** is increasing in Denmark. The nettle **"Urtica dioca"** is about 30 in. high. It is dried, stripped, and retted like flax, except that the water must be changed to prevent fermentation of the sugar present. (P. 119)

Production of **salt** from sea water is proposed in New Zealand. (P. 153)

Experiments in Scotland to increase the use of straw have shown that it can be rendered more digestible for **cattle food** by superheating with dilute caustic soda. Its use for paper pulp is also increasing. Experiments on the use of straw as **fertilizer** have shown that it stimulates the growth of "azotobacter," and other nitrogen organisms. This effect is most marked with straw containing 1 part of arsenic per 100,000. (P. 164)

Efforts are being made to locate **petroleum** in Australia, which is now entirely dependent on foreign countries for its oil supply. (P. 168)

Gas is being used extensively in Birmingham, England, as a substitute for **gasoline** in motor vehicles. 250 to 300 cu. ft. of gas are equivalent to 1 gal. of gasoline. No change in the engine is required, and the only objection is the great bulk of the gas containers. (P. 170)

The **vegetable wax** produced in Japan is extracted from the fruit kernels of a native tree, by crushing, steaming and pressing. It is refined by crude methods, which are, however, being improved. It is used for polishes, pomades and soaps, and in dressing leather. (P. 227)

The Malay Peninsula is now the largest **rubber**-producing and exporting country in the world. Exports to the United States are now greater than to any other country. (Pp. 232–6)

Exports of **dyestuffs** from the United States in July amounted to $1,278,709, distributed to over 12 countries. (P. 271)

Additions to the "conservation" list of articles, **export** of which from the United States is practically prohibited, include: phosphorus, babbitt metal, bichromate, bismuth salts, brass, bronze, caustic potash, china-wood oil, ores, alloys or compounds of chromium, cobalt, copper, manganese, molybdenum, nickel, tin, tungsten, and vanadium; crucibles, industrial diamonds, electrodes, hydrofluoric acid, mercury, emery, graphite, solder, type metal. The complete revised list is published. A complete revised list of articles requiring a license for export is also included. (Pp. 292–9)

A systematic prospecting of the placer deposits in the Ronda Mountains in Spain have shown the presence of workable **platinum** deposits, with extensive deposits of **chromium, nickel** and **magnetite ores.** The nickel is present as garnierite, with 16–20 per cent nickel, *i. e.*, equal Canadian and New Caledonian deposits. (P. 311)

Increased prices for **antimony** have caused the re-opening of mines in Italy. (P. 323)

Exports of **mineral oils** from the United States in 1916–17 were greater than ever before. (P. 354)

A marked improvement is observed in the quality of **dyestuffs** made in England. Many new dyes are available, but there is still a lack of certain dyes, *e. g.*, diamond black, B H direct cotton black, patent blue, and rhodamin 6 G. (P. 360)

Production of **iron and steel** in Canada in 1917 shows a decided increase. (P. 405)

Canada has removed the prohibition on the manufacture and sale of **oleomargarine,** which can now be sold under strict regulations. (P. 417)

The use of **chromium** in steel except for war purposes has been prohibited in England, thus stopping the manufacture of "stainless" steel cutlery, etc. Chrome steel is being used for naval, ordnance, and airplane parts. (P. 420)

A new **zinc smelter** is being erected in Mexico, to use petroleum for fuel. (P. 430)

SPECIAL SUPPLEMENTS ISSUED IN OCTOBER

BRITISH WEST INDIES—22*a*	BRITISH GUIANA—44*a*
BRAZIL—40*a*	PHILIPPINE ISLANDS—80*a*

STATISTICS OF EXPORTS TO THE UNITED STATES

HONGKONG—156	BRAZIL—Sup. 40*a*
Antimony	Fiber
Chemicals	Hides
Earthenware	Diamonds
Hides	Ipecacuanha
Leather	Rubber
Peanut oil	Carnauba wax
Aniseed oil	JAMAICA—Sup. 22*a*
Cassia oil	Logwood
Peanuts	Logwood extract
Paper	Sugar
Sugar	Rum
Tin	Fustic
	Cumato

COMMERCE REPORTS, NOVEMBER, 1917

The **mineral exports** of New Zealand include gold, silver, tungsten, ore, coal, and kauri gum. "Kauri-gum oil," obtained by distillation of **peat** found in kauri-gum swamps, is being used with gasoline, as motor fuel. (P. 435)

Efforts are being made to develop the production of **wintergreen** oil in Assain, India, when the leaves and stems of the "gaultheria" plant yield, upon distillation, about 0.68 per cent oil, as compared with as little as 0.12 per cent in other regions of India. (P. 440)

Plans have been made in France for courses of instruction for apprentices in **metallurgical** industries, to be conducted by

the employers; attendance is compulsory, but apprentices are to be paid for the period of instruction. (P. 455)

All the London **milk** dairies have been consolidated into a $20,000,000 corporation in order to effect economies in labor and operation. (P. 456)

Export duties on **manganese ore** from Brazil have been increased from $0.85 to $3.00 per ton. (P. 472)

Experiments are being conducted in Mexico upon the production from **bananas of flour, starch, vinegar, alcohol, fiber, paper and cardboard.** (P. 478)

A large **detinning** plant has been erected near Dundee, Scotland. (P. 486)

To avoid exportation of **raw hides and tanning materials** from India, efforts are being made to develop a local tanning industry. (P. 507)

Exports of **wattle bark** and extract for tanning purposes from South Africa, show a marked increase. The trees are cultivated from seed, and are cut down for stripping the bark, after five or six years. (P. 508)

Cultivation of the wild geranium for the production of **geranium oil** is being urged in India. (P. 516)

Wolframite is being mined extensively in South China. (Pp. 522 and 546)

A new law in Uruguay requires a chemical **analysis of all drugs and chemicals** to be imported. Owing to lack of laboratory facilities much delay has arisen. (P. 539)

Mineral exports from Spanish Morocco include **hematite, galena and calamine.** (P. 563)

A large part of the output of **castor oil** in England is now being used as a lubricant for airplane engines. (P. 586)

The **zinc** industry of Russian Poland has been revived, with an output nearly equal to that before the war. (P. 631)

Soap is now being made in Sweden from sewer fat, the oils of beechnuts and horse-chestnuts. (P. 641)

A company has been organized in Sweden for the manufacture of **dyes.** (P. 653)

Among the **mineral products** of Japan are antimony, chromite, copper, gold, iron, lead, manganese, platinum, mercury, silver, tin, tungsten, molybdenum, zinc, asphalt, coal, petroleum, graphite, phosphate rock, pyrite, and sulfur. (P. 668)

Although Italy has rich **zinc** deposits, the output of zinc is limited by the shortage of fuel. (P. 669)

Attempts are being made in Italy to **briquette** rice hulls for use as fuel. (P. 678)

Mineral products of South Africa include gold, diamonds, coal, copper, tin, antimony, asbestos, corundum, and lime. (P. 692)

There has been a great increase in the **vegetable oil** industry in Sao Paulo, Brazil, including cottonseed, castor oil, linseed, peanut, and cashew nut. (P. 710)

New Zealand has offered a bonus for the production of **mercury.** (P. 718)

As a **sugar substitute,** "honey of grapes" is used in Italy. It is obtained from unfermented grape juice by evaporation followed by freezing (removing water and tartaric acid), and by further evaporation under reduced pressure. (P. 756)

A large **blast furnace,** rolling mill, etc., are to be erected in Holland to prepare, from foreign ores, steel for the shipbuilding industry. (P. 771)

The business of the British **dye syndicate** has been very successful thus far. The list of colors has been greatly extended, and the manufacture of intermediates has been increased. Research is being conducted at the Universities of Oxford, Leeds and Liverpool, and a main research laboratory is being erected at Huddersfield. (P. 776)

A non-combustible substitute for **celluloid,** known as "Satolite," has been introduced in Japan. It is made from the glucine of soya bean, coagulated by formaldehyde. (P. 779)

The **mineral products** of Burma include petroleum, salt, and ores of tungsten, lead, silver, tin, gold, zinc, iron, antimony, molybdenum, platinum, and copper. (P. 780)

The methods of making and coloring **glass beads** in Venice are described in great detail. (Pp. 789–98)

The **glycerine** now being recovered in England from waste fat, etc., from the army camps, is sufficient to provide propellant ammunition for 17,000,000 shells per annum. (P. 811)

Owing to decreased demand for natural **indigo,** the production in Madras is considerably below that of last year. (P. 820)

Investigation of **vegetable fibers** in Brazil has shown some suitable for paper, but not for textiles. The latter are in great demand for bagging, etc., owing to scarcity of jute. (P. 831)

SPECIAL SUPPLEMENTS ISSUED IN NOVEMBER

FRANCE—5*a*, *b*, *c*
ITALY—8*a*
NETHERLANDS—9*b*
SPAIN—15*e*
ENGLAND—19*b*
WALES—19*c*
SCOTLAND—19*d*
ECUADOR—43*a*
PERU—46*a*
SPAIN—58*a*
EGYPT—68*a*

STATISTICS OF EXPORTS TO THE UNITED STATES

HANKOW, CHINA—492
Antimony
Soya beans
Camphor
Albumen
Gall nuts
Hemp
Hides
Bean oil
Cottonseed oil
Rape seed oil
Soya bean oil
Nut oil
Sesamum seed
Tallow
Turmeric

MALAGA—580
Fusel oil
Tartar
Thymol
Hides
Juniper oil
Lavender oil
Pennyroyal oil
Origanum oil
Rosemary oil
Thyme oil
Almond oil
Olive oil
Copper ore
Iron ore
Licorice

GLASGOW—598
Acids
Corundum
Creosote
Sodium cyanide
Hides
Magnesite
Paper stock
Ammonium sulfate

MARSEILLES—Sup. 5*c*
Benzoic acid
Citric acid
Belladonna
Cochineal
Glycerine
Gums
Gentian root
Copper matte
Glue
Hides
Nickel matte
Ocher
Copra oil
Olive oil
Palm oil
Paper stock
Graphite
Soap
Tin
Zinc oxide

ITALY—Sup. 8*a*
Hides
Mercury
Fusel oil
Olive oil
Parchment paper
Zinc ore
Citrate of lime
Pumice
Sulfur
Tartar
Artificial silk
Citric acid
Bergamot
Sesame oil
Sumac
Senna
Zinc ore
Glassware

PARIS—Sup. 5*a*
Aluminum
Bones
Carbon
Alizarin
Casein
Hides
Olive oil
Peanut oil
Essential oils
Platinum
Saffron
Zinc ore

HAVRE—Sup. 5*b*
Copper matte
Fertilizer
Optical glass
Hides
Colza oil
Flint pebbles
Prussiate of potash
Rubber

LYON—Sup. 5*b*
Calcium tartrate
Orchil extract
Gum arabic
Tartar
Copper matte
Hides
Enameled iron
Photographic plates
Artificial silk

NETHERLANDS—Sup. 9*b*
Beeswax
Chemicals
Drugs
Dyes
Cocoa butter
Fertilizers
Fibers
Hides
Ink
Leather
Matches
Paper stock
Paraffin
Rubber
Stearine
Formic acid

SPAIN—Sup. 15*e*
Antimony
Argols
Fusel oil
Glycerine
Calcium tartrate
Potash
Hides
Lithopone
Barytes
Paper stock
Mercury
Olive oil
Peanut oil
Soap

SCOTLAND—19*d*
Asphalt
Glassware
Leather
Paper stock
Guano
Hides
Gelatin
Acids
Ammonium sulfate
Bone char
Corundum
Creosote oil
Magnesite
Manganese ore

ENGLAND—Sup. 19*b*
Animal charcoal
Ammonia
Hides
Iron oxide
Alum
Barium carbonate
Carbolic acid
Creosote
Cresol
Fertilizer
Gum copal
Castor oil
Palm oil
Rape oil
Paris white
Ultramarine
Rubber
Bones
Copper
Grease
Ferro manganese
Coconut oil
Whale oil
Paper stock
Ammonium sulfate
Ammonium chloride
Bleaching powder
Cochineal
Cutch
Glycerine
Gum tragasol
Soda ash
Sodium silicate
Leather
Artificial silk
Tin

ECUADOR—Sup. 43*a*
Gold
Hides
Indigo
Kapok
Ivory nuts
Rubber

PERU—Sup. 46*a*
Aluminum
Antimony
Copper matte
Lead
Cochineal
Silver
Guano
Hides
Molybdenum
Mercury
Rubber
Gold
Sugar
Tungsten ores
Vanadium ores
Zinc ores
Kerosene
Naphtha
Crude oil
Cocaine
Potassium sulfate

SIAM—Sup. 58*a*
Gum benzoin
Hides
Stick lac
Tungsten ore

EGYPT—Sup. 68*a*
Beeswax
Gum arabic
Hides
Iron ore
Paper stock
Senna
Ivory nuts

BOOK REVIEWS

Standard Table of Electrochemical Equivalents and Their Derivatives. By CARL HERING AND FREDERICK H. GETMAN. 130 pp. D. Van Nostrand Co., New York, 1917. Price, $2.00 net.

This little book should serve a useful purpose to the electrochemist or any one engaged in electrochemical work. The tables, which are four in number, include electrochemical equivalents by weight, grams per ampere hour in the order of magnitude, electrophysical equivalents by volume and the valences of the elements in their combinations. The principal table is that of the electrochemical equivalents by weight, and is very complete. On eight pages are given the element, symbol, atomic weight, valence, milligrams per coulomb, coulombs per milligram, grams ampere per hour, ampere hours per gram, pounds per 1000 ampere hour, and ampere hours per pound. Calculations are taken up, giving by a well chosen set of examples, the method best adapted for solving such problems as are liable to arise in electrochemical work.

Part II deals with electrolysis, theory of electrolytic dissociations, Faraday law and coulometers, and a section is given to the electronic theory.

An Appendix includes a chapter on valence, chemical reactions and calculations, conversion factors used in electrochemical calculations which is taken from Mr. Hering's "Conversion Tables," and finally a glossary of terms.

It will be seen that all of this information is to be found in other books, but it is convenient to have it brought together in one volume, and it is presented in a clear and logical manner that should recommend it as a reference book.

SAMUEL A. TUCKER

A Short Manual of Analytical Chemistry, Qualitative and Quantitative—Inorganic and Organic. By JOHN MUTER, PH.D., F.R.S.E., F.I.C., F.C.S., Analyst to the Metropolitan Asylums Board, Late Editor of *The Analyst*, etc. 6th American Edition, Illustrated. xiii + 237 pp. Edited by J. THOMAS, SC.D. P. Blakiston's Son & Co., Philadelphia, 1917. Price, $2.00 net.

This manual, which is prepared primarily for the use of pharmacists, has previously passed through ten English and five American editions, indicating its acceptability to the pharmaceutical profession. The notable characteristics of the present edition is the revision of the procedures for the assaying of drugs and the inclusion of the legal standards for drugs, as laid down in the ninth decennial revision of the United States Pharmacopoeia.

It is obvious that any attempt to cover so wide a field within the compass of a short manual must involve extreme brevity of treatment of many topics and procedures. It is also true that many of the procedures for the estimation of inorganic constituents will scarcely appeal to the practicing analyst outside of pharmacy, and it may be deplored that pharmacists are disposed to accept such procedures without adequate criticism. The fact remains, however, that the continued popularity of this manual indicates that it satisfies a demand in the field for which it is prepared, and the present edition is doubtless at least as satisfactory as those which have preceded it.

H. P. TALBOT

The Chemical Engineering Catalog—1917 Edition. 517 pp. Illustrated. Obtained by special arrangement with the Publishers, The Chemical Catalog Co., Inc., New York City.

A need was felt, even before the recent new and increased capacities in our chemical industry, on the part of the chemical engineer, superintendent and buyer for a compilation containing the fullest knowledge relative to chemical-technical data, plant equipment and products, and imparting information regarding the source of supply of the manifold needs of laboratory and works. This information, so essential to the successful development of the industry, was not only lacking in coördination but also extremely meager, and the little that was obtainable was scattered in periodicals, pamphlets and individual catalogs. To supply this necessity, a joint supervisory committee was appointed by the American Institute of Chemical Engineers, the American Chemical Society and the New York Section of the Society of Chemical Industry, with the result that the first edition of the Chemical Engineering Catalog was published in 1906 by the Chemical Engineering Catalog Co., Inc. This first edition was of 288 pages of the size of THIS JOURNAL, listed 136 manufactures of chemical plant equipment, products and material, and contained in addition a number of illustrations of apparatus and machinery. If the first edition was an experiment, the edition of 1917 proves the success of the experiment. The 1917 edition comprises 517 pages, 277 being devoted to illustrations, descriptions and uses of a variety of plant equipment. Such rapid strides must have exceeded the expectations of the most optimistic sponsors of the Catalog and the editors of the volume are to be congratulated on their accomplishment. An improvement worthy of note is the division of the book into two sections, one devoted to chemical plant equipment, data of interest to the engineer and superintendent, while the other pertains to materials and supplies peculiar to the province of the buyer.

Although the Catalog has doubled in size since last year, it must be realized that it is not yet complete and represents only part of that completeness contemplated by the editors "to produce such an encyclopedia of trade information that the engineer or buyer will be able to obtain from it the data necessary to enable him to specify or purchase the equipment or material required to take a plant from a mere idea to the point where it is successfully turning out a finished product."

This has not yet been attained, but coöperation on the part of those who unquestionably will benefit by such a work, will assist so materially that it will not be long before the ideal condition will be consummated.

There is ample assurance therefore that the Catalog will then become the inseparable companion of the several classes operative in the Chemical Industry and, moreover, others who are not yet interested will eventually find in it valuable information for their respective fields of activity. With the improvements and advances noted, it is only another convincing index of the progress and achievements of the American Chemical Industry.

GEO. D. ROSENGARTEN

The Leather Specimen Book. By FREDERIC W. LACROIX, of the Pfister & Vogel Leather Co., Milwaukee, Wis. Price, $7.00.

This book, as the author claims, has been prepared especially for the use of those interested in a general way in the manufacture of leather. The description of the general processes employed is of necessity made brief, but at the same time it conveys a good idea of some of the numerous stages through which a hide or skin must pass before it becomes a finished product. The eighty-four specimens of finished leather shown, together with the text accompanying each, are most interesting. Those engaged in leather manufacture or in allied lines will find this volume both helpful and instructive.

ALLEN ROGERS

NEW PUBLICATIONS

By IRENE DEMATTY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Amidophenol: Le Diamidophenol acide en photographie. G. UNDERBERG. 16mo. 32 pp. Price, 60 cm.

Analysis: Methods in Metallurgical Analysis. C. H. WHITE. 8vo. Price, 10s 6d.

Analysis: A Systematic Course of Qualitative Analysis of Inorganic and Organic Substances. H. W. SCHIMPF. 8vo. 187 pp. Price, $1.50. John Wiley & Sons, New York.

Building Stones and Clays. C. H. RICHARDSON. 8vo. 437 pp. Price, $5.50. The University Book Store, Syracuse, N. Y.

Chemicals: Dictionary of Chemicals and Raw Products. G. H. HURST. 2nd Ed. 8vo. Price, 10s. 6d. Scott, Greenwood & Son, London.

Chemistry. JAMES KNIGHT. Edited by J. ADAMS. 12mo. 162 pp. Price, $0.75. David McKay, Philadelphia.

Chemistry: Experimental and Applied Chemistry. H. S. DOOLITTLE. 8vo. 189 pp. Price, $1.00. G. Wahr, Ann Arbor, Mich.

Chemistry: Laboratory Manual of Elementary Chemistry. H. C. COOPER. 12mo. 247 pp. Price, $1.10. John Wiley & Sons, New York.

Colloid Chemistry: An Introduction to Theoretical and Applied Colloid Chemistry. WOLFGANG OSTWALD. Translated from the German by M. H. FISCHER. 8vo. 232 pp. Price, $2.50. John Wiley & Sons, New York.

The Dyeing of Cotton Fabrics. F. BEECH. 8vo. Price, 10s. 6d. Scott, Greenwood & Son, London.

Dyes: A Book of Vegetable Dyes. E. M. MAIRET. 8vo. 125 pp. Price, 5s. D. Pepler, London.

Electric Furnace in the Iron and Steel Industry. W. RODENHAUSER AND OTHERS. 2nd Ed. 8vo. 429 pp. Price, $3.75. John Wiley & Sons, New York.

Electrical Engineering. C V. CHRISTIE. 2nd Ed. 8vo. 546 pp. Price, $4.00. McGraw-Hill Book Co., New York.

Explosives: Industrial Nitrogen Compounds and Explosives. G. MARTIN AND W. BARBOUR. 8vo. 125 pp. Price, 7s. 6d. Crosby Lockwood & Son, London.

Explosives: A Short Account of Explosives. ARTHUR MARSHALL. 8vo. 104 pp. Price, 5s. J. & A. Churchill, London.

Food Adulterants: Detection of the Common Food Adulterants. E. M. BRUCE. 3rd Ed. 88 pp. Price, $1.25. D. Van Nostrand Co., New York.

Gas Engine Troubles and Installation. J. B. RATHBUN. 3rd Ed. 12mo. 448 pp. Price, $1.00. Stanton & Van Vliet Co., Chicago.

Industrial Chemistry: Laboratory Guide of Industrial Chemistry. ALLEN ROGERS. 8vo. 212 pp. Price, $2.00. D. Van Nostrand Co., New York.

Iron and Steel: Non-Technical Chats on Iron and Steel and Their Application to Modern Industry. L. W. SPRING. 8vo. 358 pp. Price, $2.50. Frederick A. Stokes Co., New York.

Military Preparedness and the Engineer. E. F. ROBINSON. 16mo. 361 pp. Price, $2.00. Clark Book Co., New York.

Ore Mining Methods. W. R. CRANE. 2nd Ed. 8vo. 277 pp. Price, $3.50. John Wiley & Sons, New York.

Pyrometry: Practical Pyrometry. E. S. FERRY AND OTHERS. 12mo. 147 pp. Price, $1.50. John Wiley & Sons, New York.

Resins: The Distillation of Resins. H. B. STOCKS. 2nd Ed. 8vo. Price, 10s. 6d. Scott, Greenwood & Son, London.

Science: Experimental General Science. W. N. CLUTE. 12mo. 303 pp. Price, $1.00. P. Blakiston's Son & Co., Philadelphia.

Sewage Purification and Disposal. G. B. KERSHAW. 8vo. 340 pp. Price, $3.75. Philadelphia Book Co., Philadelphia, Pa.

Steam: Properties of Steam and Ammonia. G. A. GOODENOUGH. 2nd Ed. 4to. 126 pp. Price, $1.25. John Wiley & Sons, New York.

Technical Papers: The Composition of Technical Papers. H. A. WATT. 12mo. 431 pp. Price, $1.50. McGraw-Hill Book Co., New York.

Water Supply Engineering. A. P. FOLWELL. 8vo. 485 pp. Price, $3.50. John Wiley & Sons, New York.

NEW JOURNAL

Oil and Mining Journal. Semi-monthly. Published by The Oil and Mining Journal Publishing Co., Oklahoma City. Price, $2.00 a year.

RECENT JOURNAL ARTICLES

Acid Open Hearth Process. F. ROGERS. *Blast Furnace and Steel Plant*, Vol. 5 (1917), No. 12, pp. 545–549.

Agriculture and National Defense. D. F. HOUSTON. *The American Fertilizer*, Vol. 47 (1917), No. 11, pp. 21–24.

Blast Furnace Gas: A New Blast Furnace Gas-Cleaning Machine. JOHN RUDDIMAN. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 10, pp. 608–611.

British National Physical Laboratory. I. W. CHUBB. *Industrial Management*, Vol. 57 (1917), No. 3, pp. 420–426.

British Welders and the World War. FRANK MYNOTT. *Journal of Acetylene Welding*, Vol. 1 (1917), No. 6, pp. 254–256.

Caffetannic Acid a Bugaboo. C. W. TRIGG. *Tea and Coffee Trade Journal*, Vol. 33 (1917), No. 5, pp. 437–439.

Cement Floors: Protective Treatment for Cement Floors Subject to Injurious Liquids. W. P. ANDERSON. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 11, pp. 667–668.

Coal: Using Coal to the Best Advantage. E. H. HINCKLEY. *Textile World Journal*, Vol. 53 (1917), No. 22, pp. 41–45.

Color: The Physical Basis of Color Technology. M. LUCKIESH. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 11, pp. 631–637.

Cotton: Use of Cotton as a Wool Substitute. *Textile World Journal*, Vol. 53 (1917), No. 23, pp. 25–27.

Crude Oil: A New Method of Burning Crude Oil. W. K. JANSSEN. *Blast Furnace and Steel Plant*, Vol. 5 (1917), No. 12, pp. 569–570.

Dezincification of Brass Pipe. E. B. STORY. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 11, pp. 653–659.

Engineering Advice in Making Electric Power Contracts. A. L. JOHNSTON, JR. *Industrial Management*, Vol. 54 (1917), No. 3, pp. 366–369.

Ferro-Manganese: Bibliography of the Manufacture of Ferro-Manganese. E. C. BUCK. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 11, pp. 638–642.

Fertilizer Industry and the Potato Situation. H. G. BELL. *The American Fertilizer*, Vol. 47 (1917), No. 11, pp. 28–31.

Fertilizers—An Interpretation of the Situation in the U. S. J. E. POGUE. *The American Fertilizer*, Vol. 47 (1917), No. 10, pp. 25–35.

Flotation: Status of the Flotation-Patent Litigation. R. C. CANBY. *Engineering and Mining Journal*, Vol. 104 (1917), No. 22, pp. 951–959.

Flotation Tests with Hardwood Oils. R. E. GILMOUR AND C. S. PARSONS. *Mining and Scientific Press*, Vol. 115 (1917), No. 21, pp. 763–764.

Fuel: Methods for More Efficiency in Utilizing Our Fuel Resources. H. G. BARNHURST. *General Electric Review*, Vol. 20 (1917), No. 12, pp. 924–931.

Fuel Oil: Practical Details in Burning Fuel Oil under Boilers. H. J. KENNEDY. *Industrial Management*, Vol. 54 (1917), No. 3, pp. 370–383.

Furnace Refining of Copper. LAWRENCE ADDICKS. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 10, pp. 579–584.

Grinding Wheels: Economical Use of Grinding Wheels. W. T. MONTAGUE. *The Iron Trade Review*, Vol. 61 (1917), No. 22, pp. 1153–1159.

Heap-Leaching of Copper-Sulfide Ore. C. DEKALB. *Mining and Scientific Press*, Vol. 115 (1917), No. 21, pp. 749–757.

Industrial Power on the Pacific Coast. H. J. KENNEDY. *Industrial Management*, Vol. 54 (1917), No. 2, pp. 214–224.

Industrial Waste—A Tax Paid to Ignorance. W. N. BERKELEY. *Industrial Management*, Vol. 54 (1917), No. 3, pp. 321–322.

Manganese: Utilizing Domestic Manganese Supplies. EDMUND NEWTON. *The Iron Age*, Vol. 100 (1917), No. 22, pp. 1290–1292.

Miami: The Smelting of Ore. T. A. RICKARD. *Mining and Scientific Press*, Vol. 115 (1917), No. 22, pp. 784–796.

Mill Pumping Stations. A. W. ALLEN. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 11, 629–631.

Oxide of Zinc. G. E. STONE. *Mining and Scientific Press*, Vol. 115 (1917), No. 21, pp. 759–762.

Peat Production in 1916. J. S. TURP. *The American Fertilizer*, Vol. 47 (1917), No. 11, pp. 35–36.

Photographic Research Laboratory. C. E. K. MEES. *The Scientific Monthly*, Vol. 5 (1917), No. 6, pp. 481–496.

Physical Analysis of Refractory Material. COSMO JOHNS. *Blast Furnace and Steel Plant*, Vol. 5 (1917), No. 12, pp. 563–566.

Power Plant: Improving Power-Plant Operation through Instruction. H. A. FISHER. *Industrial Management*, Vol. 54 (1917), No. 3, pp. 393–395.

Pyrite in Northern New York. D. H. NEWLAND. *Engineering and Mining Journal*, Vol. 104 (1917), No. 22, pp. 947–948.

Refractories: Industrial Uses of Refractories. H. C. ARNOLD. *The Iron Trade Review*, Vol. 61 (1917), No. 23, pp. 1212–1217.

Rosin Size: The Cooking Process in the Manufacture of Rosin Size. J. A. DECEW. *Pulp and Paper Magazine*, Vol. 15 (1917), No. 46, p. 1072.

Slide Rules: Design of Special Slide-Rules. A. L. JENKINS. *Industrial Management*, Vol. 54 (1917), No. 2, pp. 241–248.

Sulfur: Recovery of Sulfur from Illinois Coals. J. E. POGUE. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 10, pp. 584–585.

Tungsten: New Derivatives of Tungsten. J. B. HILL. *Chemical News*, Vol. 116 (1917), No. 3225, pp. 235–238.

War Work of the Technical Societies. C. W. RICE. *The Iron Trade Review*, Vol. 61 (1917), No. 21, pp. 1100–1102.

Wood: Economic Importance of Wood Preservation. K. C. BARTH. *Engineering and Mining Journal*, Vol. 104 (1917), No. 23, pp. 985–990

MARKET REPORT—DECEMBER, 1917

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON DEC. 20

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	6.00	@	6.05
Alum, ammonia, lump	100 Lbs.	4.00	@	4.50
Aluminum Sulfate, high-grade	Ton	60.00	@	80.00
Ammonium Carbonate, domestic	Lb.	11	@	11¼
Ammonium Chloride, white	Lb.	15	@	17
Aqua Ammonia, 26°, drums	Lb.	18	@	19
Arsenic, white	Lb.	15	@	16
Barium Chloride	Ton	65.00	@	70.00
Barium Nitrate	Lb.	9½	@	11
Barytes, prime white, foreign	Ton	28.00	@	30.00
Bleaching Powder, 35 per cent	100 Lbs.	2.00	@	2.25
Blue Vitriol	Lb.	9⅛	@	9¼
Borax, crystals, in bags	Lb.	7¼	@	8
Boric Acid, powdered crystals	Lb.	12¾	@	14
Brimstone, crude, domestic	Long Ton	nominal		
Bromine, technical, bulk	Lb.	60	@	65
Calcium Chloride, lump, 70 to 75% fused	Ton	22.00	@	23.00
Caustic Soda, 76 per cent	100 Lbs.	6.75	@	7.00
Chalk, light precipitated	Lb.	5½	@	6
China Clay, imported	Ton	18.00	@	30.00
Feldspar	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered	Ton	35.00		
Fuller's Earth, domestic	Ton	8.50	@	15.00
Glauber's Salt, in bbls	100 Lbs.	1.00	@	1.50
Green Vitriol, bulk	100 Lbs.	1.00	@	1.05
Hydrochloric Acid, commercial, 20°	Lb.	2	@	2½
Hydrochloric Acid, C. P., conc., 22°	Lb.	2½	@	2¾
Iodine, resublimed	Lb	4.25	@	4.30
Lead Acetate, white crystals	Lb.	17	@	19
Lead Nitrate	Lb.	nominal		
Litharge, American	Lb	9½	@	10
Lithium Carbonate	Lb.	1.50		
Magnesium Carbonate, U. S. P.	Lb	18	@	20
Magnesite, "Calcined"	Ton	60.00	@	65.00
Nitric Acid, 40°	Lb.	8¾	@	9
Nitric Acid, 42°	Lb.	9	@	10
Phosphoric Acid, 48/50%	Lb.	7½	@	8
Phosphorus, yellow	Lb.	1.90	@	2.00
Plaster of Paris	Bbl.	1.50	@	1.70
Potassium Bichromate, casks	Lb.	45	@	46
Potassium Bromide, granular	Lb.	1.45	@	1.46
Potassium Carbonate, calcined, 80 @ 85%	Lb.	45	@	55
Potassium Chlorate, crystals, spot	Lb.	42	@	45
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%	Lb.	82	@	84
Potassium Iodine, bulk	Lb.	2.90		
Potassium Nitrate	Lb.	28	@	30
Potassium Permanganate, bulk	Lb.	4.10	@	4.15
Quicksilver, flask	75 Lbs.	115.00	@	120.00
Red Lead, American, dry	Lb.	10	@	10½
Salt Cake, glass makers'	Ton	30.00	@	35.00
Silver Nitrate	Oz.	53	@	56
Soapstone, in bags	Ton	10.00	@	12.50
Soda Ash, 58%, in bags	100 Lbs.	2.90	@	3.00
Sodium Acetate	Lb.	18	@	19
Sodium Bicarbonate, domestic	100 Lbs.	2.50	@	2.60
Sodium Bichromate	Lb.	17	@	18
Sodium Chlorate	Lb.	24½	@	25
Sodium Fluoride, commercial	Lb.	18	@	19
Sodium Hyposulfite	100 Lbs.	1.75	@	2.00
Sodium Nitrate, 95 per cent, spot	100 Lbs.	4.60	@	4.75
Sodium Silicate, liquid, 40° Bé	100 Lbs.	1.75	@	2.00
Sodium Sulfide, 60%, fused, in bbls	Lb.	4½	@	5
Sodium Bisulfite, powdered	Lb.	6¾	@	7
Strontium Nitrate	Lb.	22	@	30
Sulfur, flowers, sublimed	100 Lbs.	4.05	@	4.06
Sulfur, roll	100 Lbs.	3.70	@	4.15
Sulfuric Acid, chamber, 66° Bé	Ton	nominal		
Sulfuric Acid, oleum (fuming)	Ton	60.00	@	65.00
Talc, American white	Ton	15.00	@	18.00
Terra Alba, American, No. 1	100 Lbs.	85	@	90
Tin Bichloride, 50°	100 Lbs.	23.75	@	24.75
Tin Oxide	Lb.	72	@	74
White Lead, American, dry	Lb.	9	@	9½
Zinc Carbonate	Lb.	25	@	30
Zinc Chloride, commercial	Lb.	10½	@	11
Zinc Oxide, American process XX	Lb.	14	@	15

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	70	@	75
Acetic Acid, 56 per cent, in bbls	Lb.	11	@	11½
Acetic Acid, glacial, 99½%, in carboys	Lb.	35	@	36
Acetone, drums	Lb.	35	@	36
Alcohol, denatured, 180 proof	Gal.	80	@	82
Alcohol, sugar cane, 188 proof	Gal.	5.05	@	5.25
Alcohol, wood, 95 per cent, refined	Gal.	1.35	@	1.40
Amyl Acetate	Gal.	5.25	@	5.50
Aniline Oil, drums extra	Lb.	26	@	27
Benzoic Acid, ex-toluol	Lb.	3.20	@	3.30
Benzol, Pure	Gal.	43	@	45
Camphor, refined in bulk, bbls	Lb.	76½	@	77½
Carbolic Acid, U. S. P., crystals, drums	Lb.	53	@	54
Carbon Bisulfide	Lb.	7½	@	8
Carbon Tetrachloride, drums, 100 gals	Lb.	14	@	16
Chloroform	Lb.	63	@	65
Citric Acid, domestic, crystals	Lb.	75	@	78
Creosote, beechwood	Lb.	1.90	@	2.00
Cresol, U. S. P.	Lb.	18	@	20
Dextrine, corn (carloads, bags)	Lb.	7	@	8
Dextrine, imported potato	Lb.	18	@	20
Ether, U. S. P. 1900	Lb.	27	@	30
Formaldehyde, 40 per cent	Lb.	19	@	20
Glycerine, dynamite, drums included	Lb.	62	@	64
Oxalic Acid, in casks	Lb.	45	@	46
Pyrogallic Acid, resublimed, bulk	Lb.	3.15	@	3.25
Salicylic Acid, U. S. P.	Lb.	1.25	@	1.30
Starch, cassava	Lb.	—		
Starch, corn (carloads, bags) pearl	100 Lbs.	6.30	@	6.45
Starch, potato, Japanese	Lb.	10½	@	11
Starch, rice	Lb.	10	@	12
Starch : sago flour	Lb.	6½	@	7½
Starch, wheat	Lb.	5¾	@	6½
Tannic Acid, commercial	Lb.	50	@	60
Tartaric Acid, crystals	Lb.	78½	@	79

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	54	@	60
Black Mineral Oil, 29 gravity	Gal.	18	@	19
Castor Oil, No. 3	Lb.	32	@	33
Ceresin, yellow	Lb.	nominal		
Corn Oil, crude	Lb.	—	@	—
Cottonseed Oil, crude, f. o. b. mill	Gal.	1.30	@	1.35
Cottonseed Oil, p. s. y.	Lb.	18.60	@	18.70
Menhaden Oil, crude (southern)	Gal.	—	@	—
Neat's-foot Oil, 20°	Gal.	2.50	@	2.60
Paraffin, crude, 118 to 120 m. p.	Lb.	10½	@	11
Paraffin Oil, high viscosity	Gal.	35	@	36
Rosin, "F" Grade, 280 lbs	Bbl.	7.10	@	7.20
Rosin Oil, first run	Gal.	35	@	36
Shellac, T. N.	Lb.	59	@	60
Spermaceti, cake	Lb.	25		
Sperm Oil, bleached winter, 38°	Gal.	1.85	@	2.00
Spindle Oil, No. 200	Gal.	34	@	35
Stearic Acid, double-pressed	Lb.	24	@	25
Tallow, acidless	Gal.	1.57	@	1.62
Tar Oil, distilled	Gal.	34	@	35
Turpentine, spirits of	Gal.	47	@	48

METALS

Aluminum, No. 1, ingots	Lb.	38	@	40
Antimony, ordinary	Lb.	15	@	15½
Bismuth, N. Y.	Lb.	2.85	@	2.90
Copper, electrolytic	Lb.	23½	@	—
Copper, lake	Lb.	23½	@	—
Lead, N. Y.	Lb.	6¼	@	6½
Nickel, electrolytic	Lb.	55	@	56
Platinum, refined, soft	Oz.	105.00		
Silver	Oz.	85⅞	@	86
Tin, Straits	Lb.	nominal		
Tungsten (WO_3)	Per Unit	23.00	@	25.00
Zinc, N. Y.	Lb.	7⅝	@	7¾

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	7.30	@	7.35
Blood, dried, f. o. b. Chicago	Unit	6.60	@	6.65
Bone, 3 and 50, ground, raw	Ton	32.00	@	35.00
Calcium Cyanamid	Unit of Ammonia	nominal		
Calcium Nitrate, Norwegian	100 Lbs.	—		
Castor Meal	Unit	—		
Fish Scrap, domestic, dried, f. o. b. works	Unit	6.50	@	10
Phosphate, acid, 16 per cent	Ton	16.00	@	16.50
Phosphate rock, f. o. b. mine:		5.50	@	6.50
Florida land pebble, 68 per cent	Ton	2.25	@	2.50
Tennessee, 78–80 per cent	Ton	5.50	@	6.00
Potassium "muriate," basis 80 per cent	Ton	350.00	@	355.00
Pyrites, furnace size, imported	Unit	nominal		
Tankage, high-grade, f. o. b. Chicago	Unit	6.25	&	10

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(*b*) Consultation in connection with the technical phases of the company's current operations.

(*c*) Investigation and reporting on the practicability of new processes submitted to the company.

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Lummus Co., The Walter E., Boston, Mass.
Pratt Eng. & Mach. Co., Atlanta, Ga.,& N.Y.C.
Thermal Syndicate, Ltd., The, N. Y. C.
U. S. Stoneware Co., The, Akron, O.

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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.
Jacoby, Henry E., N. Y. C.
Pfaudler Co., Rochester, N. Y.
Pratt Eng. & Mach. Co., Atlanta, Ga.,& N.Y.C.

Acid Distillation Apparatus
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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.

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Guernsey Earthenware Co., Cambridge, O.
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Knight, Maurice A., East Akron, O.
Palo Co., N. Y. C.
U. S. Stoneware Co., The, Akron, O.

Acid Plants (Complete or in Part)
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General Ceramics Co., N. Y. C.
Knight, M. A., East Akron, Ohio.
U. S. Stoneware Co., The, Akron, O.

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Dow Chemical Co., The, Midland, Mich.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
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Palo Company, N. Y. C.
Powers-Weightman-RosengartenCo., Phila., Pa.

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Cleveland Brass Mfg. Co., The, Cleveland, O.
Duriron Castings Co., N. Y. C.
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United Lined Tube & Valve Co., Boston, Mass.
York Manufacturing Co., York, Pa.

Acid Ware
General Ceramics Co., N. Y. C.

Acid Ware (Vitrified Clay)
Guernsey Earthenware Co., Cambridge, O.
U. S. Stoneware Co., The, Akron, O.

Agitators or Mixers
Cleveland Brass Mfg. Co., The, Cleveland, O.
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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.
Pratt Eng. & Mach. Co., Atlanta, Ga.,& N.Y.C.
Sowers Mfg. Co., Buffalo, N. Y.
Stevens Brothers, N. Y. C.
Werner & Ffleiderer 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
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Air Washers
Carrier Engineering Corp., N. Y. C.

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Norton Co., Worcester, Mass.
Scientific Materials Co., Pittsburgh, Pa.

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Brown Instrument Co., Philadelphia, Pa.
General Electric Co., Schenectady, N. Y.

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Powers-Weightman-Rosengarten Co.,Phila.,Pa.
Unger, John S., Chicago Ill

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York Manufacturing Co., York, Pa.

Ammonia—Salts of
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

Ammonia Stills
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Analysis—Gas
Sarco Co., Inc., N. Y. C.

Analysis—Gas Apparatus
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Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Eberbach & Son Co., Ann Arbor, Mich.
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Emil Greiner Co., The, N. Y. C.
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Palo Company, N. Y. C.
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Sargent & Co., E. H., Chicago, Ill.
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Daigger & Co., A., Chicago, Ill.
Eberbach & Son Co., Ann Arbor, Mich.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
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Sargent & Co., E. H., Chicago, Ill.
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Thomas Co., Arthur H., Philadelphia, Pa.
Tirrill Gas Mach. Ltg. Co., N. Y. C.

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Merck & Co., N. Y. C.

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Merck & Co., N. Y. C.

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Merck & Co., N. Y. C.
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Knight, M. A., East Akron, O.

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Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa.
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Griebel Instrument Co., Carbondale, Pa.
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Toch Bros., N. Y. C.

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Chemical Publishing Co., The, Easton, Pa.
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Wiley & Sons, Inc., John, N. Y. C.

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Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Whitall Tatum Co., Philadelphia, Pa.

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Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

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Knight, M. A., East Akron, O.

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Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
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.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill
Schutte & Koerting Co., Philadelphia, Pa.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Tirrill Gas Mach. 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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Knight, M. A., East Akron, Ohio.

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General Electric Co., Schenectady, N. Y.

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Dow Chemical Co., The, Midland, Mich.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co.,Phila.,Pa.

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Dow Chemical Co., The, Midland, Mich.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C
Powers-Weightman-Rosengarten Co.,Phila.,Pa.

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Eimer & Amend, N. Y. C.
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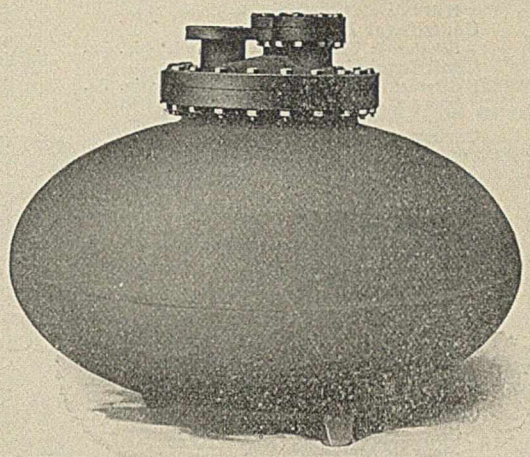

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This pump has a cast-iron shell and a lead lining. The shell is split vertically to provide easy access. The impeller is of the side-suction open type and is made of an antimony-lead composition which resists some forms of dilute acids better than bronze, particularly when they are hot.

The steel shaft is provided with a sleeve which protects it from the acid where it passes through the packing box. The two main bearings are wide and provided with ring oilers. At the outer end of the shaft is a ball thrust bearing to take care of the end thrust of the shaft and impeller. The pump is mounted on a heavy cast-iron base which may be bolted to skids, floor or a foundation.

Users of these pumps who have had many kinds of pumps in their chemical plants say that when both first cost and up-keep are considered, the total cost is only about one-third as great as any other acid pump they have had in service.

Bulletin 148 describes these pumps. Write for it.

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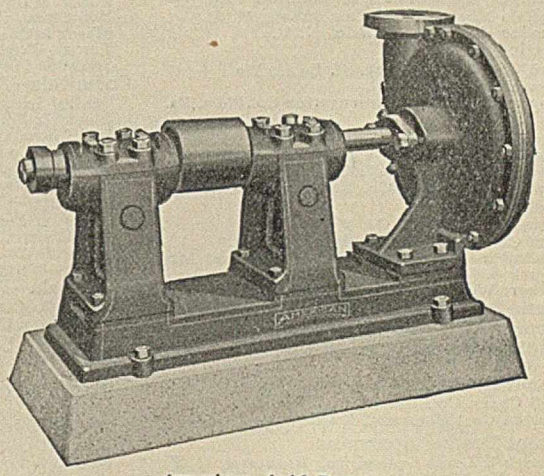
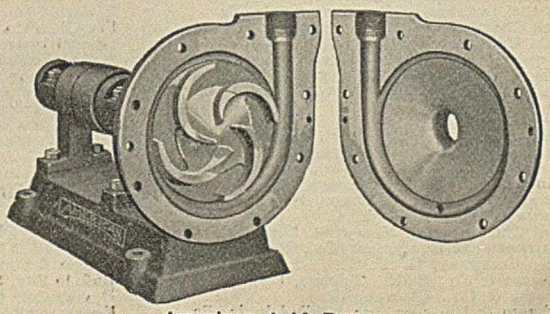


American Acid Pump



American Acid Pump
With casing opened showing Lead Lining and Antimony-Lead Composition Impeller

CLASSIFIED LIST OF CHEMICAL EQUIPMENT—(*Continued*)

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Dow Chemical Co., The, Midland, Mich.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

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Carboy Inclinators
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem Co., Henry, St. Louis, Mo.

Carboy Stoppers
Whitall Tatum Co., Philadelphia, Pa.

Carboy Stoppers (Acid Proof)
Knight, M. A., East Akron, O.

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Bausch & Lomb Optical Co., Rochester, N. Y.
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Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Duriron Castings Co., N. Y. C.
Eimer & Amend, N. Y. C.
Guernsey Earthenware Co., Cambridge, O.
Heil Chem. Co., Henry, St. Louis, Mo.
Herold China & Pottery Co., Golden, Colo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.

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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.
Pacific Foundry Co., San Francisco, Cal.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N.Y.C.

Castings—Caustic
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., 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.
Pratt Eng. & Mach. Co., Atlanta, Ga., & N.Y.C.
Sowers Mfg. Co., Buffalo, N. Y.
Werner & Pfleiderer Co., Saginaw, Mich.

Castings—Chemical, Acid and Caustic
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.

Castings—Evaporator & Vacuum Pan
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.

Caustic Potash
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

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.
Heil Chem. Co., Henry, St. Louis, Mo.
Mallinckrodt Chemical Wks., St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

Caustic Soda Dissolvers—Automatic
Lummus Co., The Walter E., Boston, Mass.

Cement Filler
Toch Bros, N. Y. C.

Cement Refractory
Heil Chem. Co., Henry, St. Louis, Mo.
Norton Co., Worcester, Mass.

Cement Testing Apparatus
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
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.

Centrifugals
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Cal.
Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
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
Central Scientific Co., Chicago, Ill.
Chicago Surgical & Electrical Co., Chicago Ill.
Heil Chem. Co., Henry, St. Louis, Mo.

Centrifugal Dryers
Schaum & Uhlinger, Inc., Philadelphia, Pa.

Centrifugal Engineers
Schaum & Uhlinger, Inc., Philadelphia, Pa.
Sharples Specialty Co., The, West Chester, Pa.
Tolhurst Machine Works, Troy, N. Y.

Cerium Oxalate
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

Charcoal
Booth Apparatus Co., Syracuse, N. Y.
Heil Chem. Co., Henry, St. Louis, Mo.

Chemical and Process Patents
Foster, A. B., Washington, D. C.

Chemical Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Central Scientific Co., Chicago, Ill.
Devine Co., J. P., Buffalo, N. Y.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Schaum & Uhlinger, Inc., Philadelphia, Pa.
Scientific Materials Co., Pittsburgh, Pa.

Chemical Glass Tubing
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C
Heil Chem. Co., Henry, St. Louis, Mo.

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.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill
Dearborn Chemical Co., Chicago, Ill.
Dow Chemical Co., The, Midland, Mich.
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.
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.
Powers-Weightman-Rosengarten Co., Phila., Pa.
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.
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y C.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.
Scientific Materials Co., Pittsburgh, Pa.

Chemicals—Laboratory
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.
Scientific Materials Co., Pittsburgh, Pa.

Chemicals—Medicinal
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

Chemicals—Photographic
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.

Chemicals—Technical
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Heil Chem. Co., Henry, St. Louis, Mo.
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Powers-Weightman-Rosengarten Co., Phila., Pa.

Chemical Glassware
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco.
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Eimer & Amend, N. Y. C.
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Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Independent Glass Apparatus Co., Phila., Pa.
Laboratory Supply Co., Columbus, O.
Palo Company, N. Y. C.
Sargent & Co., E. H., 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.
Powers-Weightman-Rosengarten Co., Phila., Pa.

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.
Central Scientific Co., Chicago, Ill.
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.
Merck & Co., N. Y. C.
Palo Company, N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.
Scientific Materials Co., Pittsburgh, Pa.

Chemical Specialties
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

Chemists' and Assayers' Supplies
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

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)
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

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
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa.

Cobalt—Metal & Salts
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

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.
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.
Central Scientific Co., Chicago, Ill.
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
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.

Colors—Aniline and Alizarine
Badische Co., N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
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.
Central Scientific Co., Chicago, Ill.
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.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thermal Syndicate, Ltd., The, N. Y. C.

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Heil Chem. Co., Henry, St. Louis, Mo.

Concentrators—Sulphuric Acid
Thermal Syndicate, Ltd., The, N. Y. C.

Condensers (Barometric and Surface)
Birmingham Mch.& Fd'y Co.,Birmingham, Ala.
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
Central Scientific Co., Chicago, Ill.
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.
Columbus Laboratories, Chicago, Ill.
Foster, A. B., Washington, D. C.
Hersey Co., Ltd., Milton, New York, Montreal, Winnipeg.
Institute of Industrial Research, Washington.
Levin, Isaac H., Newark, N. J.
Little, Arthur D., Inc., Cambridge, 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.
Singer-Perlstein Co., Milwaukee, Wis.
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.
Wiederhold, Ferdinand L., Jersey City, N. J.
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
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co.,Phila.,Pa.

Cores
Norton Co., Worcester, Mass.

Corn Oil (Extracted)

Counters—Revolution
Brown Instrument Co., Philadelphia, Pa.

Critical Point Determination Apparatus
Brown Instrument Co., Philadelphia, Pa.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
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.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
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.
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.
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.
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
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.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
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.

Crystallizers—Ammonia Nitrate
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., 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.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chemical Company, Henry, St. Louis, Mo.
Hoskins Mfg. Co., Detroit, Michigan.
Norton Company, Worcester, Mass.

Cylinders (Glass)
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
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
Devine Co., J. P., Buffalo, N. Y.
General Filtration Co., Inc., Rochester, N. Y.
Lummus Co., The Walter E., Boston, Mass.
Swenson Evaporator Co., Chicago, Ill.

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Dishes (Crystallizing)
Fry Glass Co., H. C., Rochester, Pa.

Dishes (Glass)
Fry Glass Co., H. C., Rochester, Pa.

Dishes (Petri)
Fry Glass Co., H. C., Rochester, Pa.

Dishes (Platinum)
Bishop & Co., J., Malvern, Pa.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.

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
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Bausch & Lomb Optical Co., Rochester, N. Y.
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Heil Chem. Co., Henry, St. Louis, Mo.
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Palo Company, N. Y. C.
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Schaar & Co., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
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Thomas Co., Arthur H., Philadelphia, Pa.
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Heil Chem. Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
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Drum Dryers—Vacuum and Atmospheric
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.

Dry Blast Plants
Carrier Engineering Corp., N. Y. C.

Dryers—Atmospheric
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.

Dryers—Centrifugals
Schaum & Uhlinger, Inc., Philadelphia, Pa.

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.
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Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Central Scientific Co., Chicago, Ill.
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Jacoby, Henry E., N. Y. C.
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Palo Company, N. Y. C.
Werner & Pfleiderer Co., Saginaw, Mich.

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Thwing Instrument Co., Philadelphia, Pa.

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Heil Chem. Co., Henry, St. Louis, Mo.

Electrical Instruments
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Central Scientific Co., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Heil Chem. Co., Henry, St. Louis, Mo.
Hoskins Mfg. Co., Detroit, Mich.
Palo Company, N. Y. C.
Thwing Instrument Co., Philadelphia, Pa.

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General Electric Co., Schenectady, N. Y.
Heil Chem. Co., Henry, St. Louis, Mo.
Leeds & Northrup Co., Phila., Pa.
Palo Company, N. Y. C.

Electrical Supplies
General Electric Co., Schenectady, N. Y.

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General Electric Co., Schenectady, N. Y.

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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.
Central Scientific Co., Chicago, Ill.
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.
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.

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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.
Birmingham Mch. & Fdy.Co.,Birmingham, Ala.
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.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Devine Co., J. P., Buffalo, N. Y.
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.

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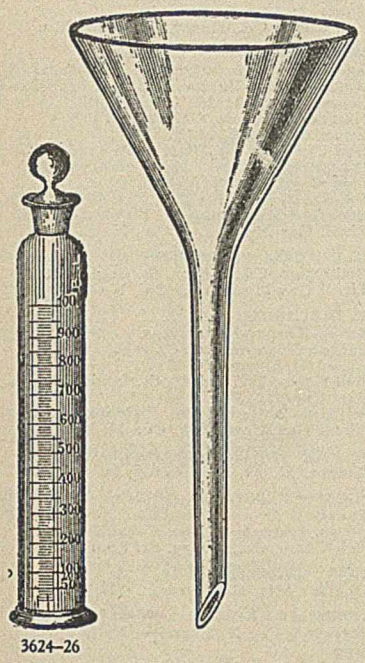

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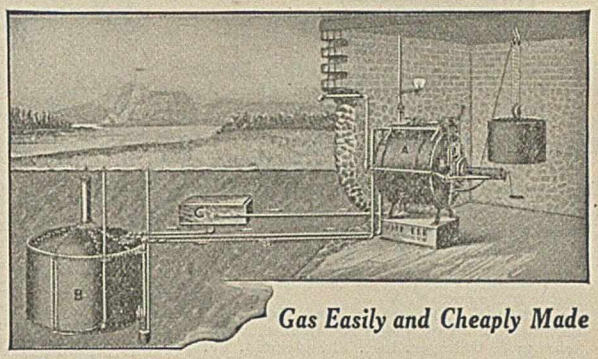

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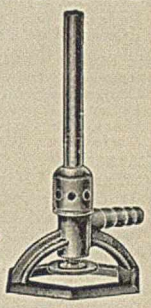

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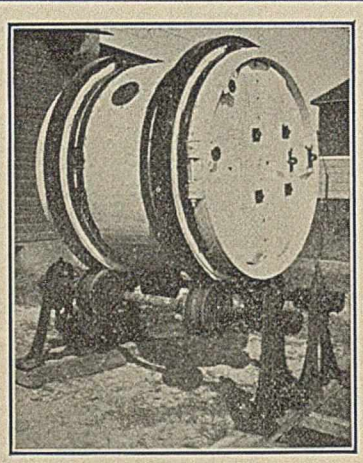

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Scientific Materials Co., Pittsburgh, Pa.
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Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.

Evaporators—Single and Multiple Effects
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Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.

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General Electric Co., Schenectady, N. Y.

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Duriron Castings Co., N Y. C.

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Badger & Sons Co., E. B., Boston. Mass.
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Devine Co., J. P., Buffalo, N. Y.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Lummus Co., The Walter E., Boston, Mass.
Schaum & Uhlinger, Inc., Philadelphia, Pa.
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
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Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Norton Co., Worcester, Mass.

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Schaum & Uhlinger, Inc., Philadelphia, Pa.

Fabroil Gears & Pinions
General Electric Co., Schenectady, N. Y.

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Knight, Maurice A., East Akron, Ohio.
U. S. Stoneware Co., The, Akron, O.

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Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
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.
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.

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Bausch & Lomb Optical Co., Rochester, N. Y.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa.

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Braun-Knecht-Heimann Co.,San Francisco.Cal.
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
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.

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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.
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.

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.
Central Scientific Co., Chicago, Ill.
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.
Schutte & Koerting Co., Philadelphia, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

Filtros
General Filtration Co., Inc., Rochester, N. Y.

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Devine Company, J. P., Buffalo, N. Y.

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Belden Brick Co., Canton, O.

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Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
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Fry Glass Co., H. C., Rochester, Pa.
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Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Whitall Tatum Co., Philadelphia, Pa.

Fuel Gas Plants
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Heil Chem. Co., Henry, St. Louis, Mo.
Tirrill Gas Mach. Ltg. Co., N. Y. C.

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Whitall Tatum Co., Philadelphia, Pa.

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Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Tirrill Gas Mach. Ltg. Co., N. Y. C.

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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.

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Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco,Cal.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Electric Heating Apparatus Co., N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Tirrill Gas Mach. Ltg. Co., N. Y. C.

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Bausch & Lomb Optical Co., Rochester, N. Y.
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Braun-Knecht-Heimann Co., San Francisco,Cal.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Electric Heating Apparatus Co., N. Y. C.
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Palo Company, N. Y. C.
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Eimer & Amend, N. Y. C.
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Schutte & Koerting Co., Philadelphia, Pa.
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Tirrill Gas Mach. Ltg. Co., N. Y. C.

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Tirrill Gas Mach. Ltg. Co., N. Y. C.

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Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Tirrill Gas Mach. Ltg. Co., N. Y. C.

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Eberbach & Son Co., Ann Arbor, Mich.
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Scientific Materials Co., Pittsburgh, Pa.
Whitall Tatum Co., Philadelphia, Pa.

Glass Blowing
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Pfaudler Co., Rochester, N. Y.

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Independent Glass Apparatus Co., Phila., Pa.
Scientific Materials Co., Pittsburgh, Pa.
Whitall Tatum Co., Philadelphia, Pa.

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Abbé Engineering Co., N. Y. C.
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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.
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Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.

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Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
Brown Instrument Co., Philadelphia, Pa.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Electric Heating Apparatus Co., N. Y. C.
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Electric Heating Apparatus Co., N. Y. C.
General Electric Co., Schenectady, N. Y.
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International Glass Co., The, Millville, N. J.
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 Mach. Ltg. Co., N. Y. C.

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Tolhurst Machine Works, Troy, N. Y.

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Braun Corporation, Los Angeles, Cal.
Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
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.
Scientific Materials Co., Pittsburgh, Pa.
Taylor Instrument Cos., Rochester, N. Y.
Thomas Co., Arthur H., Philadelphia, Pa.

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Taylor Instrument Cos., Rochester, N. Y.

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General Electric Co., Schenectady, N. Y
York Manufacturing Co., York, Pa.

Ichthyol
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.

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Devine Co., J. P., Buffalo, N. Y.

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Chicago Surgical & Electrical Co., Chicago, Ill.
Heil Chem. Co., Henry, St. Louis, Mo.

Indicating Instruments
Heil Chem. Co., Henry, St. Louis, Mo.
Taylor Instrument Cos., Rochester, N. Y.

Indicators—(Speed & Test)
Brown Instrument Co., Philadelphia, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa.

Industrial Burners & Specialties
Heil Chem. Co., Henry, St. Louis, Mo.
Tirrill Gas Mach. Ltg. Co., N. Y. C.

Industrial Motor Control Devices
General Electric Co., Schenectady, N. Y.

Injectors for Acids and Gases
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Instrument—Precision Manufacturers
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Scientific Materials Co., Pittsburgh, Pa.

Iodine—Salts of
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Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co.,Phila.,Pa.

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Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co.,Phila.,Pa.

Iron and Steel Analysis Apparatus—Manufacturers
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa.

Jars (Hydrometer)
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Eimer & Amend, N Y C
Heil Chem. Co., Henry, St. Louis, Mo.
Whitall Tatum Co., Philadelphia, Pa.

Jars (for Primary & Storage Batteries)
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
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Guernsey Earthenware Co., Cambridge, O.
Heil Chem. Co., Henry, St. Louis, Mo.
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.
Heil Chem. Co., Henry, St. Louis, Mo.
Herold China & Pottery Co., Golden, Col.
Knight, M. A., East Akron, O.
U. S. Stoneware Co., The, Akron, O.

Kettles—Caustic Soda
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.

Kettles (Chemical Castings)
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Devine Co., J. P., 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.

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Devine Co., J. P., Buffalo, N. Y.
Elyria Enameled Prod. Co., Elyria, O., N.Y.C.
Pfaudler Co., Rochester, N. Y.
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., So. 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.
Jacoby, Henry E., N. Y. C.
Pfaudler Co., Rochester, N. Y.
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.

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Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Sargent & Co., E. H., Chicago, Ill.
Schaum & Uhlinger, Inc., Philadelphia, Pa.
Scientific Materials Co., Pittsburgh, Pa.

Laboratory Burners
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa.
Tirrill Gas Mach. Ltg. Co., N. Y. C.

Laboratory Chemicals
Central Scientific Co., Chicago, Ill.
Dow Chemical Co., The, Midland, Mich.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co.,Phila.,Pa.

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Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa.
Tirrill Gas Mach Ltg. Co., N. Y. C.

Laboratory Glassware
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C
Heil Chem. Co., Henry, St. Louis, Mo.

Laboratory Supplies
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
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.
Heil Chem. Co., Henry, St. Louis Mo.
Laboratory Supply Co., The, Columbus, O.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Tirrill Gas Mach. Ltg. Co., N. Y. C.
Whitall Tatum Co., Philadelphia, Pa.

Laboratory Supplies, Platinum
Central Scientific Co., Chicago, Ill.
Baker & Co., Inc., Newark, N. J.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.

Lace Leather
Schieren Co., Chas. A., N. Y. C.

Lacquer
General Bakelite Co., N. Y. C.

Lactic Acid
Heil Chem. Co., Henry, St. Louis, Mo.
Powers-Weightman-Rosengarten Co.,Phila.,Pa.

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.

Lead Lined Pipe and Accessories
Badger & Sons Co., E. B., Boston, Mass.
Schutte & Koerting Co., Philadelphia, Pa.

Leather Belting (Regular Oak Tanned and Duxbak Waterproof; Round; Link)
Schieren Co., Chas. A., N. Y. C.

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.

Machinery—Chemical
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., 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.
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
General Filtration Co., Inc., Rochester, N. Y.
Heil Chem. Co., Henry, St. Louis, Mo.
Stokes Machine Co., F. J., Philadelphia, Pa.
Werner & Pfleiderer Co., Saginaw, Mich.

Machinery—Mixing and Kneading
Abbé Engineering Co., N. Y. C.
Elyria Enameled Products Co., Elyria, O.
Jacoby, Henry E., N. Y. C.
Pfaudler Co., Rochester, N. Y.
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.
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
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.

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
Dow Chemical Co., The, Midland Mich.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-RosengartenCo.,Phila.,Pa.

Mercury—Salts of
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co.,Phila.,Pa.

Metallographic Apparatus
Bausch & Lomb Optical Co., Rochester, N. Y.
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chemical Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
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
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Hoskins Mfg. Co., Detroit, Mich.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

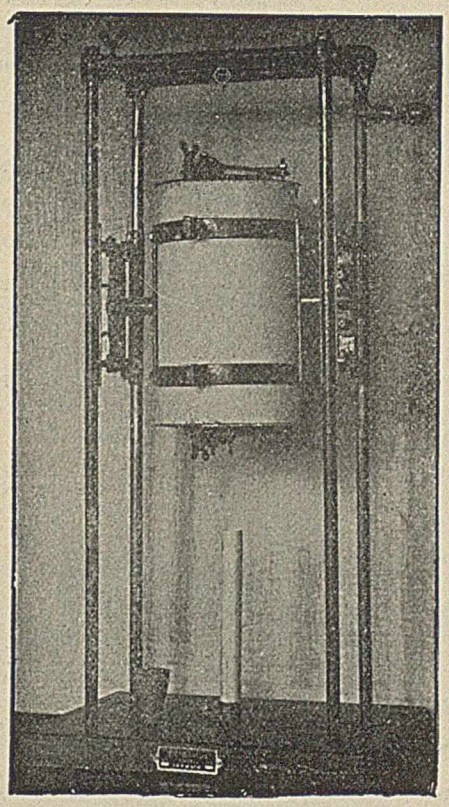
Meters—Flow Air, Gas, Water
General Electric Co., Schenectady, N. Y.

Microscopes
Bausch & Lomb Optical Co, Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ili
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.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

Microtomes
Bausch & Lomb Optical Co., Rochester, N. Y.
Central Scientific Co., 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.
Thomas Co., Arthur H., Philadelphia, Pa.

Micro Photo. Apparatus Mfrs.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa.

Mills—Ball, Pebble and Tube
Abbé Engineering Co., N. Y. C
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.



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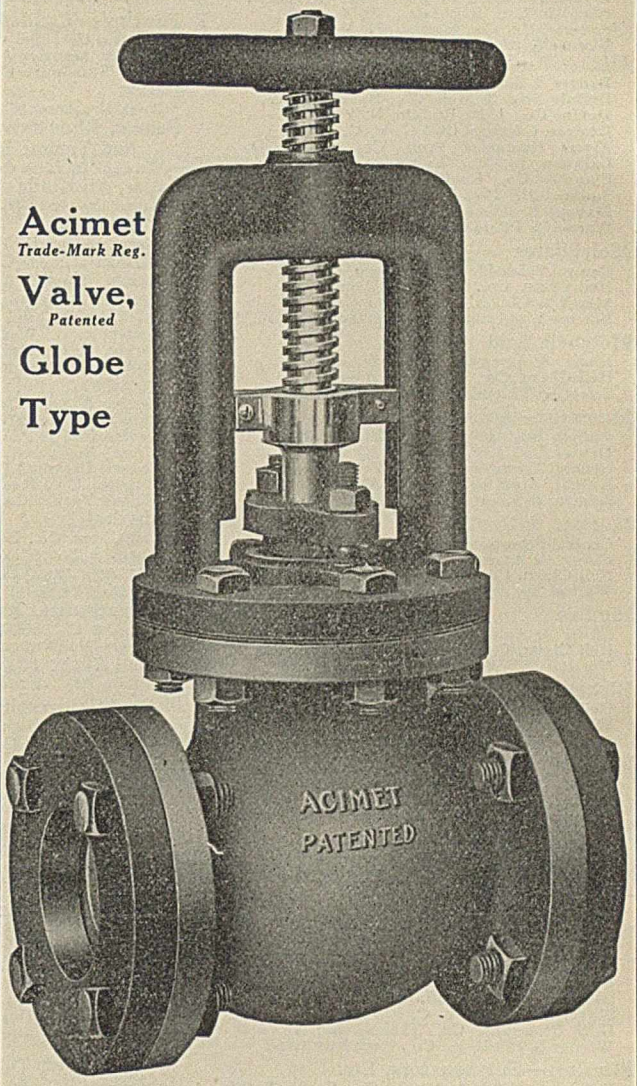

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Elyria Enameled Products Co., Elyria, O.
Pfaudler Co., Rochester, N. Y.
Sowers Mfg. Co., Buffalo, N. Y.
Werner & Pfleiderer Co., Saginaw, Mich.

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.
Lummus Co., The Walter E., Boston, Mass.
Pfaudler Co., Rochester, N. Y.
Sowers Mfg. Co., Buffalo, N. Y.
Stevens Brothers, N. Y. C.
Werner & Pfleiderer Co., Saginaw, Mich.

Molybdates
Central Scientific Co., Chicago, Ill.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co.,Phila.,Pa.

Molybdic Acid
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
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.

Mortars & Pestles
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y C.
Heil Chem. Co., Henry, St. Louis, Mo.
Whitall Tatum Co., Philadelphia, Pa.

Muffles
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Norton Co., Worcester, Mass.

Nickel—Salts of
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co.,Phila.,Pa.

Nitrating Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Schaum & Uhlinger, Inc., Philadelphia, Pa.

Nitrating Pots
Bethlehem Fdy. & Mach.Co., So.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.
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.
General Ceramics Co., N. Y. C.
Pratt Eng. & Mach. Co., Atlanta, Ga.,& 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.
Central Scientific Co., Chicago, Ill.
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.
Taylor Instrument Cos., Rochester, N. Y.
Thomas Co., Arthur H., Philadelphia, Pa.

Optical Instruments
Bausch & Lomb Optical Co., Rochester, N. Y.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Thwing Instrument Co., Philadelphia, Pa.

Optical Pyrometer
Heil Chem. Co., Henry, St. Louis, Mo.
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.
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.
General Ceramics Co., N. Y. C.
Pfaudler Co., Rochester, N. Y.
Whitall Tatum Co., Philadelphia, Pa.

Perhydrol
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.

Pharmaceutical Dryers
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Pharmaceutical Preparations
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co.,Phila.,Pa.

Phenol Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Photo-Micrographic Apparatus
Bausch & Lomb Optical Co., Rochester, N. Y.
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Thomas Co., Arthur H., Philadelphia, Pa.

Picric Acid Apparatus
Knight, Maurice A., East Akron, O.

Pipe and Accessories (Acid Proof)
Bethlehem Fdy.&Mach.Co., So.Bethlehem,Pa.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Duriron Castings Co., N. Y. C.
Elyria Enameled Prod. Co., Elyria, O.
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.
Thermal Syndicate, Ltd., The, N. Y. C. (Fused Silica.)
United Lined Tube & Valve Co., Boston, Mass.
U. S. Stoneware Co., The, Akron, O.

Pipe and Fittings—Lead or Tin Lined
Schutte & Koerting Co., Philadelphia, Pa.
United Lined Tube & Valve Co., Boston, Mass.

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.
Central Scientific Co., Chicago, Ill.
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.
Central Scientific Co., Chicago, Ill.
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.
Palo Company, N. Y. C.
Sargent & Co., E. H., 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.
Central Scientific Co., Chicago, Ill.
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.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.

Portable Ozonators
General Electric Co., Schenectady, N. Y.

Potassium—Salts of
Dow Chemical Co., The, Midland, Mich.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co.,Phila, Pa.

Pots—Acid Proof Stoneware
Knight, Maurice A., East Akron, O.

Precision Instrument Makers
Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa.

Protecting Tubes, Thermocouples
Hoskins Mfg. Co., Detroit, Mich.

Publishers
Chemical Publishing Co., Easton, Pa.
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.
Central Scientific Co., Chicago, Ill.
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.
Thomas Co., Arthur H., Philadelphia, Pa.
Williams Patent Crusher & Pulv. Co., Chicago.

Pumps
Tirrill Gas Mach. Ltg. Co., N. Y. C.

Pumps—Acid
American Well Works, The, Aurora, Ill.
Bausch & Lomb Optical Co., Rochester, N. Y.
Central Scientific Co., Chicago, Ill.
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.
Heil Chem. Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Schutte & Koerting Co., Philadelphia, Pa.
U. S. Stoneware Co., The, Akron, O.

Pumps (Chemical)
American Well Works, The, Aurora, Ill.

Pumps (Laboratory Vacuum)
Abbé Engineering Co., N. Y. C.
Bausch & Lomb Optical Co., Rochester, N. Y
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Central Scientific Co., Chicago, Ill.
Crowell Mfg. Co., Brooklyn, N. Y.
Daigger & Co., A., Chicago, Ill.
Devine Co., J. P., Buffalo, N. Y.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
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.

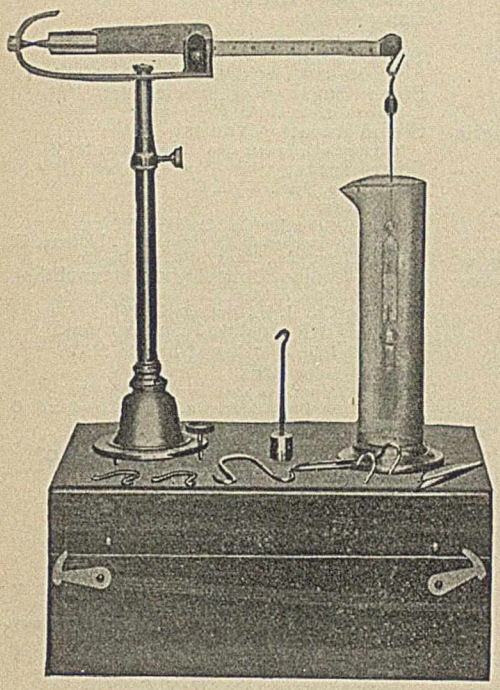
Pyrometer Tubes
Norton Co., Worcester, Mass.

Pyrometers
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco.
Brown Instrument Co., Philadelphia, Pa.
Central Scientific Co., Chicago, Ill.
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.
Hoskins Mfg. Co., Detroit, Mich.
Leeds & Northrup Co., The, Philadelphia, Pa.
Palo Company, N. Y. C.
Sargent & Co., E. H., 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.
Heil Chem. Co., Henry, St. Louis, Mo.

Pyrometers (Optical)
Braun-Knecht-Heimann Co., San Francisco.
Brown Instrument Co., Philadelphia, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.

WESTPHAL BALANCES



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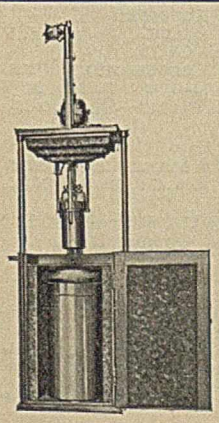

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Pyrometers (Radiation)
Heil Chem. Co., Henry, St. Louis, Mo.
Leeds & Northrup Co., The, Philadelphia, Pa
Taylor Instrument Cos., Rochester, N. Y.
Thwing Instrument Co., Philadelphia, Pa.

Quartz
Booth Apparatus Co., Syracuse, N. Y.

Quartz Glass
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco.
Brown Instrument Co., Philadelphia, Pa.
Central Scientific Co., Chicago, Ill.
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.
Scientific Materials Co., Pittsburgh, Pa.
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
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
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.
Central Scientific Co., Chicago, Ill.
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.
Powers-Weightman-Rosengarten Co. Phila., Pa.
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.
Brown Instrument Co., Philadelphia, Pa.
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
General Electric Co., Schenectady, N. Y.
Heil Chem. Co., Henry, St. Louis, Mo.
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.
Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa.
Taylor Instrument Cos., Rochester, N. Y.

Reduction Kettles
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.

Refineries—(Oil—Sugar Installation)
Lummus Co., The Walter E., Boston, Mass.

Refractories
Guernsey Earthenware Co., Cambridge, O.
Heil Chem. Co., Henry, St. Louis, Mo.
Herold China & Pottery Co., Golden, Colo.
Norton Co., Worcester, Mass.

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
Heil Chem. Co., Henry, St. Louis, Mo.
Hoskins Mfg. Co., Detroit, Mich.

Resistance Wire—Base Metal
Heil Chem. Co., Henry, St. Louis, Mo.
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.
Heil Chem. Co., Henry, St. Louis, Mo.

Retorts
Badger & Sons Co., E. B., Boston, Mass.
Bausch & Lomb Optical Co., Rochester, N. Y.
Braun-Knecht-Heimann Co., San Francisco.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Central Scientific Co., Chicago, Ill.
Daigger & Co. A., Chicago, Ill.
Devine Co., J. P., Buffalo, N. Y.
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.
Thermal Syndicate, Ltd., The, N. Y. C.

Retorts (Cast Iron)
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Heil Chem. Co., Henry, St. Louis, Mo.
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.
Devine Co., J. P., 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.
Central Scientific Co., Chicago, Ill.
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 Mach. 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.
Central Scientific Co., Chicago, Ill.
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
Central Scientific Co., Chicago, Ill.
Heil Chem. Co., Henry, St. Louis, Mo.
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 Mach. Ltg. Co., N. Y. C.

Shelf Dryers—Vacuum
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., 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.
Brunt & Co., H. H., Chicago, Ill.
Central Scientific Co., 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.
Scientific Materials Co., Pittsburgh, Pa.
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
Devine Co., J. P., Buffalo, N. Y.
Swenson Evaporator Co., Chicago, Ill.

Sodium-Benzol-Sulphonate Dryers
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.

Sodium—Salts of
Dow Chemical Co., The, Midland, Mich.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

Soldering Iron Heaters
Tirrill Gas Mach. Ltg. Co., N. Y. C.

Solenoids
Central Scientific Co., Chicago, Ill.
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.
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
Central Scientific Co., Chicago, Ill.
Chicago Surgical & Electrical Co., Chicago, Ill.
Heil Chem. Co., Henry, St. Louis, Mo.

Stills—Aniline, Phenol and Betanaphthol
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., 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.
Jacoby, Henry E., N. Y. C.
Palo Company, N. Y. C.
Pfaudler Co., Rochester, N. Y.
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.
Central Scientific Co., Chicago, Ill.
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.
Schutte & Koerting Co., Philadelphia, Pa.
Scientific Materials Co., Pittsburgh, Pa.
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.
U. S. Stoneware Co., The, Akron, O.

Stoppers—Rubber
Central Scientific Co., Chicago, Ill.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Whitall Tatum Co., Philadelphia, Pa.

Storage Battery Recharging Apparatus
General Electric Co., Schenectady, N. Y.

Strontium—Salts of
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

Sugar Mill Machinery
Devine Co., J. P., Buffalo, N. Y.
Swenson Evaporator Co., Chicago, Ill.

Sulphonating Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.
Duriron Castings Co., N. Y. C.

Sulphuric Acid
Heil Chem. Co., Henry, St. Louis, Mo.
New Jersey Zinc Co., The, N. Y. C.
Powers-Weightman-Rosengarten Co., Phila., Pa.

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
Heil Chem. Co., Henry, St. Louis, Mo.
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.
Schutte & Koerting Co., Philadelphia, Pa.

Tachometers
Brown Instrument Co., Philadelphia, Pa.
Palo Company, N. Y. C.
Taylor Instrument Cos., Rochester, N. Y.