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EDITORIALS

FROM AN "ADOPTED" ONE

On paper bearing a broad margin of black, indicative of the irreparable loss of a father, there came recently the following charming, childlike letter. This little link in the chain of international attachment was received by a member of the American Chemical Society who had quickly answered the appeal of the American Ouvroir Funds by "adopting" the orphaned son of a French engineer.

> Mon cher Parrain:
>
> Maman m'a dit que j'avais un parrain en Amérique. Je voudrais bien vous connaître mais c'est bien loin, l'Amérique. Quand je serai grand je pourrai peutêtre aller vous voir. Je vais a l'école. Je travaille bien. Je tâcherai que vous soyez content de moi. Je vous embrasse de tout mon coeur.
>
> Votre petit filleul
> Marcel Pierron
>
> 23 Janvier, 1919
> 4 rue Gallieni
> Asniéres, Siene

Interest is actively increasing in the work of the organization which is placing in our hands in such a dignified and comprehensive manner information concerning these little ones. From the February number of *The Catalyst* it is learned that the Delaware Section has already raised $2000 for this purpose and that the Philadelphia Section is likewise engaged in raising a goodly sum.

Let the good work go on!

THE SOLDIER, THE SAILOR, AND THE CHEMIST

An amazing thing about the early months of our participation in the war was the slowness with which high officials of the War and Navy Departments waked to the importance of chemistry in a conflict such as was then raging in Europe. It was not by the strictly war-making departments that the first stimulus to chemistry organization and chemical research was given, but by the Interior Department, through its Bureau of Mines.

In view of the comprehensive and vigorous way in which the service of the chemist was later utilized by both the War and Navy Departments, the question naturally arises: Why were they so tardy in grasping the significance of chemistry in this great undertaking? Doubtless the reasons are many, but we believe one of the most fundamental to be the attenuated character of the chemistry atmosphere at West Point and Annapolis.

This statement contains no reflection whatever upon the able instructors in chemistry at either of the great institutions for the training of our land and sea officers. These institutions cannot be expected to turn out military or naval chemists, even if there were such things; such instruction as is given must be elementary and more or less superficial, because of the limited time available for the subject. This side of the question gives no worry, for civilian assistance from men with the highest chemical training may always be relied upon when the pinch of war comes.

It is, however, extremely desirable that every student at West Point and at Annapolis should receive a clear picture of the chemical industries of this country as a whole, their interrelations, and their function in the transformation of raw material into the supplies which support a modern army and navy. Then, too, they should be given from time to time a general view of the trend of chemical research on lines bearing directly upon military and naval problems. General surveys of this character, to be most effective, should be given by the recognized leaders in the chemical industries and in chemical research.

We would like to suggest, therefore, that the Secretary of War and the Secretary of the Navy request the President of the American Chemical Society to appoint a committee which will give annually, at West Point and at Annapolis, five or six general lectures. The leading chemists of this country would consider it a patriotic privilege to participate in the undertaking, and our future generals and admirals would set out upon their careers with a clearer grasp and a more sympathetic understanding of that science from which war-making can never be divorced.

ARE YOUR NEEDS TAKEN CARE OF?

In this issue, page 257, there is printed a general schedule of classification of government statistics of imports and exports, followed by schedules of special interest to every producer of finished products and to every consumer of imported raw material in the chemical industries. These schedules have been prepared under the supervision of Mr. G. B. Roorbach of the U. S. Shipping Board (not of the Department of Commerce, as erroneously stated in our last issue).

To those who may wonder why so much space is devoted to the publication of this material, we would say that we consider this one of the most important contributions which has ever reached this office. Why?

Government statistics of interest to the chemical industries have always been lamentably weak. The information has been thrown into basket clauses in a way useless to one trying to develop a business intelligently. It has generally been an awful job to upset the normal practices of humdrum departmental matters in Washington. This time, however, someone has seen the light, and action has sprung from within. The various government divisions, hitherto working independently, each under its own system of classification, have realized the efficiency of a uniform system, and that the industries are entitled to far more detailed information than has previously been furnished. The published material represents a joint effort.

Another party to full coöperation is lacking, the individual manufacturer. You are now invited by Mr. Roorbach to join in the project. You know in detail exactly the kind of statistical matter you would like the Government to publish regularly and promptly for your information. Look over these lists and see whether the items you are interested in are included. If not, write Mr. Roorbach, and *write him promptly*, for the final form of the system must be quickly determined if instructions are to reach all foreign consuls in time for the necessary changes to be made in official procedure, and for the new system to become effective with the beginning of the next fiscal year.

THE WOMAN CHEMIST HAS COME TO STAY

War brought woman into industrial chemistry. The draft of the men of the laboratories into war service made necessary her increased employment. Many were the misgivings, but these have proved groundless. Evidence from all sides warrants the statement that in this comparatively new line she has abundantly made good. Perhaps the most interesting testimony is offered by Mr. William M. Brady, chief chemist of the Illinois Steel Company, in a statement published in the February number of *The Chicago Chemical Bulletin.*

Speaking of the women in his laboratory, Mr. Brady says:

> They learned the work as quickly as any men of like training could have learned it. * * * They were and are careful, conscientious, reliable workers in the field of industrial chemistry, taking their turns at night work cheerfully, and so far as I can learn, contentedly.

As to capacity for work, Mr. Brady does not deal in generalities but gives convincing figures:

> During the month of July there were employed on iron and steel work, thirty-one men and seven women. Total number of determinations made in July on iron and steel, 68,798—made by women, 10,741, or 15.6 per cent of the total. Per cent of women employed, 18.5—not quite their share; they were learning the work.
>
> During the month of October there were thirty-six men and an average of six and a half women employed on iron and steel work, three women leaving during the month, two to go back to school, one securing a better position. This to explain the one-half woman. Total number of determinations made in October on iron and steel, 66,956; made by women, 10,721, or 16 per cent of the total. Percentage of women employed, 15.3. From this it is readily seen that as soon as the women learned the work, they carried their share of the work. During the hot weather of last summer, when to sleep, for those working at night, was almost impossible, the percentage of women off duty was less than the men.
>
> The percentage of women off duty on account of sickness is not greater than the men. In fact it has not equaled the men in our particular case, several of our men being on extended sick leave.
>
> Requests for days off duty by women are not excessive, and are not more than those of men.

In conclusion he pays the following tribute to his women chemists:

> They have added tone to our laboratory by their pleasing personalities. They have proved beyond a doubt that they can do and will do at any hour of the day or night, careful, conscientious, reliable chemical work. They have passed the crucial test of service. They have been weighed in the chemical balance and not found wanting.

Such testimony means only one thing: The woman chemist has come to stay. This of course increases the present oversupply of chemists, and adds another point to the argument in last month's editorial, "Back to the Colleges and Universities." Read page 255 of this issue.

"AM I MY BROTHER'S KEEPER?"

When an accident of an unusual and unexpected character occurs in a laboratory, particularly a university laboratory, the details are frequently written up for publication in the journals, so that fellow-chemists, working with the same substance or under the same set of conditions, may profit by the unfortunate experience. The same cannot be said of accidents in industrial plants. Here a shroud of secrecy seems to be the rule. It is a phase of that same unfortunate psychology which has proved so detrimental to the industry in many other matters.

This subject was discussed at length and from every angle at the February meeting of the Advisory Committee, and it was the unanimous opinion of the Committee that full publicity regarding details of accidents in the chemical industries is extremely desirable. For this reason a section of THIS JOURNAL will be set aside for the prompt publication of such matter whenever it can be legitimately obtained. Communications on this subject are urgently requested.

If the life of one workman is saved through this publicity, the reward will be ample.

NEEDED REFORMS IN THE PATENT OFFICE

Patent matters are to the fore nowadays: not in matters of litigation but in careful study of the system. For some time past a committee of the National Research Council has been thoroughly investigating the matter from every standpoint, with the sympathetic desire to accomplish changes which will bring the office into more perfect accord with present conditions and insure its yielding that full measure of usefulness which its founders hoped. The report of the committee is published on page 250 of this issue to enable general participation in the further discussion of the subject, and it is asked that all suggestions be forwarded direct to the acting chairman of the committee.

As a further contribution to this subject there is printed on page 237 of this issue the forceful address of Mr. Thomas Ewing, former Commissioner of Patents, on "The Needs of the U. S. Patent Office," before the War Emergency Reconstruction Conference at Atlantic City last December. Because of his many years of successful conduct of the office of Patent Commissioner, Mr. Ewing speaks from an intimate knowledge of the situation, and, being no longer connected with the office, with an engaging frankness and earnestness which carry conviction.

Mr. Ewing pleads for the pressure of well-informed public opinion to be brought to bear upon Congress in order to secure the needed reforms. To develop such pressure it will first be necessary to convince the public that the most efficient working of the Patent Office is one which directly benefits each and every citizen. On this subject we stated in 1916 at Seattle, during the course of a presidential address:

> The value of the patent system as a national asset lies not only in the constant additions to daily welfare, but also in the eventual public ownership of the new ideas underlying these

> contributions, for the life of a patent is only seventeen years, during which time expenditure both of brain and of funds is necessary to bring the idea to its highest practical development; then the idea legally becomes the property of the nation for unrestrained use.* * * * * If these general considerations ever find full lodgment in the public mind, there will be no difficulty in securing such congressional action as will perfect the patent system and legal procedures incident thereto, thus enabling it to serve fully those high ends for which it was designed.

Perhaps the best method for bringing this home to the general public would be the publication of popular articles showing how the general welfare has been served, not only through the fostering of the inventive spirit among certain creative individuals, but also through successful development of products and processes which as originally patented would have been of little value, but under patent protection were successfully developed and became at the end of the seventeen-year period available to the public in perfected state and at largely reduced cost.

That the pressure of public opinion should be brought to bear upon Congress for remedial patent legislation is well illustrated by certain existing legislation under which those with whom we are at war are given definite advantage over our Allies. Under the Act of August 17, 1916, a nine months' extension for filing, paying fees, etc., was granted those unable on account of the war to take action within the period now fixed by law, and operated further to relieve from defaults which occurred after August 1, 1914, and before January 1, 1918, apparently assuming that the war would be well over before the latter date. This act specifically excluded enemies from the benefits of the legislation.

A few months later the Trading with the Enemy Act was passed, under which:

> Any such enemy, or ally of enemy, who is unable during war, *or within six months thereafter*, on account of conditions arising out of war, to file any such application, or to pay any official fee, or to take any action required by law within the period prescribed by law, may be granted an extension of nine months beyond the expiration of said period, provided the nation of which the said applicant is a citizen, subject, or corporation shall extend substantially similar privileges to citizens and corporations of the United States.

To correct the injustice in time allowance in the two acts, bills were introduced in both the House and the Senate to grant the nine months' extension where default occurred *within six months after the close of the war*, instead of before January 1, 1918, thus giving to our Allies the same privileges our enemies enjoy. Up to the present time, however, practically a year after the introduction of the bills and with the end of the war in sight, the measure has not become law.

This failure to correct defective legislation affects not only our Allies but also our own citizens who have been unable owing to war conditions to file applications, pay fees, etc., in foreign countries within the period fixed by the laws of those countries, for their right to an extension depends upon the rights we accord to the citizens of foreign countries.

Surely Congress does not desire to give special privileges in these matters to our enemies, but the lack of legislation has brought about just that a result.

NOTES

A new development of the A. C. S. News Service—the Associated Press is beginning to send out over its wires abstracts of the Weekly Bulletins. Mr. John W. Harrington moves quietly but effectively. Find a subject which has a real news punch and try your hand.

In planning for demobilization England failed to include the chemical among the "pivotal" industries. Does this mean that England is slipping backward, that her public men are already forgetting the lesson of the war? It is to be hoped not, in view of the fine service rendered by the English chemists during the war.

Professor J. R. Withrow calls attention on page 253 of this issue to a matter which soon may affect every laboratory. Measures for enforcement of prohibition legislation are now being drafted in many states. Those in charge of such legislation can have no desire to inflict any hardship upon the work of the chemist, but it is up to us to point out the need for alcohol as a chemical reagent and the necessity of distilling apparatus in laboratory operations.

If these matters are properly presented in advance of legislation many vexing situations will be avoided.

One of the pleasures of a strict rule is the privilege of breaking it every now and then. Our practice is against the use of the name of any commercial firm in this editorial section, but we do wish to express to Lord and Taylor, of New York City, appreciation of their policy in placing beside displays of beautifully dyed silks, large placards bearing the words:

DYED WITH AMERICAN DYES

If such coöperation were general among department stores the carefully cultivated propaganda of the last three years would be of no avail.

One of the most interesting developments of the ante-peace period has just been announced, by which some three thousand enemy-owned patents will become in perpetuity available to American chemical interests. As a result of negotiations with the Alien Property Custodian the American Dyes Institute has just accomplished the formation of a company to be known as the Chemical Foundation, Inc. This new organization, in which many American chemical interests are represented, will purchase from the Custodian all enemy-owned patents, trade marks, etc., not hitherto disposed of. The Foundation will, in turn, grant non-exclusive licenses to any American citizen, or corporation in which 75 per cent of the stock is owned by American citizens.

The charter provides that all profits over and above a small fixed return to the holders of stock shall be devoted to the advancement of the interest of chemistry and the allied sciences in the useful arts and manufactures in the United States.

CONTRIBUTIONS FROM THE CHEMICAL WARFARE SERVICE, U. S. A.

PRODUCTION OF GAS DEFENSE EQUIPMENT FOR THE ARMY

ANOTHER CREDITABLE CHAPTER OF AMERICAN MANUFACTURING ACHIEVEMENT DURING THE WAR

By Bradley Dewey, Colonel, Chemical Warfare Service, U. S. A.

Received January 29, 1919

At the time of America's entrance into the war in April 1917, almost no information had come to this country about gas warfare or the requirements of gas defense equipment. In fact, it had been the policy of the allied nations, as soon as the possibilities of gas warfare were realized, to surround the whole subject with considerable secrecy, as it had been decided that inasmuch as the Germans had initiated the use of deadly gases, it was desirable to undertake immediate plans to retaliate in kind and, if possible, with even greater and more deadly effect.

The only persons who had given the matter any study were Colonel (then Major) L. P. Williamson, Medical Corps, U. S. Army, who was stationed at the Army War College in Washington, in 1917, and Lieutenant Commander Marks of the Navy. Throughout the European war Colonel Williamson had studied every available document regarding gas warfare. Beyond the knowledge which he possessed, we had little or nothing; such an article as a gas mask had never been produced in this country. During the twenty months of our participation in the war, there grew up an organization which completed over five and one-quarter million gas masks, together with vast quantities of other defense material for the use of our armies. This accomplishment, the result of unstinted effort on the part of a loyal personnel and the most excellent coöperation of the varied manufacturing interests of the country, deserves place in the annals of America's accomplishments in the world war.

It will be well at this point to give a picture of a complete gas mask together with its more important requirements.

The gas mask, so-called, is a device to protect the eyes and

Fig. 1—Types of Gas Masks Used by American, Allied and German Armies

Sitting left to right—1. German gas mask. 2. Russian gas mask. 3. Italian gas mask. 4. British mask for motor truck drivers. 5. British aeroplane respirator. 6. Experimental mask with metal facepiece. Designed by Major Connel, of Medical Corps, American Army.

Middle Row—7. First emergency method put into practice after initial gas attack in April 1915. Colonel Goodwin, of Medical Dept., British Army, devised this mask. 8. British "P. H." helmet—emergency type first used in summer of 1915. 9. British "box respirator," standard type used by British Army. 10. French M-2 mask, original French type used until spring of 1918. 11. Original French artillery mask designed by Tissot. 12. French "A. R. S." mask, last type used by French Army.

Top Row—13. Original American Navy mask. 14. American Navy mask, final type. 15. American "box respirator," a type used by U. S. Army throughout the war, the improved design developed at Gas Defense Plant to simplify manufacture. 16. American A. T. mask, all rubber mask in limited production at end of war. 17. American K. T. mask, sewed fabric mask in limited production at end of war. 18. American "Model 1919" mask, improved type ready for production when armistice was signed. This mask embodied the good features of 17 and 18 and was extremely simple to manufacture.

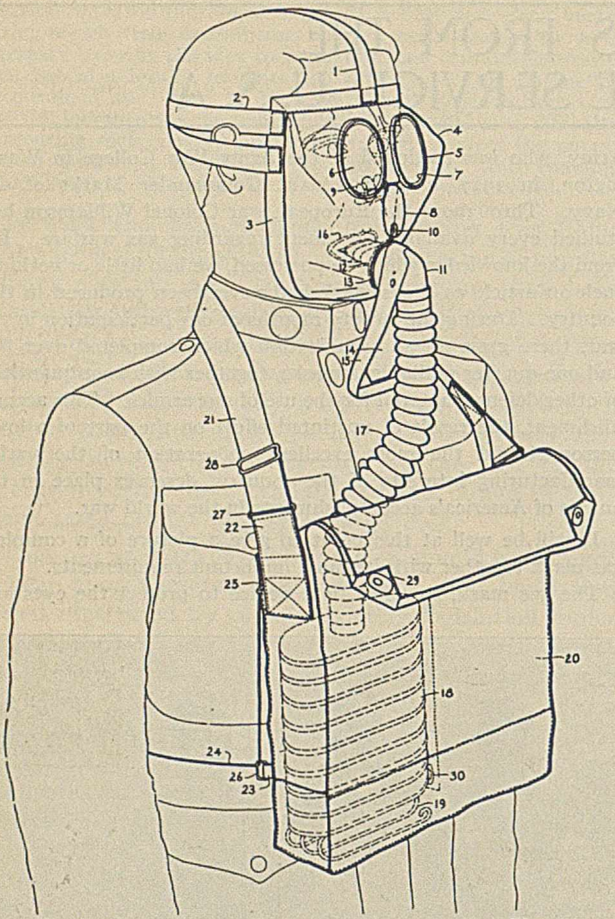

Fig. 2—Diagrammatic Cross Section of the Gas Mask

1—Cotton tape
2—Elastic tape
3—Binder
4—Facepiece
5—Eye cup
6—Lens
7—Lens washer
8—Nose spring
9—Nose pad
10—Nose rivet
11—Die casting
12—Die casting nut
13—Die casting washer
14—Flutter valve
15—Flutter guard
16—Mouthpiece
17—Hose
18—Canister
19—Spring
20—Knapsack
21—Shoulder strap
22—Large Loop chape
23—Small Loop chape
24—Body cord
25—Eyelet
26—Small loop
27—Large loop
28—Center bar slide
29—"Lift the Dot" fastener
30—Grommet

lungs from harmful chemicals used in warfare. The first chemical used by the Germans was chlorine, followed by phosgene, a much more poisonous gas; then came xylyl bromide and similar lachrymators (tear producers); later diphosgene (trichlormethyl chloroformate) and chlorpicrin, both lethal and lachrymatory; later still diphenylchlorarsine, which in the form of a particulate cloud caused extreme irritation of the throat and lungs; and finally, mustard gas, which seriously affected the eyes, skin, and lungs. These represent the principal types of materials used, but gas warfare was not confined to the use of these alone; many substances of widely different chemical properties were used before the end of the war. It is evident, then, that the mask, or, as it is more correctly known, the respirator, must remove all traces of gas or smoke from the air before the air reaches the eyes, nose, or mouth. The respirator, which was manufactured in large quantity and which was furnished to our Army, copied in principle but not in details the "Small Box Respirator" used by the British. Its principal features were:

1—A canister of metal containing both neutralizing and absorptive chemicals and a smoke filter. The air to be breathed passes in through an inlet check valve and through chemicals and smoke filter.

2—A flexible rubber hose through which the purified air passes from the canister to the facepiece.

3—A facepiece effectively covering the eyes, cheeks, lower forehead, nose, mouth, and chin, provided with eyepieces permitting vision and a harness to hold the facepiece in place when wearing the mask.

4—An exhalation valve which affords easy discharge of exhaled air and at the same time instantly closes upon inspiration.

5—A knapsack slung from the neck or shoulder, in which the mask and canister are carried.

In the box respirator type manufactured, the inhaled air passing through the canister and hose went directly into the mouth through a rubber mouthpiece, which in this manner offered protection to the lungs in the event of the failure of the fit of the facepiece or of damage to the facepiece. At the same time the mask was provided with a spring and rubber device which closed off the air passage through the nose and compelled breathing entirely through the mouth.

It is also worth while to enumerate a few of the principal requirements to be fulfilled by a respirator.

1—It must successfully remove all gas fumes or smokes from the air to which a soldier is exposed, and must do this for the maximum of time for which the soldier is liable to be on duty.

2—It must be reasonably comfortable to the wearer.

3—The fit of the facepiece around the face must be a perfect gas-tight joint.

4—The material of the facepiece must be substantially impermeable to all noxious gases.

5—The eyepieces must be strong and provide for good vision.

6—The complete equipment must have durability, for all personal equipment of a soldier in the field receives extremely hard usage.

7—The resistance to flow of air through the various parts must be kept at a low figure in order that the fighting efficiency of the individual may not be too much reduced.

8—It must be of minimum weight and bulk.

The points mentioned indicate but few of the severe requirements which had to be met during the course of production. All of them were not apparent in the early days, but became of importance and had to be met as the war progressed.

At the end of May 1917, when the need for furnishing General Pershing's first division of regulars with masks arose, Colonel Williamson attacked the problem with whole-hearted enthusiasm.

Fig. 3—American Gas Mask of "Box Respirator" Type Used by the U. S. Army throughout the War

Early in 1917, Mr. Van H. Manning, of the Bureau of Mines, with a wonderfully coöperative spirit and great foresight, had called the attention of the War Department to the Bureau's facilities for conducting gas investigation. Consequently Colonel Williamson hurried to Mr. G. A. Burrell, who was in charge of war gas investigations for the Bureau of Mines, and impressed him with the seriousness of the problem. Mr. Burrell called upon the writer to undertake the task of furnishing 25,000 masks within three weeks time.

It was hardly realized that the lack of existing technical data and experience would make the accomplishment of such a production impossible in so short a time. Arrangements were immediately made with the B. F. Goodrich Company, of Akron, Ohio, who had been working with Lieutenant Commander Marks of the Navy, for the making of the mask and the various rubber parts involved. At the same time, arrangements were made for complete assembly and the production of the canister at the American Can Company. In addition to this, special charcoal and soda-lime granules for the absorption of the gases had to be prepared.[1]

At the end of two months, twenty thousand of these masks had been produced and shipped. These first masks, measured by comparison with our later product and the product in England which was the result of over a year's experience close to the front, were far from satisfactory. In addition, the experience gained in the struggle to obtain this production emphasized the magnitude of the problem. Consequently, when, on the last of July, the Army itself took up the manufacture of gas masks, it was with a more complete realization of the seriousness of the task.

EARLY ORGANIZATION AND PRODUCTION

In July 1917, when the order for the first twenty-five thousand had been completed and the Surgeon General confirmed the arrangements which had been made for the production of 1,100,000 masks during the next year, there was authorized to take care of this production program, a personnel of one Major, two Captains and ten Lieutenants.

The period during July and August was taken up in securing the allotted personnel and in determining some fundamental points of design. This was accompanied by production arrangements for parts of 320,000 masks, metal part arrangements for the entire 1,100,000 masks, and assembly arrangements for the same quantity. The spirit of coöperation and desire to serve the Government was early evident, as was shown by the attitude of the B. F. Goodrich Company in giving technical and cost information to the Goodyear Tire and Rubber Company and the United States Rubber Company, in order that they might intelligently bid on a project in which no one but the B. F. Goodrich Company had any experience. This was a distinct departure from practice in competitive industry.

By the end of August it was clearly realized that the personnel provided was not adequate to meet the many tasks which were arising. Though an increased personnel was authorized, the way was not made entirely easy for those producing gas masks, as no end of army red tape and obstacles had to be overcome in actually securing the personnel. While arrangements had been made with the Hero Manufacturing Company, of Philadelphia, in July for the assembly of the required schedule of masks, and operations were actually started in August, it was December before the personnel of an organization even partially adequate to carry on the various problems of supply and design could be secured.

The period of September to December may be characterized as a struggle to secure adequate personnel of trained men, to overcome old-time obstacles existing in army purchase procedure, to determine important points of design, to correct faults pointed out by the overseas organization, then growing in spite of difficulties, and to work out with the various contractors, suitable methods of manufacture.

Early in October, Major H. W. Dudley, Royal Engineers, came to the States from England, assigned as an adviser by the British Government. Major Dudley brought with him a wealth of invaluable experience on the technical side of manufacturing masks. Coupled with intimate contact with the development of the British manufacture, Major Dudley had had sufficient contact with field conditions to bring to us a well-balanced judgment on various questions. He told of the importance of wrinkles in the band, through which gases leaked; of the importance of doping thread holes with gelatine to keep the gas from being carried through by the thread; of the importance of having mouth bushings inside of the mouthpiece so that the soldiers in the excitement and surprise of a gas attack would not bite the mouthpiece and cut off their own breath. He told of the crawling up of gas along the inside seam of the canister and the necessity for doping it as a prevention. He told of the necessity of testing the canister chemicals for hardness and of eliminating all dust. He informed us of the necessity of testing all die castings to make sure that they did not leak, and the testing of fabrics for permeability to the various gases.

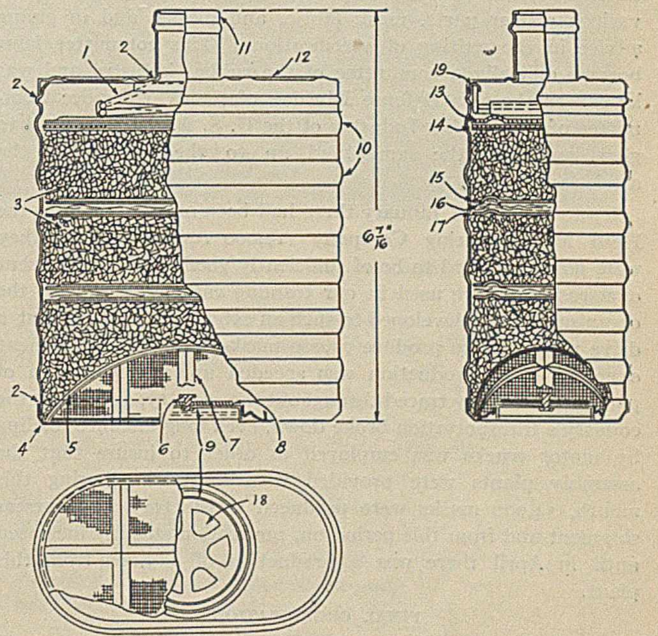

Fig. 4—Cross Section of the Gas Mask Canister Showing Details of Filling

1—Heavy spring to prevent filling from rattling
2—Solder joints
3—Chemical fillings
4—Bottom of canister
5—Copper screen
6—Check valve stud
7—Spider to support screen
8—Rubber check valve
9—Removable plug

10—Bulging ribs
11—Nozzle for expansion hose
12—Can top
13—Heavy screen to hold filling in place
14—Cloth to catch fine particles
$\left.\begin{matrix}15\\17\end{matrix}\right\}$ Light wire screen
16—Cotton baffle
18—Air intake holes
19—Lips to hold spring

A few months showed us that these were not minor points but that every one was vital and that they were but samples of the innumerable points which came up day by day.

After making a study of the facilities which were available, Major Dudley made some definite recommendations which had an important bearing on our whole program.

1—Correction of granule[1] process to bring in line with British practice.

2—The institution of gas-chamber testing of masks and canisters.

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[1] The manufacture of these chemicals is to be considered in a subsequent article.

[1] The granules were one of the constituents of the filling of the canister

3—Emphasis of necessity for minimum bulk and weight of respirator.

4—Strongly advising a better centralization of facilities devoted to gas-mask production.

It was also during this time that the manufacturers' rubber committee was organized, composed of the following:

Dr. W. C. Geer, B. F. Goodrich Company, *Chairman*
Dr. Theodore Whittelsey, United States Rubber Company
Mr. C. R. Johnson, Goodyear Tire & Rubber Company
Mr. William Stephens, Goodyear Tire & Rubber Company (vice Mr. Johnson who entered the Gas Defense Service, January 1918)

This committee rendered valuable service in carrying on experimental work in connection with the development of the various rubber parts, mask fabric, and masks, and in giving advice in the writing of specifications. This committee later became officially a committee of the rubber industry and was known as the Gas Defense Division of the War Service Committee of the Rubber Industry of the U. S. A. It continued to give service of the same kind up to the signing of the armistice.

Up to the first of January there had been manufactured at the Hero Manufacturing Company 117,000 respirators, but they were not considered to be of sufficiently good quality to be sent overseas and were used in our training camps. However, the organization had developed to such an extent in January that a drive was made to produce 75,000 masks suitable for shipment overseas. The production was speeded up, transportation of parts was carefully traced throughout the country, and, when the country's transportation broke down, even long-distance hauling by motor trucks was employed in order to insure that the assembly plants were provided with material. During this month, 54,000 masks were produced satisfactory for overseas shipment and from this period on, production steadily increased until in April there was a production of 363,000 from this plant.

FINAL ORGANIZATION

The continued expansion of the army program during the early months of 1918 resulted in a consequent increase in program and personnel for the Gas Defense Service, until at the signing of the armistice there were in the organization 274 officers, 2353 enlisted men, and 13,000 civilians. There existed at various points in the country over 80 organized detachments of the Gas Defense Division. An estimate of the number of employees engaged in contractors' plants providing materials for the Gas Defense Division was 25,700. In July the various activities which had sprung up as a result of the use of gas by the Germans had been consolidated into one service known as the Chemical Warfare Service under Major General William L. Sibert, and our organization had become the Gas Defense Division of the Chemical Warfare Service. In order to secure better contact with various producing facilities, headquarters were located at 44th Street, New York City. The organization finally developed was as follows:

STAFF

Col. Bradley Dewey, Officer in Charge
Lt. Col. A. L. Besse, Assistant Officer in Charge
Lt. Col. Chas. Almy, Jr., Assistant to Officer in Charge
Maj. F. A. Dewey, Special Assistant
Maj. P. V. Hollenbeck, Quartermaster
Capt. A. B. Comstock, Legal Adviser

GAS DEFENSE PLANT

Mr. R. R. Richardson, Manager
Lt. Col. P. L. Coonley, Assistant

HERO MANUFACTURING COMPANY, ASSEMBLY PLANT

Capt. H. P. Scott, Jr., In charge
Capt. R. M. Graham, Inspection
Capt. P. M. Wiswall, Assembly
Lt. W. C. Northrop, Accounting

PROCUREMENT SECTION

Mr. Robert Skemp, In charge
Major T. H. Barth, Assistant

Maj. A. C. Dickinson
Maj. P. R. Llewellyn
Maj. Wilwyn Herbert
Capt. J. S. Wolf
Capt. K. B. Blake
Capt. Leonard Macomber
Capt. W. DeY. Kay
Capt. R. V. Puff
Capt. E. C. Herman
Capt. E. P. Pierce
1st Lt. R. B. Kempton

TECHNICAL SECTION

Maj. C. R. Johnson, In charge
Maj. Waldemar Kops, Assistant

FIELD TESTING SECTION

Capt. K. Atterbury, In charge
Capt. Paul B. Moulton, Assistant

CHEMICAL MANUFACTURING

Maj. J. C. Woodruff, In charge
Maj. I. W. Wilson, Assistant

COMPTROLLING

Maj. H. P. Schuit, In charge
Capt. Prior Sinclair, Assistant
1st Lt. P. B. Prentice, Cost Accounting

OFFICE ADMINISTRATION

Maj. M. L. Emerson, In charge
Capt. R. E. Taylor, Adjutant

Some of the larger detachments were:

ASTORIA CHEMICAL PLANT, manufacturing carbon and granules under Maj. I. W. Wilson. There was also located at Astoria a chemical development laboratory under Maj. T. L. Wheeler.

AKRON DETACHMENT, rubber parts (including all rubber companies west of the Alleghenies), Capt. L. B. Dana, Officer in Charge, Capt. W. H. Coburn and 1st Lt. H. D. Fitzgerald, assistants.

NEW BRITAIN DETACHMENT, metal parts.
Capt. M. G. Vincent, Officer in Charge

PROVIDENCE DETACHMENT, fabrics and metal parts.
1st Lt. A. W. Keller, Officer in Charge

SAN FRANCISCO DETACHMENT, carbon.
Capt. W. E. Brophy, Officer in Charge

CLEVELAND DETACHMENT, carbon.
1st Lt. E. J. Noble, Officer in Charge

HORSE MASK FACTORY
Capt. W. S. McKinney, Officer in Charge

GAS DEFENSE PLANT

Early experience showed the necessity for extreme care in the manufacture and inspection of all gas defense articles, and by November 1917 it was evident that the ordinary commercial organization was not adapted to carry on the manufacture of this new and important article on the scale necessitated by the new army program. Consequently, after consultation with many representative leaders such as Associate Justice Brandeis, Everett Morss, Harry L. Dennison, Harry Kendall, Howard H. Coonley, and Sidney Hillman, it was deemed advisable to establish a strictly government-owned and controlled organization to handle the additional output of gas masks.

The appropriation made by Congress for the purchase of gas masks could be construed to cover the manufacture of the mask in a government factory. Consequently, on November 20, 1917, the Secretary of War authorized the establishment of a government-operated plant under the direction of the Officer in Charge, Field Supply Section, Gas Defense Service of the Medical Corps, which became the Gas Defense Division of the Chemical Warfare Service when the latter was organized.

On December 5, 1917, Mr. R. R. Richardson, of Chicago, was appointed general manager of the new Gas Defense Plant, at a salary of one dollar a year. Mr. Richardson was at that time head of the Chicago Carton Company. Following this appointment and a conference in Washington on the general requirements of the situation, Mr. Richardson enlisted the

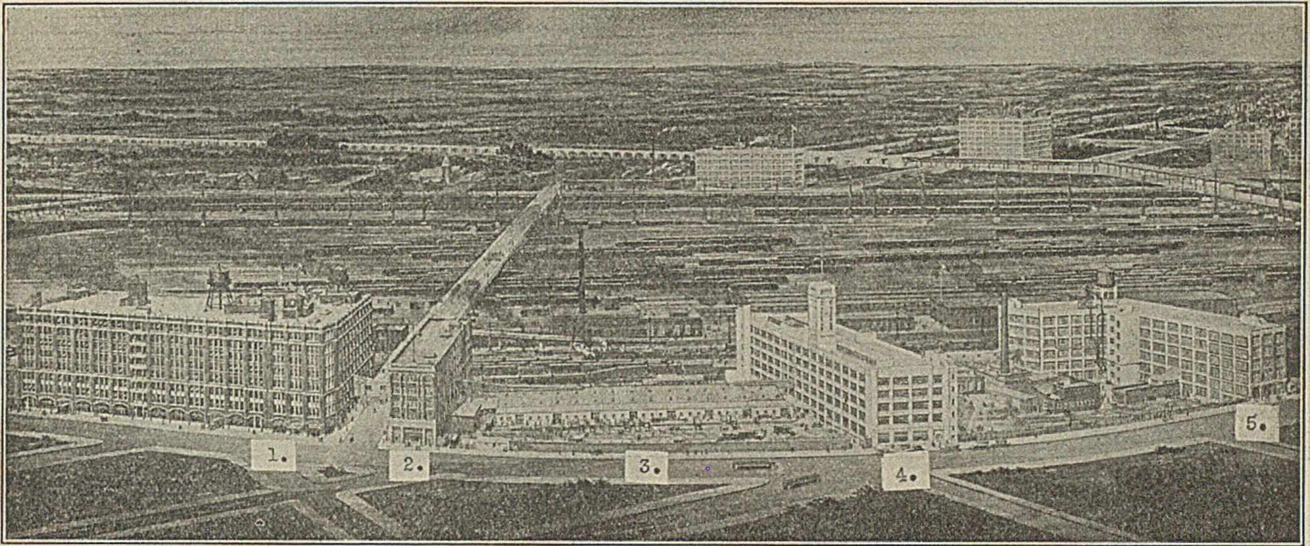

FIG. 5—GENERAL VIEW OF GAS DEFENSE PLANT
1—Ford Building 2—Goodyear Building 3—Warehouse 4—Stewart Building 5—National Casket Building

services of Mr. P. L. Coonley (now Lieutenant Colonel), of Chicago, vice president of the Link Belt Company.

With the chief executive heads appointed, steps were taken to secure proper executive personnel to carry on the work of the plant. Experienced officials were drawn from New York, Boston, Chicago, and other manufacturing centers. These men were either known personally to the chief executive and his assistant or else highly recommended to them by well-known business men.

In the latter part of November 1917 a lease was secured on the Stewart Building, Jackson and Second Avenues, Long Island City, to house the operations of the plant. The building was new and well lighted and had excellent transportation facilities. This building, 5 stories in height and with a total floor space of 175,000 sq. ft., represented the central manufacturing unit of the Gas Defense throughout its entire history. The actual operation at the plant may be said to have commenced during the week of December 24, 1917, when the first sewing machines were installed. On January 1, 1918, ten sewing machine operators who had had experience in the garment trade in New York City were employed to start operations. With these as a nucleus, a school for training of operators was started and carried on until the latter part of March, when a sufficient number of operators were available to act as instructors in the plant.

The organization of the Gas Defense Plant consisted of eleven main divisions as follows: Operating, Inspection, Personnel, Planning, Advisory, Controlling, General Office, Protection, Supply, Check Inspection and Salvage, Control Inspection.

At the signing of the armistice the following occupied the managerships of the various divisions:

OPERATING DIVISION

Mr. E. L. Flory, of Chicago, Ill., In charge
Mr. E. J. Mulholland and Major L. E. Cover, Assistants

INSPECTION DIVISION

Maj. R. T. Smith, of Pittsburgh, Pa., In charge
Mr. H. S. Doty and Capt. T. H. Heneage, Assistants

PERSONNEL DIVISION

Mr. Jesse Briegel, of Chicago, Ill., In charge
Mr. E. J. Kilduff and Mr. P. O. Badger, Assistants

PLANNING DIVISION

Mr. F. C. Wales, of Boston, Mass., In charge
2nd Lt. C. H. Adamson and Master Engineer R. C. Erb, Assistants

ADVISORY DIVISION

Mr. G. D. McKibbon, of Chicago, Ill., In charge
2nd Lt. G. White, Assistant

CONTROLLING DIVISION

Mr. W. B. Harris, of East Orange, N. J., In charge
Mr. H. J. Goodyear and Mr. C. W. Patten, Assistants

GENERAL OFFICE DIVISION

Mr. G. J. Quinn, of Boston, Mass., In charge
Mr. E. J. Ruegg, Assistant

PROTECTION DIVISION

Capt. C. I. Mansur, of Chicago, Ill., In charge
Sgt. C. H. Wirt, Assistant

SUPPLY DIVISION

Maj. T. J. Dee, of Chicago, In charge
Mr. E. V. Burke and Captain A. F. Best, Assistants

CHECK INSPECTION AND SALVAGE DIVISION

Mr. G. Crossman, of Wolcott, N. Y., In charge
2nd Lt. L. W. Moses, Assistant

CONTROL INSPECTION DIVISION

Maj. S. D. Warner, of Douglaston, L. I., In charge
2nd Lt. H. E. Fisher, Assistant

This organization was unique in that it included both civilians and soldiers under the same authority.

Because of the desire of so many workers to participate in an active way in the winning of the war, the labor problem at the Gas Defense Plant was comparatively simple. Gradually, the general personnel of the plant assumed proportions in which approximately 60 per cent of the employees were female and 40 per cent male. Many female employees were experienced sewing machine operators. Inspection work was carried on by women of high grade, and preference was given to those having husbands or sons at the front.

As the demands for gas masks increased, it became necessary for the Gas Defense Plant to expand. About January 31 an adjoining building, with a total floor area of 78,000 sq. ft., occupied by the Goodyear Tire & Rubber Company, was taken over. On June 20 a warehouse was completed between the two buildings, affording an additional floor space of 30,500 sq. ft. On June 24, the Gas Defense Plant took over the National Casket Company building, located due south of the Stewart Building. This had a floor area of approximately 140,000 sq. ft. Finally on August 15 occupation of the Ford Motor Company's building, adjoining the Goodyear Building, was begun. This added a floor space of approximately 500,000 sq. ft.

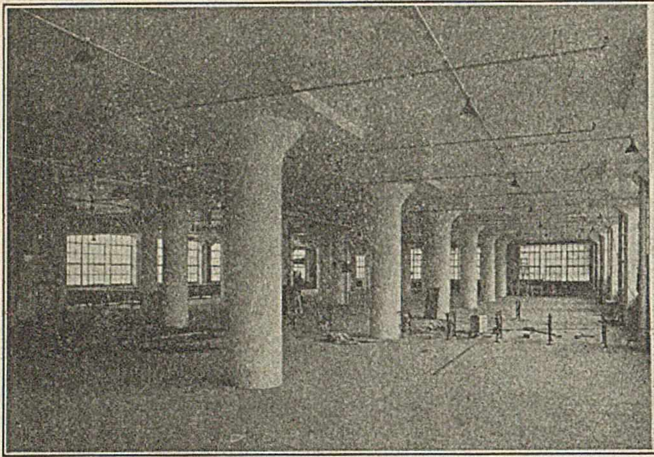

FIG. 6—SHOWING FIRST FLOOR OF STEWART BUILDING, JANUARY 15, 1918

FIG. 7—SHOWING FIRST FLOOR OF STEWART BUILDING, FEBRUARY 15, 1918

Thus it can be seen that starting with a floor space of 157,000 sq. ft. the Gas Defense Plant expanded in 7 months to occupy a floor space of 1,000,000 sq. ft., or 23 acres.

Simultaneous growth was taking place in the personnel of the plant. On January 1, ten sewing machine operators were hired. On June 1 the employees numbered 4,686. On November 6 the high-water mark was reached with a total personnel of 12,350.

During the conduct of manufacturing operations at the Gas Defense Plant, two distinct types of masks were manufactured, the box respirator type already described, and a mask developed in this country during the last six months of the war known as the "K. T.," which was without mouthpiece or noseclip.

On March 4 the first actual shipment of box respirator masks was made from the Gas Defense Plant. From this date the production increased by leaps and bounds. Some idea of the production figures attained can be obtained from the fact that between March 4, when the first shipment of masks was made, and November 26, when the last mask was manufactured, a total of 3,146,413 masks of the box respirator type passed through the final inspection of this plant. The greatest daily production of 43,926 completed masks was reached on October 26.

In August 1918, manufacture of the K. T. mask was started. This mask had been developed during the preceding months by the Technical Section of the Gas Defense Division. This mask, described later, differed radically in design from the box respirator and though considerable difficulty was encountered in its manufacture, on September 14 the first satisfactory K. T. masks were completed, and up to November 11, when the armistice was signed, a total production of 189,603 had been accomplished.

The final manufacturing records of the Gas Defense Plant showed that the total production of finished gas masks was 3,614,925.

DESCRIPTION OF MASK MANUFACTURE

A visitor making a tour of the Gas Defense Plant would have been impressed particularly with the extreme care exercised in each operation and the strict attention paid to the minutest detail of inspection and assembly. In passing through the plant one of the striking features was the extensive use of conveying equipment to move masks and assembled parts from one point to another with a minimum cost. Notwithstanding the fact that the layout of the plant was changed three times with a large increment of floor space, yet throughout it all one could see carefully planned flow of material with a minimum amount of congestion of traffic or of retracing.

Another impressive feature was the arrangement of benches and work tables in such a way that the operators were as close to each other as existing factory codes and individual efficiency

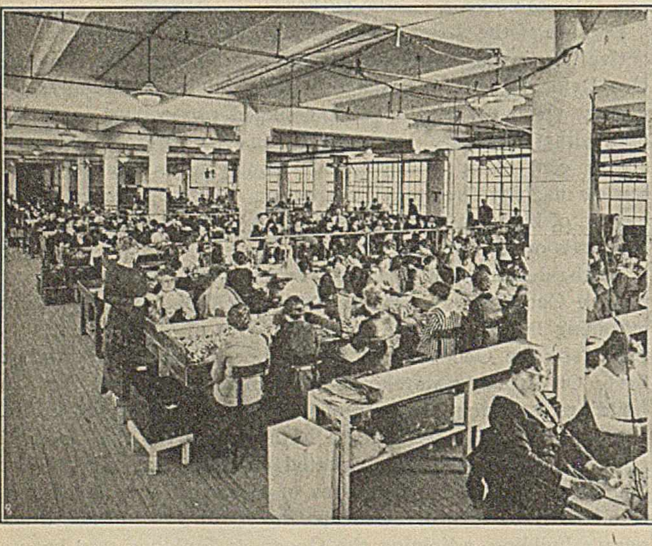

FIG. 8—PORTION OF ONE INCOMING INSPECTION ROOM

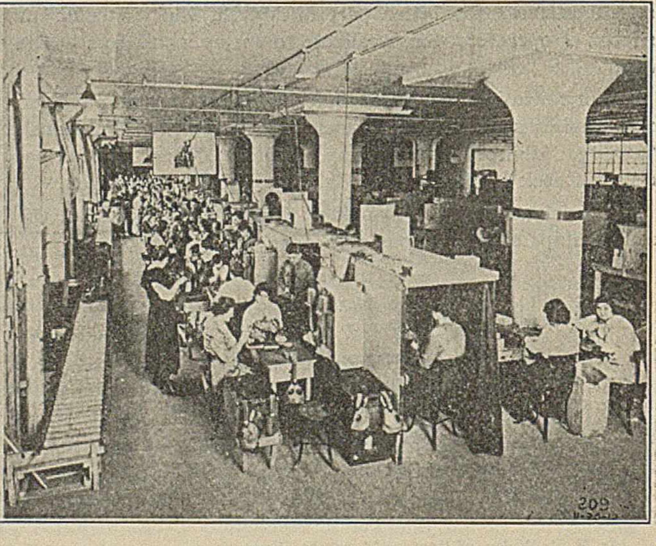

FIG. 9—PORTION OF FINAL INSPECTION ROOM

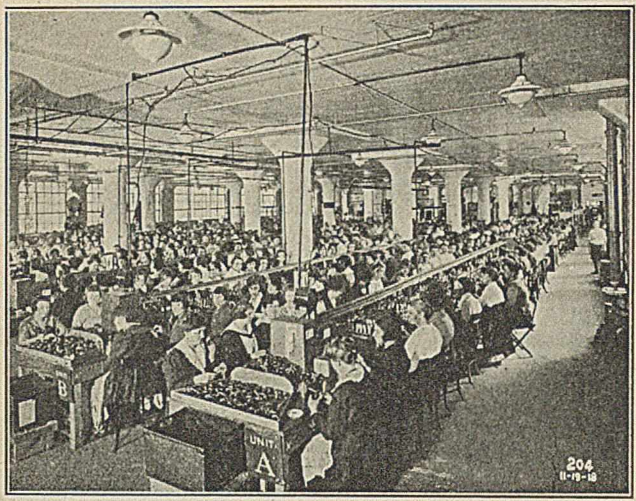

FIG. 10—PORTION OF ASSEMBLY DEPARTMENT

would permit. This in itself was a big point in cutting down the unnecessary moving of material.

A brief description of the manufacture of the mask will be given.

INCOMING INSPECTION—All facepiece materials and parts were received in the National Building. The cases were opened and all the parts, with the exception of fabrics and tapes, were distributed into fiber unit boxes of convenient size for use on the belt conveyors installed throughout the plant. These unit boxes solved the difficulty of keeping together the required number of all parts needed in the assembly operations.

The unit boxes were sent by elevator to the top floor of the building and distributed for incoming inspection. A thorough 100 per cent inspection was made of each part before sending it to the Assembly Department. The inspectors were carefully chosen and were sent to a school for training before they were assigned to this important work. Every feature found to be essential to the manufacture of a perfect gas mask was carefully checked.

The incoming inspection of the flexible rubber hose leading from the canister to the facepiece can be taken as an illustration. Each piece of hose was given a visual inspection for buckles or blisters in the ends or in the corrugations; for cuts, air pockets, or other defects on the interior; for loose seams where fabric covering was cemented to the rubber tube; for weaving defects in the fabric itself; and for careless application of the cement. Special tests were conducted for flexibility, as a stiff hose would produce a strain on the soldier's mouth; for permanent set to insure that the hose was properly cured; for the adhesion of the fabric covering to the hose; and for kinking when the hose was doubled on the fingers. Finally each piece was subjected to a test for leaks under water with a pressure of 5 lbs. per sq. in.

Each eyepiece and the three-way metal connection to the facepiece were subjected to a vacuum test for leakage. The delicate exhalation valve was carefully examined for defects which would be liable to cause leakage. Fabric for the facepiece was given a high-tension electrical test on a special machine developed at the plant to overcome the difficulty met in the inspection of this most important material. It was of course necessary that the facepiece fabric be free from defects but just what constituted a defect was the source of much discussion. The electrical test eliminated all personal views and gave an impartial test of the fabric. The machine consisted of two steel rolls between which a potential difference of 4,000 volts was maintained; the fabric was led through the rolls and wherever there was a pinhole or flaw the current arced through and burned a clearly visible hole.

PRELIMINARY FACEPIECE OPERATIONS—All preliminary facepiece operations were performed in the National Building. Blanks were died out from the facepiece fabric in hydraulic presses. Each face blank was swabbed to remove bloom and the eye washers were cemented about the eyeholes. The pockets for holding the noseclips were also cemented to the blanks. The bands which formed a gas-tight seal of the mask about the face were died out from rubberized fabric to which a felt backing was attached. The harness consisting of elastic and cotton tapes was also sewed together at this point.

DESCRIPTION OF CONVEYORS—The preliminary operations having been completed, forty sets of each of the parts needed to make a complete facepiece were placed in the unit boxes and sent on trucks to the top floor of the Stewart Building. The third, fourth, and fifth floors of this building, devoted to the making of facepieces, had a double line of roller coveyors running the entire length of each floor. These conveyors started at the rear end of the fifth floor, running the entire length of the building, turning at the front end and running back the entire length. They then passed through the floor on a spiral and continued the entire length of the fourth and third floors in a similar manner.

This conveyor system was laid out to facilitate the flow of materials through operations and also to prevent the material going from one operation to another without being inspected.

After each process the material was inspected before it proceeded to the next operation. The operators and inspectors worked on opposite sides of the conveyor, with the two rows of inspectors between the two rows of conveyors. The unit boxes were fed to the operators on the upper conveyor, the parts being removed as the operator needed work and the finished work placed on the table between the upper and lower conveyors. The inspectors would then inspect the material, replace the accepted parts in the unit boxes, and send them to the next operation on the lower conveyor. On succeeding operations the upper and lower roller conveyors were alternated so that the material was kept separate and the flow of material between the operations was smooth and even.

FACEPIECE OPERATIONS—The sewing machine operations were next performed. First the died out blanks were pleated to form the facepiece. The operator had to register the various notches

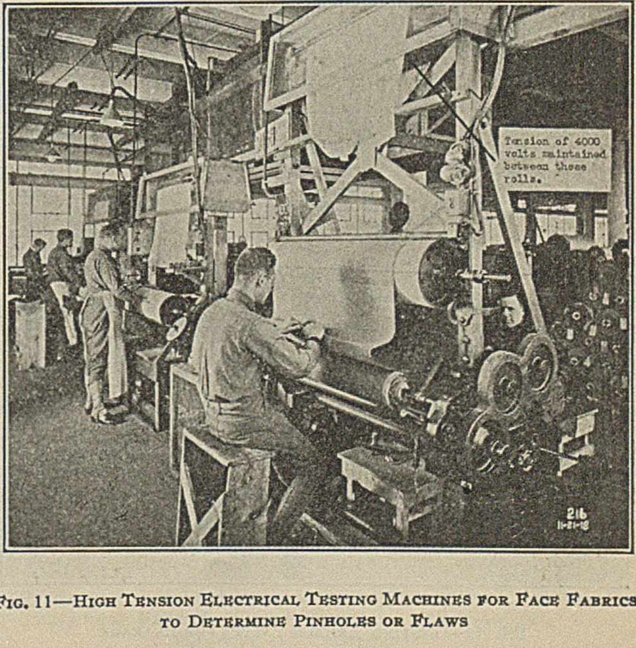

FIG. 11—HIGH TENSION ELECTRICAL TESTING MACHINES FOR FACE FABRICS TO DETERMINE PINHOLES OR FLAWS

in the blank to an accuracy of $^1/_{32}$ in. and to locate the stitches in some cases as closely as $^1/_{64}$ in. The band was next sewed to the periphery of the facepiece after which the harness was attached. The stitches on the outside of the facepiece were covered with liquid dope, which filled the needle holes and made the seams gas-tight.

In addition to the inspection of each operation, the completed facepiece was submitted to a control inspection to discover any defects that might escape the attention of the inspectors on the various operations.

ASSEMBLY OPERATIONS—The facepieces were now ready for assembly and were sent down the conveyor to the third floor for insertion of the eyepieces, which was done in specially designed automatic presses. The eyepieces had to be carefully inserted so that the facepiece fabric extended evenly around the entire circumference.

After inspection, the facepiece with the eyepieces inserted were sent in the unit boxes from the third to the second floor where the assembly was completed.

Before manufacture began on a large scale, the most satisfactory method of conducting each assembly operation was worked out and the details standardized, so that operators could be quickly and efficiently trained. No detail was considered too small if it improved the quality of the mask. The assembly operations proceeded as follows:

The exhalation valve was first joined to the three-way metal tube which formed the connection between the facepiece, flexible hose, and mouthpiece. Each valve was then tested for leakage under a pressure difference of a one-inch head of water. No valve was accepted which showed leakage in excess of 10 cc. per min. under these conditions.

The metal guard to protect the exhalation valve was next assembled, followed by the flexible hose. The three-way tube was then assembled to the facepiece by means of a threaded connection and the rubber mouthpiece attached. To illustrate the attention to details the following operation may be cited:

The contact surfaces between each rubber and metal part were coated with rubber cement before the parts were assembled. The connection was then tightly wired, care being taken that none of the turns of wire should cross and finally the wire was covered with adhesive tape so that no sharp edges would be exposed.

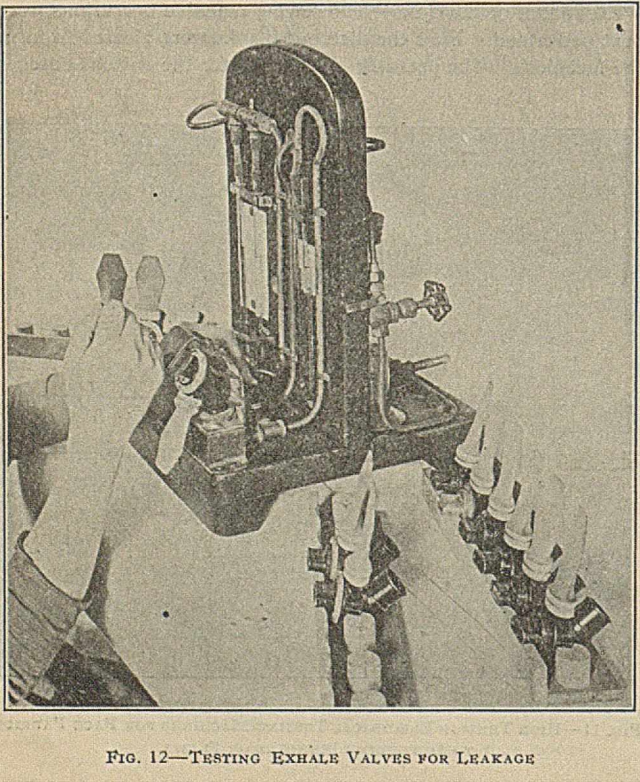

FIG. 12—TESTING EXHALE VALVES FOR LEAKAGE

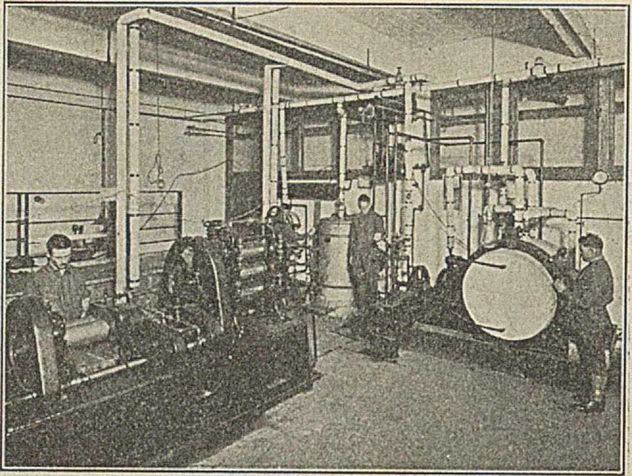

FIG. 13—LONG ISLAND LABORATORY. EXPERIMENTAL RUBBER LABORATORY FOR MANUFACTURE OF RUBBER PARTS ON SMALL SCALE

The masks, completely assembled except for the canisters, were inspected and hung on racks on specially designed trucks which prevented injury in transit, and were delivered to the Finishing Department.

CANISTER FILLING—Meanwhile the canisters were being filled in the Ford Building.

The canisters, canister parts, and chemicals were received on the first floor. All chemicals were tested before they left the manufacturing plant at Astoria and each drum was checked to see that it had been approved.

Canisters and all other parts were sent to the receiving stores department on the sixth floor where they were inspected and the accepted material placed in storage.

The chemicals were first screened in such a way that the fine and coarse materials were separated from the correctly sized materials. They were then carried on a belt conveyor to the storage bins on the seventh floor, whence they were fed by gravity through pipes to various mixing machines on the fourth and fifth floors. A special mixing machine was developed to mix the carbon and granules in the proper proportions for use in the canister. The mixed chemicals were then led to the canister-filling machines. There was a separate mixing machine for each filling machine, of which there were eighteen in all.

The can-filling department was laid out in six units, three located on the fifth floor and three on the fourth. Each unit had a capacity of 20,000 cans per day. A system of double belt conveyors was also installed here to conduct empty canisters to the machines and carry away the filled ones.

Each filling operation was carefully inspected and special stops were placed on the belt conveyors so that a canister could not go to the next operation without having been inspected. Operators and inspectors were stationed on opposite sides of the belt. The chemicals were placed in the canister in three equal layers which were separated by pads of cotton wadding. The first layer was introduced from the filling machine (which delivered automatically the proper volume of chemicals), the canister was shaken to pack the chemicals tightly, the cotton baffle inserted, the second layer of chemicals introduced and so forth. On top of the top layer of chemicals were placed a wire screen and a specially designed spring which held the contents of the canister securely in place. The metal top was then fitted and securely soldered.

Each canister was tested under water for possible leaks in joints or soldering, with an air pressure of 5 lbs. per sq. in. A

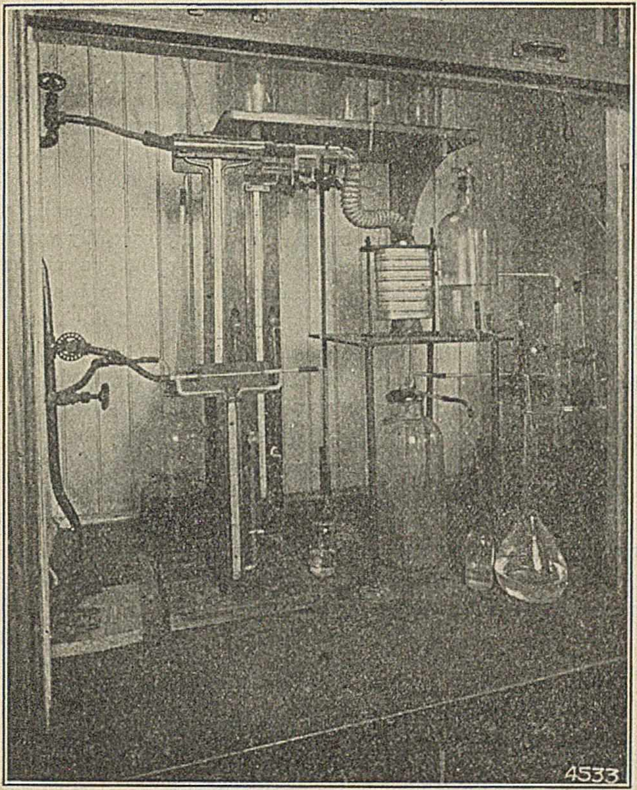

Fig. 14—Long Island Laboratory Chemical Department. Apparatus for Testing Life of Canister against Mustard Gas

test was also made for the resistance which it offered to breathing, a rate of flow of air through the canister of 85 liters per min. being maintained and the resistance being measured in inches of water.

The filled canisters were then painted a distinctive color to indicate the type of filling and conducted by conveyor to the second floor of the Stewart Building for assembly to masks.

FINISHING DEPARTMENT—In the finishing department, the filled canisters, as received by conveyor from the Ford Building, were conducted down the middle of the finishing tables and assembled to masks.

The finished masks were then inspected, placed in unit boxes, ten to a box, and returned by belt conveyor to the second floor of the Goodyear Building for the final inspection.

FINAL INSPECTION—Final inspection of the completely assembled masks was as rigid as could be devised, and was closely supervised by army representatives. Only the most painstaking and careful women were selected for this work and the masks were examined in every detail to discover any defect that might have escaped previous inspection. Finally, each mask was inspected over a bright light in a dark booth for small pinholes which the ordinary visual inspection might not have detected.

As a check on the quality on the final inspectors' work a reinspection of 5 per cent of the passed masks was conducted. Where it was found that a particular inspector was making numerous mistakes, her eyes were examined to see whether it was due to faulty eyesight or careless work. Masks containing known defects were purposely sent to these inspectors to determine whether they were capable of continuing the inspection work. In this way the desired standard was maintained.

A daily report of the final inspection was sent back to each of the assembly departments involved so that defects might be eliminated immediately and the percentage of rejects kept as low as possible.

After the final inspection the masks were numbered, packed in knapsacks, and the filled knapsacks placed in packing cases, twenty-four to a case. The cases were conveyed to the Packing Department in the Ford Building, where the covers were nailed on, the cases stenciled and immediately shipped or sent to storage.

EMPLOYEES

No account, no matter how brief, would be complete without some statement describing the spirit of enthusiasm and loyalty shown by the employees of the Gas Defense Plant. Without the organizing talent of Mr. Ralph R. Richardson and the zeal and enthusiasm manifested by the workers, the tremendous production of gas masks in such a short space of time could not have been accomplished.

Furthermore, though the plant was started with quality as its only watchword, and employed in many places one inspector for every three operators, nevertheless the total mask cost, after charging in all equipment expenses, was 50 cents lower than that for masks produced on contracts.

CHEMICAL MANUFACTURE

Extensive facilities were established for the manufacture of the carbon and granules used as gas-absorbing materials in the canister of the gas mask. A full description of the manufacture of these materials will be given in a later issue of This Journal.

HORSE MASKS

It was also necessary to provide protection for horses against poisonous gases. Fortunately a horse is so constituted that he can stand much greater concentration of tear-producing gases than a man and does not require protection of the eyes. Furthermore, a horse breathes only through his nostrils and it is not necessary to cover his mouth with the gas mask.

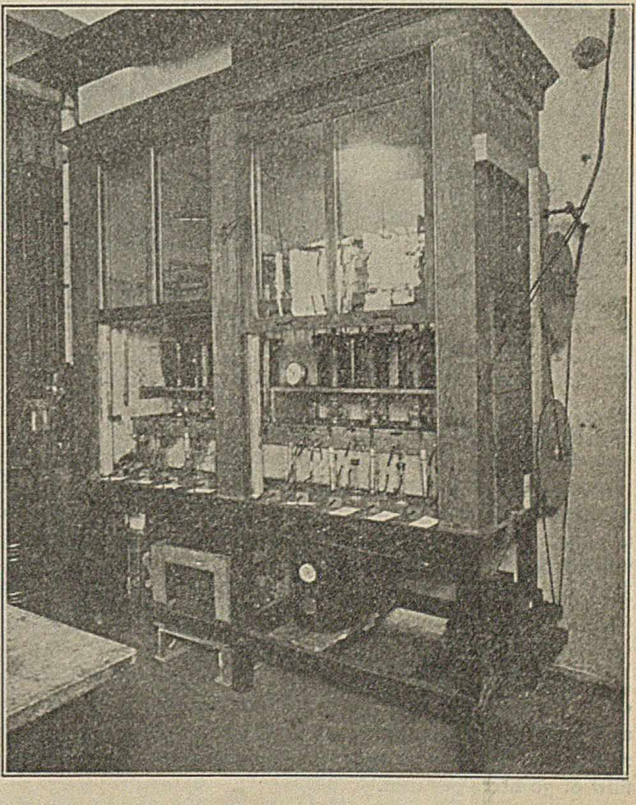

Fig. 15—Long Island Laboratory Chemical Department. Intermittent Flow Canister Testing Apparatus to Test against Phosgene and Chlorpicrin

The American mask for horses, which was modeled after the English, but much improved, consisted of a cloth nose bag of special material saturated with chemicals to absorb and destroy the various gases employed.

The mask was provided with a harness for attachment to the horse's harness and, when not in use, was enclosed in a small canvas knapsack.

The chemicals employed consisted of a mixture of hexamethylenetetramine, nickel sulfate, sodium carbonate, and glycerin. The hexamethylenetetramine gave protection against phosgene. The nickel hydroxide formed in the reaction was to give protection against the possible use by the Germans of prussic acid.

The process of impregnation was as follows:

A solution of hexamethylenetetramine, glycerin, and nickel sulfate was mixed with a solution of sodium carbonate and water in a heavy steam-jacketed mixing kettle with heavy geared stirrers. The mixture was conducted by pipes to the impregnating apparatus which consisted of a rotary laundry washing machine. The masks were treated in this machine for a period of 15 min. and then placed in a power-operated wringer and the solution driven off to a definite weight. Following this operation they were suspended on wire supports and conducted through a hot-air drying machine and dried to a definite weight.

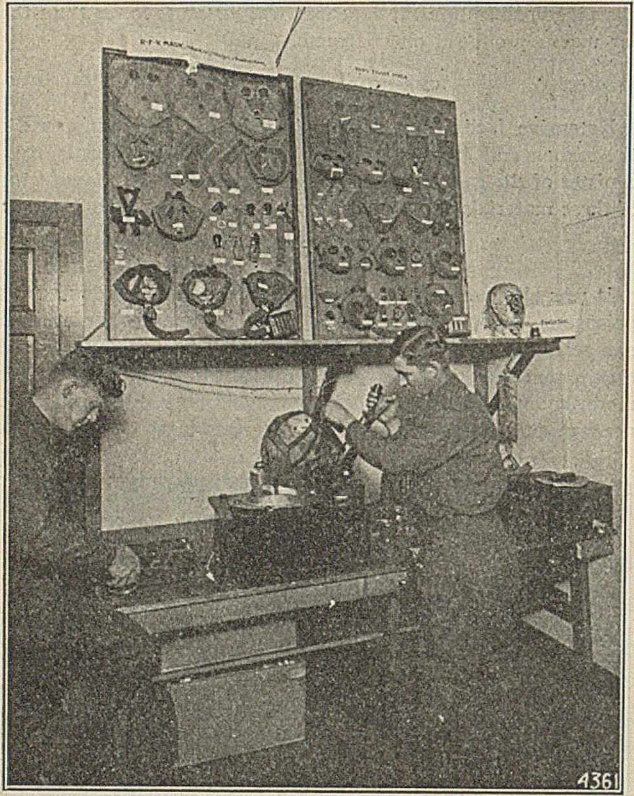

Fig. 16—Long Island Laboratory. Machine Design Unit Showing Device for Testing Completed Masks for Leakage

For chemical control of the factory production, one-quarter of 1 per cent of all masks produced were tested in a phosgene gas apparatus and had to stand a 15 min. test against a mixture of 2000 parts of phosgene to one million parts of air at a rate of flow of 30 liters per min.

In February 1918 a plant for the manufacture of horse masks was established at the Fifth Avenue Uniform Company, New York City, under the direction of the Gas Defense Division. This plant produced 378,000 horse masks at the rate of 5,000 per day.

MISCELLANEOUS GAS DEFENSE EQUIPMENT

In addition to man and horse masks, there were many other types of gas defense equipment supplied in large quantities by the Gas Defense Division. These include:

1—Dugout blankets which were used at the entrance of dugouts to make them gas-proof. These were specially woven all-cotton blankets which were treated in the field with a mixture of 85 per cent heavy steam cylinder oil of paraffin base and 15 per cent boiled linseed oil.

2—Protective suits and gloves used for the protection of the body against mustard gas burns. The suits were made of a special oiled fabric and the gloves of cloth impregnated with a pyroxylin compound.

3—Protective ointments applied to the skin for protection against mustard burns. A mixture of zinc oxide, lard, lanolin, and linseed oil was found most satisfactory. The ointment was put up for shipment in small metal containers.

4—Gas warning signals, for gas attack alarms, of which a modified klaxon horn is the best example.

5—Trench fans, which consisted of a canvas flapper on a wooden handle, used for removing gas from trenches and dugouts after gas attacks.

6—Oxygen inhalators, a mechanical apparatus for administering oxygen to gassed persons.

For the development of these devices and for the solution of many other gas defense problems, great credit is due to Dr. W. K. Lewis and an able corps of assistants of the Gas Defense Section of the Research Division, Chemical Warfare Service, which was located at the American University, Washington, D. C.

TECHNICAL LABORATORIES

Laboratories were a necessity as a part of the gas defense production organization. They were located at various points throughout the country to carry on control work, to perform tests required from time to time, and to carry many development problems from the research stage into production.

PHILADELPHIA CONTROL LABORATORY—In October 1917 a chemical laboratory was established at Philadelphia, Pa., to exercise chemical control over the product of the Hero Manufacturing Company, then getting under way as the first plant to produce gas masks under government supervision. This laboratory was constructed in record time, being started on October 10 and finished to the point where operations could begin on November 11. It occupied at first a floor space of 7500 sq. ft.; in January 1918 the size was doubled. Maj. R. P. Rose (then Captain) was assigned as officer in charge, with Capt. E. J. Hull (then 1st Lieutenant) as his assistant. The total personnel numbered 85.

A laboratory for the testing of gas masks and other gas defense apparatus naturally differed radically from an ordinary chemical laboratory. Besides the usual chemical equipment, it was provided with apparatus for testing both finished masks and gas-absorbing materials, such as carbon and granules, for life against the various warfare gases. These tests were of two kinds, machine tests and actual man breathing tests in a gas chamber.

The first gas chamber was completed in this laboratory on November 11, 1917. The chamber measured 24 ft. long, 7 ft. wide, and 9 ft. high, and was divided into three compartments, the gas chamber proper and a small ante-chamber at each end for making it possible to enter without the escape of gas. The sides of the chamber were made of wood with glass windows

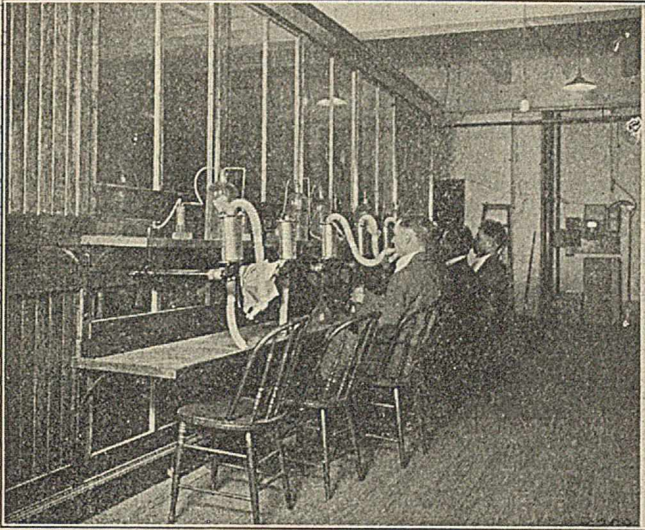

Fig. 17—Philadelphia Control Laboratory. Side View of Gas Chamber Showing Subjects Making Outside Breathing Tests of Canister

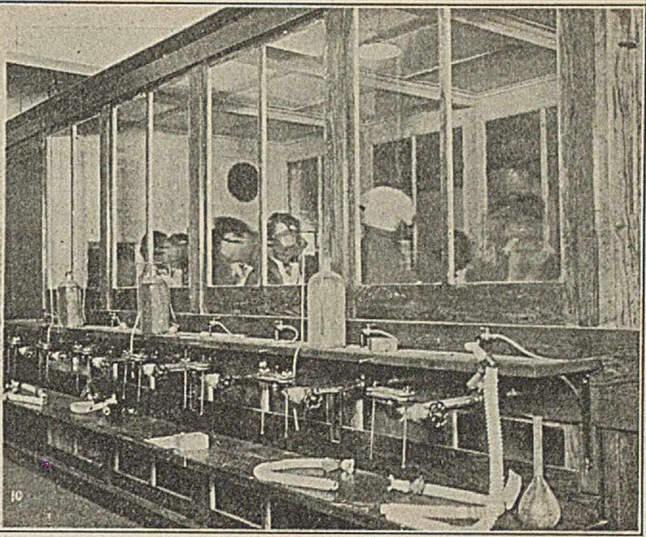

Fig. 18—Philadelphia Control Laboratory. View of Gas Chamber Showing Subjects Testing Masks Inside

although later the use of double walls with a ventilated air space of 18 in. between was found more satisfactory. The walls and flooring were carefully sealed so as to be gas-tight. A powerful ventilating system was provided whereby the chamber could be emptied in a quarter of a minute and the entire room in which the chamber was situated in one minute. This gas chamber was in continuous operation in the center of the city for a year, using concentrations of phosgene as high as 1 per cent, without any complaints ever being received.

To obtain absolute results as to the protection afforded by a gas mask, actual man breathing tests in a gas chamber had to be employed. This testing throughout the war was done by enlisted men of the Gas Defense Division. Many hours were spent each day by men testing masks and canisters in gas. Too much credit cannot be given to these men for the splendid spirit with which they performed this arduous and dangerous task.

Besides the gas chamber, there were laboratories for making machine gas tests on absorbents, for research and general routine, one for rubber and fabric testing, and a well-equipped machine shop.

This laboratory performed daily routine tests as a control on gas mask production as well as special investigations of chemical problems bearing on gas defense. Routine tests were made for (1) activity of carbon and granules when tested against phosgene, chlorpicrin, hydrocyanic acid, and arsine, (2) permeability of face fabrics by chlorpicrin and mustard gas, (3) man tests and machine tests of completed canisters against various gases, (4) complete dissection with necessary chemical and physical tests of samples of completed masks representing the daily product of the assembly plant.

LONG ISLAND CONTROL LABORATORY—A control laboratory was organized in March 1918 which was to perform the same functions for the Gas Defense Plant that the Philadelphia Laboratory did for the Hero Manufacturing Company. It occupied one floor of the Goodyear Building, comprising 15,000 sq. ft., with Capt. S. H. Lawton in charge and later Capt. J. S. Little. It contained two gas chambers, a rubber laboratory with facilities for permeability tests on gas mask fabric, a canister testing laboratory, and several others devoted to special chemical investigation.

MECHANICAL DEVELOPMENT LABORATORY—This laboratory was organized in March 1918 at Long Island City for the purpose of developing mechanical features of gas defense apparatus and for testing devices and ideas from all sources.

Maj. L. E. Cover (then Captain) was in charge. This laboratory, occupying approximately one floor of the Goodyear Building, included a complete machine and metal working shop, a complete rubber experimental shop with facilities for mixing, calendering, vulcanizing, and a drafting and blue-print equipment. It carried on progressive development of canisters to meet changing requirements, development of various rubber parts, especially the important exhalation valve, and of new types of mask carriers to permit greater freedom of movement of the soldier.

LONG ISLAND LABORATORY—In July 1918 a consolidation and reorganization of various laboratories took place, with a view to getting better coördination of effort. The Control and Mechanical Development Laboratories, together with a Mask Development Department which had been organized in the Gas Defense Plant, were combined into one laboratory to be known as the Long Island Laboratory. This laboratory occupied three floors of the Goodyear Building and was organized with Maj. C. R. Johnson in charge, and Maj. Waldemar Kops, assistant. It included 43 officers, 265 enlisted men, and 103 civilians, divided into the following departments:

Mask Development Department, responsible for development of the assembled mask with all parts, including the knapsack but excluding the canister; Maj. Waldemar Kops in charge, and Mr. G. S. Meikle, assistant.

Canister Development Department, responsible for development and design of the canister; Mr. B. C. Batcheller in charge, and Capt. R. M. Holmes, assistant.

Miscellaneous Apparatus Department, responsible for all other gas defense apparatus; Mr. W. H. Hampton in charge.

Chemical Department, which carried on the original functions of a control laboratory, with additional development investigations and special chemical service to the other departments of the laboratory, such as testing in the gas chamber of mask designs and canister designs. One-half to 1 per cent of masks and canisters from the Defense Plant were given man-house and machine tests each day. Maj. R. P. Rose was in charge, with Captains R. D. Evans, R. T. Will, and J. J. R. Bristow, assistants.

Mechanical Service Department, combined with the machine shop, drafting room, and outside facilities, provided complete mechanical service for the various departments; Capt. L. E. Fulford in charge, and 1st Lt. D. R. Long, assistant.

Specification Branch, associated with the laboratory and responsible to the Technical Director, wrote all specifications

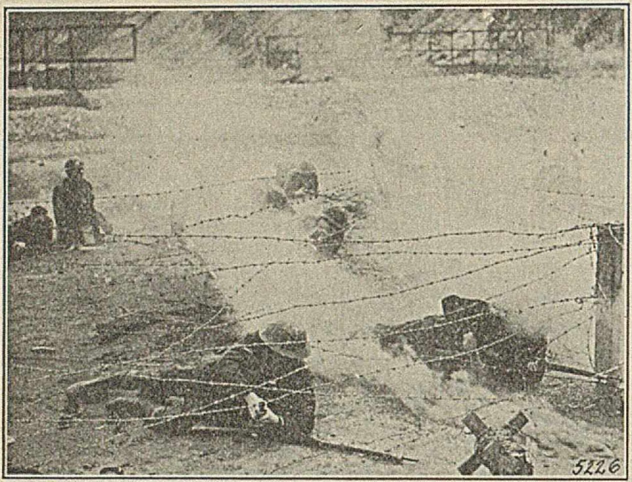

FIG. 19—TESTING SECTION. STAGING OF MINIATURE SMOKE ATTACK

for the Gas Defense Division and was in close contact with all development work and manufacturing; Maj. O. E. Stevens in charge, and Capt. W. M. Rile, assistant.

Under this new organization much better coördination was secured, and the development work was carried on with more efficiency.

Its function was to take ideas from all sources, including the Research Division of the Chemical Warfare Service, and carry these ideas from the form in which they existed at early inception to the manufacturing stage. It was provided with workshops completely equipped to carry on various mask-making and assembly operations on a small scale.

This organization carried to conclusion the development of the A. T. and K. T. type masks, two new types, of which nearly 350,000 had been completed for expeditionary shipment at the signing of the armistice. Had the war continued, these masks would have put the American Expeditionary Forces in a premier position with respect to gas defense. They eliminated poor vision, uncomfortable noseclip pressure, uncomfortable mouthpiece, and general discomfort in long wear. The old mask gave very unsatisfactory vision, due to the fact that the eyepieces dimmed because of moisture from the face, and had to be wiped frequently, at considerable disadvantage to the soldier, in order to secure proper vision. These new masks made use of the principle originally used by the French, carrying incoming air from the canister over the eyepieces before it was inhaled by the soldier.

The use of mustard gas by the Germans required long wearing of gas masks as the substance itself stayed in the ground very persistently after shell bombardment. It was therefore quite necessary that the soldiers be provided with a mask representing the maximum possible comfort combined with safety. This was embodied in these new types. They made it possible for soldiers to carry on offensive operations in gas masks.

The A. T. type mask was made of stockinette and rubber and was suitable for production in the various rubber plants throughout the country. The K. T. type was made of rubberized fabric and was suitable for sewing operations in the Gas Defense Plant. The two types were identical from the standpoint of the user and both were manufactured in order to secure the maximum possible production.

The final development of the Long Island Laboratory led to a combination of the best features of each mask in a model which could be died out of a sheet of stockinette and rubber, and with the sewing of one seam six inches long made a complete facepiece. This mask had tremendous manufacturing possibilities and preparations were actually under way to put it in large-scale production at the signing of the armistice.

During this same time, the Canister Development Department was keeping pace with the requirements of the Gas Defense Division, and at the signing of the armistice, complete specifications were available and a small production started for a canister which gave added assurance of protection against smokes together with lower resistance to breathing, which was extremely desirable for fighting efficiency.

As evidence of the variety of work carried on and the multitude of ideas coming from this laboratory, a museum was organized for the careful filing and labeling of all samples and devices produced. When hostilities ceased, the number of specimens in the museum numbered 1300.

AKRON RUBBER TESTING LABORATORY—Many of the component parts of the gas mask were made of rubber and in order to exercise proper control over all such articles a thoroughly equipped testing laboratory was established at Akron in the midst of the rubber companies, under Lt. R. M. Gage. Daily tests for physical and chemical properties were made on samples of the output of each manufacturer. By this means the quality of all rubber stocks and materials used was kept under control.

FIELD TESTING SECTION

Along with development activities of the Gas Defense Division, there grew up an interesting division known as the Field Testing Section. It was organized to provide field testing conditions for the regular product and for the development organization. It was originally composed of 1 officer and 18 enlisted men and its activities expanded until it had a force of 11 officers and 185 men. Capt. K. Atterbury was officer in charge, with Capt. P. B. Moulton, assistant.

The later additional duties of this section included a preliminary course of training for officers for overseas duty in chemical

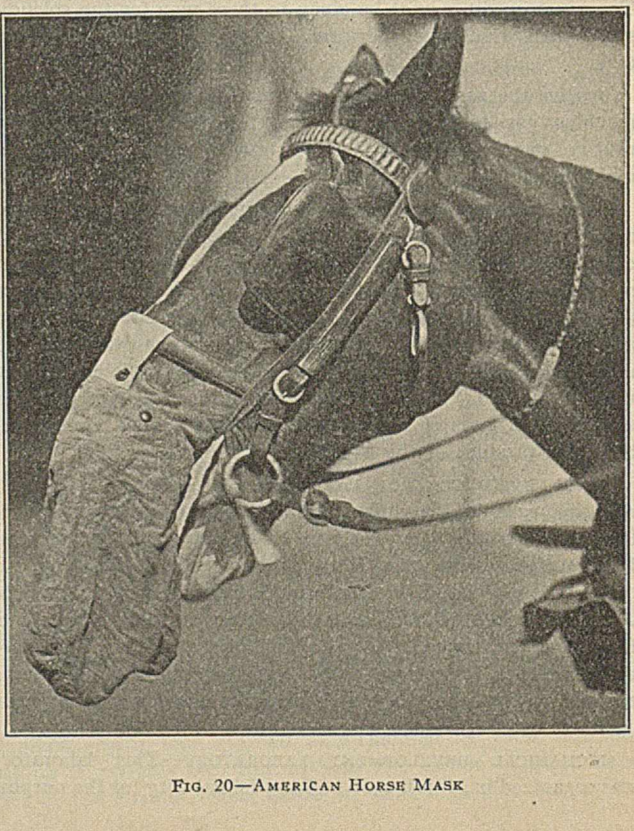

FIG. 20—AMERICAN HORSE MASK

warfare service, military training of Gas Defense Division officers located in New York City and vicinity, and training of boat crews carrying offensive gas supplies. This organization spent a great amount of time doing all kinds of vigorous physical work and exercise under simulated field conditions while wearing gas masks. They rendered most valuable service in pointing out weaknesses of design as developments took place, and especially those uncomfortable features of the masks which were only apparent through long wear. During the course of its activities it built a complete trench system in the Pennsylvania Railroad yards, with an elaborate dugout which matched any of the famous German quarters on the western front. It carried on a large-scale field test at the Lakehurst Proving Grounds on the A. T. and K. T. masks in which a gas attack under large scale and high concentration conditions was realized.

CONCLUSION

As to the production record of the Gas Defense Division, it is interesting to note without further comment the following extract from the War Department:

> A mistaken impression that delayed production compelled American soldiers to depend on British and French masks has been current in this country. This theory is entirely unfounded. * * * It may be stated authoritatively that prior to the July counteroffensive against Germany, an American gas mask had been shipped across the Atlantic for every American soldier in France. There is in addition an ample military reserve. * * * The American attacking forces are protected against gas by masks which actual field tests prove give twenty times the protection afforded by German gas masks.

The work of this division may be summed up in the statement that American soldiers were provided with equipment which neutralized the best efforts of German chemical knowledge as evidenced by the offensive methods and materials employed. This was accomplished by an organization located three thousand miles from the point of use and source of practical field information. This organization grew from the acorn stage to the great oak in mushroom time. Its growth was due to the patriotic enthusiasm of its personnel: officers, enlisted men, civilian workers, and clerical force.

Gas Defense Division
Chemical Warfare Service, U. S. A.
19 West 44th St., New York City

TESTING NATURAL GAS FOR GASOLINE CONTENT[1]

By G. G. Oberfell, S. D. Shinkle and S. B. Meserve

Received January 4, 1919

In a previous article[2] one of the writers had occasion to describe a method for testing natural gas for gasoline content. The method described in that article was intended especially for testing casing-head gas which is generally rich in gasoline content. That method consisted in extracting the gasoline vapors from the gas with oil as the absorbing medium and recovering the gasoline by distillation. The method described in this article employs the use of a solid absorbing medium such as charcoal and is applicable to both lean and rich natural gas.

DESCRIPTION OF ABSORBER

The series tube absorber shown in Fig. 1 is preferably made of aluminum and consists of 4 tubes, B B, fastened rigidly to the supporting plates, C C. The tubes are each 22 cm. long and have an internal diameter of 2 cm. Each tube has a removable perforated disc, D D, 3 cm. from the bottom, which is held in place by a hollow cylinder fastened to the disc and resting against a plate, E, at the bottom of the tubes.

The absorption tubes are connected in series by means of tubes attached to the bottom plate E, and top plate, F. The plates are held in place by means of thumbscrews, GG. The absorber is made airtight by means of rubber gaskets, HH, fitting closely on the plates at each end.

METHOD OF OPERATION

(1) FILLING THE TUBES—Charcoal or other material of high absorption value should be used. The plate F is removed and each tube is filled with the absorbent to within about 3 cm. from the top. The height of the absorbent in each tube is then about 15 cm.

After the tubes are filled the plate F is replaced in such a manner as to connect all 4 tubes in series, providing this arrangement is desired. By proper arrangement of the plate, 2 of the tubes will be in series ready for test while the other 2 will be by-passed. By the latter arrangement duplicate tests may be made with one filling.

(2) ARRANGEMENT OF APPARATUS—The following arrangement of the apparatus has been used in tests conducted in the laboratory: Gas → flow meter → calcium chloride → dry meter → manometer → absorption tubes → manometer → suction (when needed).

The flow meter was used to control the rate of gas flow. An orifice flow meter has been used and found satisfactory for rough determination of gravity of the metered gas, the determination being made as follows: The flow meter is checked against the dry meter, the time being recorded for delivery of a certain volume of air, V, with a constant differential height, H, on the manometer of the flow meter. To determine the specific gravity of the gas the flow meter differential is maintained at the height H and volume V of gas passed through it. The time for the gas flow is recorded. The specific gravity of the gas is calculated as follows:

$$\text{Specific gravity of gas} = \frac{(\text{Time for gas flow})^2}{(\text{Time for air flow})^2}$$

The calcium chloride was used to prevent possible deterioration of the absorbent due to moisture. Also, during distillation moisture is liable to condense in the receiving vessel with the other vapors absorbed by the charcoal and thereby cause difficulty in gravity determinations. The open manometers were placed before and after the absorption tubes in order to get the pressure drop through the absorber. The dry meter was arranged with a manometer so that the pressure of the metered gas could be obtained. The temperature of the gas was taken by means of a thermometer placed at the inlet to the dry meter. Suction was used in cases where the gas pressure was insufficient to give the required volume of gas.

(3) METHOD OF DISTILLATION AND GRAVITY DETERMINATIONS—The distillation apparatus and the method

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[1] Published by permission of the Director of the Chemical Warfare Service.

[2] This Journal, 10 (1918), 211.

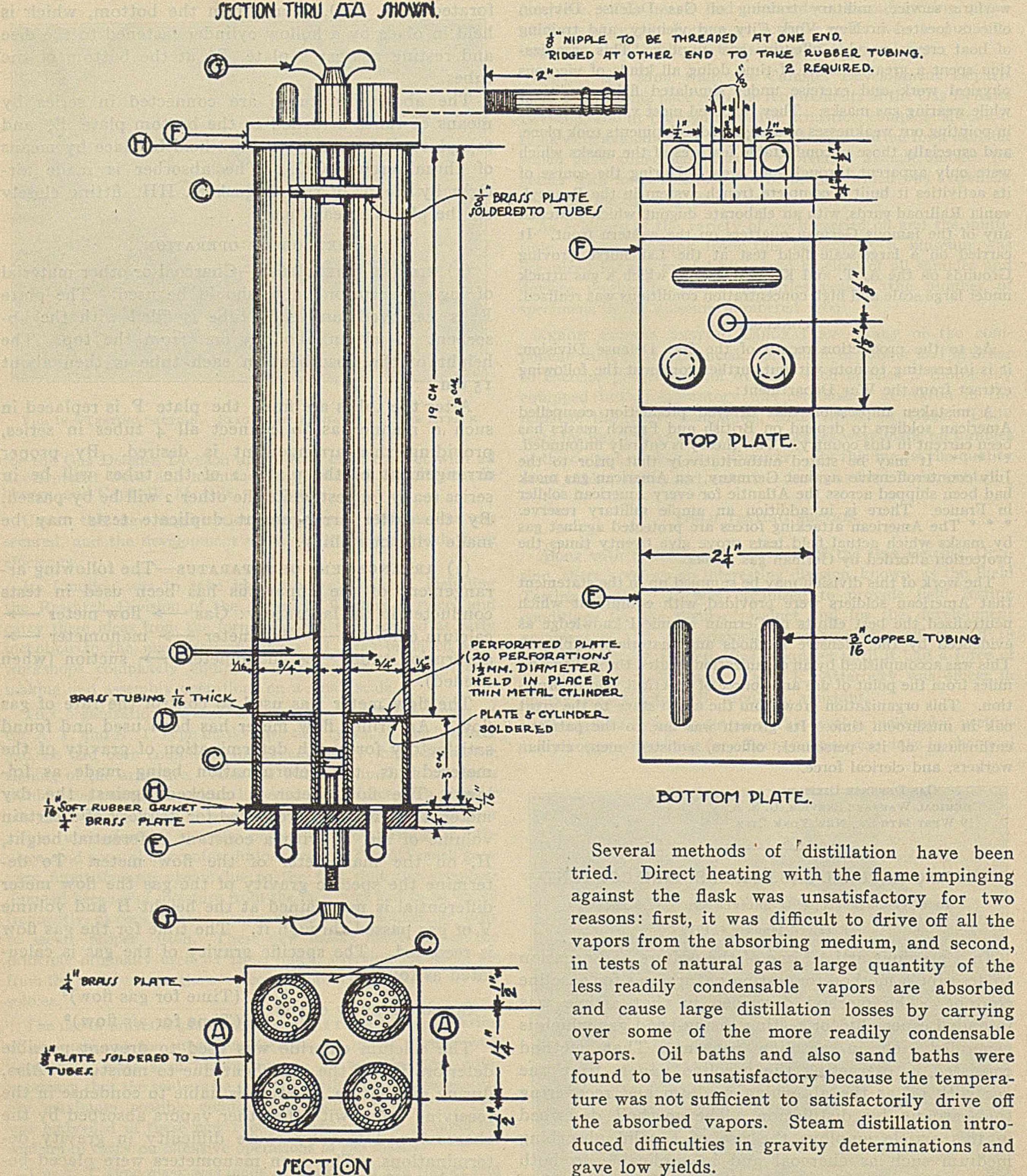

Fig. 1—Series Tube Absorber

for the determination of the gravity of the distillate are essentially the same as described in the previous article.[1] The distillations were made after adding 600 cc. of straw oil (petroleum distillate about 30° Bé.) to the charcoal in the distilling flask.

Distillation tests were also made in which 200 cc. of glycerin were added to the charcoal which was placed in a 500 cc. Pyrex flask.

Several methods of distillation have been tried. Direct heating with the flame impinging against the flask was unsatisfactory for two reasons: first, it was difficult to drive off all the vapors from the absorbing medium, and second, in tests of natural gas a large quantity of the less readily condensable vapors are absorbed and cause large distillation losses by carrying over some of the more readily condensable vapors. Oil baths and also sand baths were found to be unsatisfactory because the temperature was not sufficient to satisfactorily drive off the absorbed vapors. Steam distillation introduced difficulties in gravity determinations and gave low yields.

The most satisfactory methods so far tried are distilling in the presence of straw oil or in the presence of glycerin. The advantage of using glycerin is twofold: first, the charcoal can be regenerated easily by washing with water, and second, if the distillate were contaminated with glycerin it would be removed by washing the distillate with water. If the distillate were contaminated with oil, an error would be introduced in calculating the yields of gasoline, since separation of oil and gasoline is not practical with such a small

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[1] *Loc. cit.*

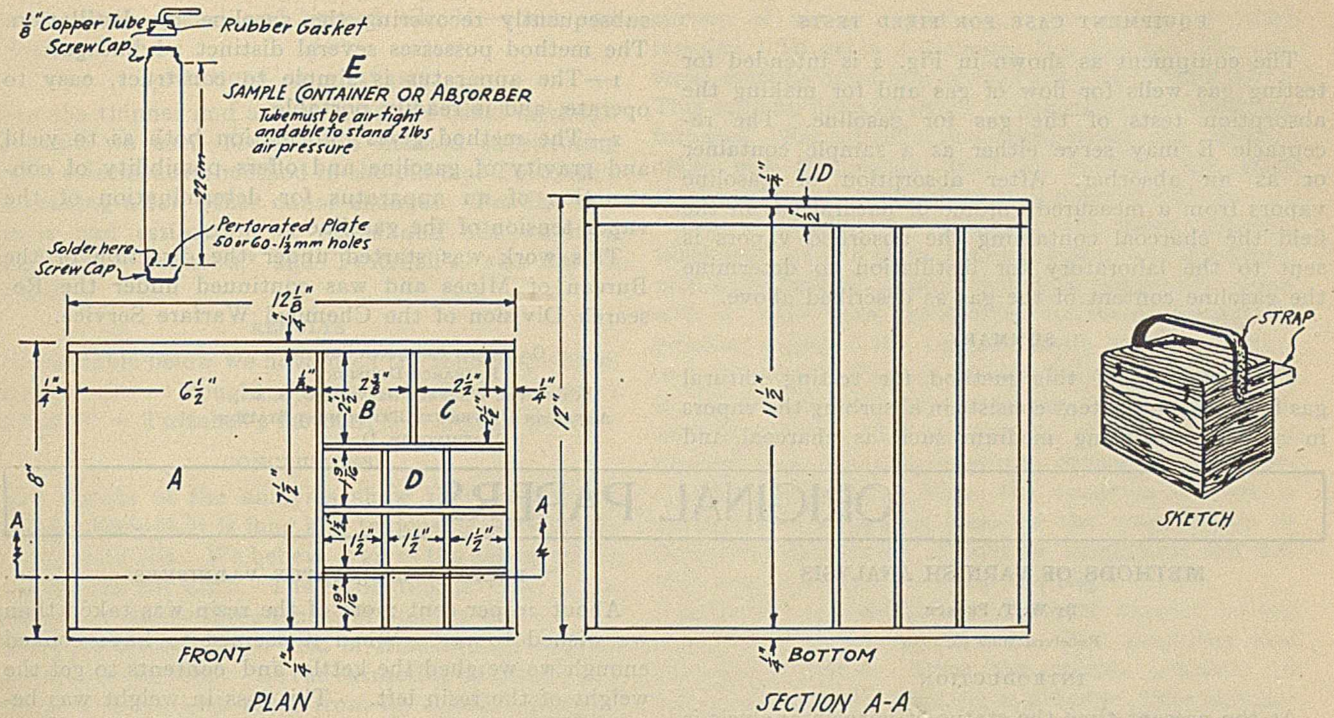

Fig. 2—Equipment Case for Field Tests

Compartment A holds dry test meter
Compartment B holds tube absorber
Compartment C holds orifice meter
Compartments D (9) hold receptacles for samples

Shellac all parts
Equip lid with hinges and hooks
See sketch for arrangement of strap handle

volume of gasoline as would be obtained in a test.

Extensive tests have not been carried out to determine how many times a charcoal can be regenerated and thereby continue to be of value for absorption tests of this nature. This would of course depend upon several factors, chief of which is the quality of the charcoal. However, charcoal which had been regenerated three times gave satisfactory results. The method of regeneration used is as follows:

Record Card of Tests

Yield pts./1000 cu. ft. (60° F. and 30 in. Hg) = $\frac{\text{Distillate cc.} \times 1000}{\text{Cu. ft. gas used} \times \text{factor} \times 473}$

1 Locality: Homer, Ohio
2 Date of test: November 15, 1918
3 Source of gas: inlet to gasoline plant
4 Test began: 10.07 A.M.
5 Test finished: 10.52 A.M.
6 Test duration, min.: 45
7 Barometer, in. of Hg.: 29.13
8 Pressure of meter, in. of Hg: 1.13
9 Total gas pressure, in. of Hg: 30.26
10 Temperature of gas, deg. F.: 64
11 Conversion factor, 60° F. and 30 in. Hg: 1.000
12 Meter reading, finish, cu. ft.: 935.70
13 Meter reading, start, cu. ft.: 925.70
14 Meter reading difference, cu. ft.: 10
15 Gas rate, cu. ft. per hr.: 15
16 Gas used, cu. ft., 60° F. and 30 in. Hg: 10.00
17 Absorbent, kind: charcoal
18 Absorbent, preliminary treatment: none
19 Absorbent, laboratory number: A-658
20 Absorbent, accelerated CCl_4 time, min.: 20.8
21 Absorbent, weight before test, grams: 19.0, 19.0, 19.0, 19.0
22 Absorbent, weight after test, grams: 24.5, 23.7, 21.6, 21.72
23 Distillation method: 600 cc. of oil added
24 Distillate, cc., 60° F.: 9.76
25 Distillate, sp. gr., 60° F./60° F.: 0.6292 equals 92.5 ° Bé.
26 Distillate, color: water white
27 Distillate, odor: ethereal
28 Distillate, per cent H_2SO_4 absorption: less than 1 per cent
29 Distillate, yields pts./1000 cu. ft. gas (uncorrected): 2.06
30 Distillate, yields pts./1000 cu. ft. gas (60° F. and 30 in. Hg): 206
31 Distillate, yields gals./million cu. ft. gas (uncorrected): 258
32 Distillate, yields gals./million cu. ft. (60° F. and 30 in. Hg): 258

Remarks:

Test by......................
Check by......................

The glycerin is decanted off the charcoal. The charcoal is then placed on a Buchner funnel and washed with about 500 cc. of water. The water is added to the decanted glycerin and filtered. The filtrate is evaporated until all the water has been removed. The glycerin so recovered is ready to be used over again.

The charcoal is left on the Buchner funnel and a stream of tap water is run through it for 2 hrs. At the end of this period the charcoal is placed in an oven and dried for several hours at 140° C. (usually over night).

(4) Data recorded—The preceding form has been used for recording data of tests.

RESULTS

Tests were made of natural gas for gasoline content. In Table I are presented the results of tests with the series tube absorber using charcoal as the absorbing medium and results of comparative tests with the portable oil absorber.[1] These results show that the two methods compare favorably, the yield by the portable oil absorber being about 6 per cent low. Comparison is also made with plant production for the days during which the tests were made.

Table I—Comparison of Oil Absorption Method and Charcoal Absorption Method in Tests of Natural Gas for Gasoline Content

	Charcoal Absorption Method	Oil Absorption Method	
		Portable Absorber	Plant Yield
Number of tests averaged	4	2	2 days' product
Source of gas	Inlet to gasoline plant		
Gasoline recovered, Bé. 60° F./60° F.	90.2	90.4	88.6
Gasoline yield, Pts./M. cu. ft. gas	1.76	1.65	1.55
Gasoline yield, per cent[2]	100.0	93.8	88.1

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[1] "Extraction of Gasoline from Natural Gas by Absorption Methods," by G. A. Burrell, P. M. Biddison and G. G. Oberfell, Bureau of Mines *Bulletin*, 120 (1917).

[2] Calculated from charcoal absorption method as giving 100 per cent yield.

EQUIPMENT CASE FOR FIELD TESTS

The equipment as shown in Fig. 2 is intended for testing gas wells for flow of gas and for making the absorption tests of the gas for gasoline. The receptacle E may serve either as a sample container or as an absorber. After absorption of gasoline vapors from a measured volume of natural gas in the field the charcoal containing the absorbed vapors is sent to the laboratory for distillation to determine the gasoline content of the gas as described above.

SUMMARY

The principle of this method for testing natural gas for gasoline content consists in absorbing the vapors in a solid absorbing medium such as charcoal, and subsequently recovering the gasoline by distillation. The method possesses several distinct advantages:

1—The apparatus is simple to construct, easy to operate, and is readily portable.

2—The method gives information both as to yield and gravity of gasoline and offers possibility of construction of an apparatus for determination of the vapor tension of the gasoline.

This work was started under the direction of the Bureau of Mines and was continued under the Research Division of the Chemical Warfare Service.

Gas Mask Research Section
Research Division
Chemical Warfare Service, U. S. A.
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ORIGINAL PAPERS

METHODS OF VARNISH ANALYSIS

By W. T. Pearce

Received June 15, 1918

INTRODUCTION

At the present time the status of varnish analysis is not good. It is generally agreed that the following of any of the published methods will give results that vary in the hands of different analysts and that do not represent either the quantities or qualities of the materials used. The consensus of opinion among varnish chemists is that a complete chemical analysis would reveal little as to the relative merits of competitive grades of varnishes. This opinion needs to be fully investigated. The literature on varnish materials clearly indicates the need of more work on the physical and chemical properties of resins and the need of research on the analysis of oil mixtures.

Varnish analysis to date seems to consist chiefly of the following determinations: thinners (turpentine, benzine, etc.), resins, rosin, oil, and drier. Tests for factory control include specific gravity, viscosity, hardness of film, drying test, and panel test.

In outlining the work to be carried out in this laboratory, we thought it wise to make up a few varnishes, differing widely in composition in order to investigate the accuracy of existing methods. Along with this we have studied the problem of identifying and estimating the different oils used.

PREPARATION OF THE VARNISHES

About 20 per cent more of the resin was taken than we wished to use. When it seemed to have cooked enough we weighed the kettle and contents to get the weight of the resin left. This loss in weight was between 20 and 30 per cent, except in the cases where only rosin was used, and then it was nearly 7 per cent. The hot boiled oil (or oils) was then added and the kettle and contents weighed to get the weight of oil added. This mixture was cooked in the usual way. A kettle of the same dimensions containing a volume of oil equal to that in the varnish was heated the same length of time at the same temperature to give the loss in weight of the oil in the varnish. In this way we were able to calculate to within one per cent of the oil and resin in the material. The loss in weight of the oils was between 1 and 2 per cent.

MATERIALS USED

The linseed oil was kept at 200° C. for 2 hrs. with oxide of lead added. The constituents of the varnishes used for the analyses reported in this paper are: No. 2—Sierra Leone copal, rosin (colophony), linseed oil, turpentine, and drier; No. 3—rosin, Chinawood oil, drier, and turpentine; No. 5—East India copal (white), rosin, menhaden, Chinawood and linseed oils, drier, benzine, and turpentine; No. 6—East India copal (white), soy bean, Chinawood and linseed oils, drier, turpentine, and benzine; K—Sierra Leone copal and

No.	Resins		Rosin		Oil		Thinners		Benzine	
	Estimated	Found	Estimated	Found	Estimated	Found	Estimated	Found	Estimated	Found
2	15.8	13.82 (D) 20.04 (T) 15.65 (B)	4.54	4.12 4.59	36.9	40.98 (D) 34.81 (S) 33.56 (B)	40	39.01		
3			8.01	8.19 7.97	34.3	32.10 36.04 (D)	57.7	56.93		
5	17.1	17.47 17.23 (B) 17.69 25.18 (D)	1.23	1.44 1.30	48.3	39.45 (D) 47.64 47.97 (B)	34.5	33.0	13.8	13.93
6	13.0	13.22 13.43			46.4	46.68 46.15 (B) 31.3 (D)				
Q			15	14.03 14.08	85	84.12 84.46 (B)				
R			20	20.15 21.04	80	77.66 (B)				
M	20	20.60 20.53 (B)			80	79.40 79.47 (B)				
K	40.35	38.67 (B)			59.7	61.33 (B)				
L	19	21.52 (B)			81	78.48 (B)				

linseed oil; L—kauri and linseed oil; M—rosin and Chinawood oil.

METHODS OF ANALYSIS

For the thinner and ash we used the usual methods. For rosin we used McIlhiney's method substituting Wolff's esterification method in the place of Twitchell's and making a few other minor changes. For the separation and estimation of resins and oils we used Boughton's,[1] Darner's,[2] and Twitchell's, and Scott's methods.

RESULTS

In the table below we have used the following abbreviations: B = Boughton's method; D = Darner's method; T = Twitchell's method; S = Scott's method.

CONCLUSIONS

The results of the analyses show that Boughton's method, although it is long and tedious, is satisfactory for resins and oils. We believe it gives the actual values to within one per cent. The estimation of rosin is accurate to probably three-tenths of one per cent.

We have spent a good deal of time endeavoring to find a shorter method. As the extracting in Boughton's method is made with ether from an aqueous solution containing alcohol, we tried to find a solvent that would not require alcohol to break the emulsion. A large number of solvents were tried but none gave good results. This problem will be included in our next year's work.

ACKNOWLEDGMENT

The writer wishes to express his thanks to Dr. E. F. Ladd, who not only suggested the work but gave advice and encouragement while it was in progress.

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THE REDUCTION OF TUNGSTIC OXIDE[3]

By C. W. DAVIS

Received August 19, 1918

Powdered metallic tungsten is being produced at the present time by several industrial concerns for use in the manufacture of alloys. The available literature on the reduction of tungstic oxide to the metal, although extensive, fails to give definite information concerning the conditions involved. The following work was undertaken to supplement existing data.

GENERAL

Mennicke[4] shows that tungstic acid, as it comes from the filter press after its precipitation with acid, contains considerable water. When air dried, there is still over 7 per cent total water in the material. This must be removed before reduction, for the steam that would be liberated during the heating would cause the material to fly in all directions, thus tending to separate the tungstic oxide from the reducing material (when carbon in some form is used) due to the great difference in their specific gravities. Even when dried in a current of air at 100° C., 3.7 per cent total water remains. To get a sufficiently dry product, the material must be dried in a current of air at about 500° C. This may be done in either reverberatory or revolving furnaces. For all reduction experiments, the tungstic oxide was thoroughly dried at 500° C., the color changing from a pure yellow to a greenish yellow.

For a satisfactory reduction, the dried tungstic oxide must be in a state of fine division, and if reduced with some form of carbon, should be completely mixed with it. The most satisfactory treatment consists of grinding together the tungstic oxide and the carbon in a tube mill. Steel or wooden balls should be used, as Mennicke[1] states, for porcelain or flint introduces more impurities. The purpose to which the finished product is to be put, however, determines the permissible impurities. When the tungsten powder is to be added to molten steel for the manufacture of tungsten steel, traces of iron or manganese are not injurious, and silica goes into the slag.

It is well, as Mennicke and others[1] suggest, to use some form of binding material when preparing this mix for reduction. Since the specific gravities of tungstic oxide and carbon are so different, their segregation during the processes of reduction is quite apt to occur. Colophonium, being itself a good reducing agent, easily obtained in a pure condition, and easily pulverized, is to be recommended. The quantity of this material used by different operators varies from 10 to 30 per cent of the carbon requirement of the reduction.

PRELIMINARY EXPERIMENTS

The material used in the experiments described in this article was an impalpable, canary-yellow powder. As received, the tungstic acid gave off 8.3 per cent of water at a temperature of 500° C. Analysis of the tungstic oxide, dried at 500° C., showed a tungstic oxide content of 99.4 per cent; insoluble in potassium hydroxide, 0.55 per cent (largely silica).

The reduction processes used are conveniently treated in two sections, that of using some form of solid carbon being the more common, while the reduction performed by some reducing gas gives a purer product. In both cases, the reduced material must be cooled in a reducing atmosphere as the powdered tungsten readily oxidizes when heated. The oxidation, once started, is pyrophoric in action, and is incandescent after the removal of the source of heat.

The temperature necessary for the reduction of tungstic oxide to the metal, using some form of carbon, is given variously, ranging all the way from red heat up to the temperature obtained with the electric furnace. The following preliminary tests on small samples show what takes place:

Tungstic oxide was mixed with carbon (sugar charcoal). The samples were placed in porcelain crucibles, the covers being luted on with fire clay.

The results in Table I indicate that at a temperature of 650° to 850° C. the reduction produces a blue or purple oxide; at a temperature of 900° to 1050° C. the reduction produces a chocolate-brown material, a

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[1] Bureau of Standards, *Technologic Paper* 65.

[2] N. D. Agr. Expt. Sta., *Paint Bulletin*, 1, No. 6.

[3] Published by permission of the Director of the U. S. Bureau of Mines.

[4] "Die Metallurgie des Wolframs," 1911, p. 183.

[1] *Loc. cit.*

mixture of oxides; at a temperature above 1050° C. a gray product is obtained which, as will be shown later, is undoubtedly metallic tungsten. Mennicke[1] says that the reduction of tungstic oxide to the blue and brown oxides takes place at 1000° to 1100° C., while the metal is produced at 1100° to 1200° C. Continued heating causes reoxidation with the formation of a green substance. Since this action occurs on the surface and is complete only after the carbon is all gone, its formation was doubtless due to air leaking into the crucibles.

TABLE I

SAMPLE No.	Weight Sample Grams	Weight Carbon Grams	Temp. Degrees C.	Time Min.	Residue after Heating	Carbon Left
1	1	0.1	700	180	Bulk purple, top green	None
2	1	0.1	1000	10	Top blue, rest chocolate-brown	Some
3	1	0.1	1000	20	Same as No. 2, but more blue	None
4	1	0.1	1000	40	Same as No. 2, but top green	None
5	1	0.1	1000	90	Same as No. 2, but more green	None
6	1	0.2	1100	15	Gray powder, top green	Some
7	1	0.2	1100	45	Gray powder, more green	Some
8	1	0.2	1100	120	All green	None
9	5	1.0	650	30	Bulk blue, top green	Some
10	5	1.0	650	60	Bulk purple, top green	Some
11	5	1.0	800	15	Bulk blue, top green	Some
12	5	1.0	850	30	Bulk blue, top green	Some
13	5	1.0	900	20	Bulk brown, top blue	Some
14	5	1.0	900	40	Bulk brown, top green	Some
15	5	1.0	1000	60	Bulk brown, top green	Some
16	5	0.75	1100	120	Bulk gray, top brown	Some
17	5	0.75	1100	180	Bulk gray, top green	Trace
18	10	1.5	1100	120	Bulk gray, top green	Trace
19	10	1.0	1100	60	Bulk brown, top blue, bottom gray	Trace

TESTS ON THE TEMPERATURE AND THE QUANTITY OF CARBON REQUIRED

To get a more accurate measure of the temperature with its resulting changes in reduction, another set of experiments was carried out. These tests were run in a quartz tube closed with a fire-clay plug at one end; the other end was fitted with a pyrometer tube luted to the main tube so that, in each case, the hot junction was near the center of the charge.

TABLE II

SAMPLE No.	Weight Sample Grams	Weight Carbon Grams	Temp. Degrees C.	Time Min.	Residue after Heating	Carbon Left
1...	25	3.75	1100	90	All gray, green at end	Some
2...	25	3.75	1100	60	Tube broken, all green	Some
3...	25	3.75	900	105	Bulk brown, trace gray	Some
4...	25	3.75	900	300	Bulk brown, some gray	Some
5...	25	3.75	1000	420	Olive-green	None
6...	25	3.75	1000	240	Bulk brown, some gray	Some
7...	25	3.75	1050	180	Bulk gray, ends green	Some
8...	25	2.5	1050	180	Bulk brown, some gray	None
9...	25	3.3	1100	180	Bulk gray, some brown	None
10...	25	3.5	1100	180	Bulk gray, trace brown	None

The results in Table II indicate that the temperature must be at least 1050° C. for the reduction to metallic tungsten. Under the conditions of the test, the carbon content necessary for adequate reduction depended both on the temperature of reduction and the resulting time required, the ratio being about 10 parts tungstic oxide to 1.4 parts carbon. Moissan[2] used 10 parts tungstic oxide to 1 part of carbon. This was, however, at the temperature of the electric furnace and for a short period of heating. Mennicke[3] used 10 parts tungstic oxide, 1.4 parts charcoal, and 0.2 part colophonium, the temperature reaching 1400° C. in about 7 hrs. The carbon requirement, if figured on the basis that the resulting gas is all carbon dioxide, is 10 parts tungstic oxide to 0.77 part carbon. If it is considered that the reaction goes to carbon monoxide, the carbon requirement is 10 parts tungstic oxide to 1.55 parts carbon.

Analysis of the gray material resulting from reduction at 1100° C. showed:

	Per cent
Carbon	2.25
Tungsten	97.07
Not determined	0.68

This indicates that the material is metallic tungsten.

The brown material resulting from reduction at 1000° C. gave on analysis:

	Per cent
Carbon	13.5
Tungstic oxide	30.0
Tungsten	55.0

The reduction in this case was incomplete.

REDUCTION WITH CHARCOAL IN IRON TUBE

A reduction was conducted with 500 g. of tungstic oxide dried at 500° C. This was mixed and ground with 75 g. of wood charcoal. The apparatus consisted of a 2 in. pipe, 2 ft. 6 in. long, capped at each end; a 1/2 in. pipe was attached to one cap so that a pyrometer could be introduced at the center of the charge. The other cap was fitted with a 1/4 in. pipe so that gas could be introduced if desired. The charge was placed at the center of the large pipe and held in place by fire-clay plugs, one having a hole for the pyrometer. This apparatus, which contained the charge, was placed in a fire-brick furnace so that the portion containing the charge was in the heat zone, while the ends of the tube protruded on each side. The heat was furnished by a gasoline pressure burner. During reduction, the 1/4 in. pipe was closed and the pyrometer tube inserted. The maximum temperature during the 3 hrs. of heating was 1120° C. While cooling, producer gas was admitted at one end of the tube (the other being closed), so that the reducing atmosphere was maintained.

The product resulting from reduction was gray, lumpy, and friable. This seemed to be metallic tungsten, and the following analysis shows its condition of purity:

	Per cent
Tungsten	98.2
Carbon	0.3
Silicon dioxide	0.8
Not determined	0.7

A small quantity of partially reduced material was left at the end where the pyrometer was introduced. Some of the silica is due to the poor quality of charcoal used. The ash content of the charcoal was 4.4 per cent. The charcoal used, therefore, should be as pure and free from ash as possible. Since the iron pipe after heating at 1100° C. and cooling again is quite badly oxidized, it would seem advisable to use an alundum or fire-clay tube in the process.

REDUCTION WITH LAMPBLACK IN FIRE-CLAY CRUCIBLE

An experiment was tried showing the reduction of tungstic oxide with lampblack in a fire-clay crucible. 250 g. of tungstic oxide were mixed with 37.5 g. of lampblack and placed in a fire-clay crucible. A fire-clay disk on which was placed a small quantity of

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[1] *Loc. cit.*

[2] *Compt. rend.*, **116** (1893), 1225.

[3] *Loc. cit.*

lampblack was inserted in the crucible above the charge, leaving sufficient space to cover the crucible. The covered crucible was heated at 1100° C., the complete time of heating being $1^1/_2$ hrs. As this includes the time required to heat the furnace, the time of heating at 1100° C. was less than one hour. The crucible was completely cooled before removing the charge. The resulting material, as a whole, was well reduced. There was some oxidized material at the top of the charge, due to air leaking into the crucible around the cover. Analysis of the material from the crucible reduction is as follows:

	Per cent
Tungsten	98.6
Carbon	0.4
Silicon dioxide	0.4
Not determined	0.6

The lampblack gave an ash content of 0.6 per cent. Although the silica in the product was reasonably low and the reduction excellent, the carbon content was a trifle high. The carbon content can be reduced by regulating the ratio of carbon to tungstic oxide in the charge, or by washing out the carbon. This product was washed to remove the carbon, and dried at 150° C. It then gave an analysis of:

	Per cent
Tungsten	99.1
Carbon	0.1

The fire-clay crucible was not attacked in the reduction, and the material was easily removed in the form of friable lumps.

CONTINUOUS PROCESS FOR REDUCTION WITH CHARCOAL

In the foregoing reductions there was always some material which was not completely reduced. Although this material could be used again in the next charge, it was thought advisable to try out a continuous process where there would be no material left in an oxidized condition, and where the reduced material would be cooled without cooling the container, which would remain at the temperature required for reduction. The apparatus consisted of a 1 in. pipe, 3 ft. long, set at a slant in a furnace so that a portion 9 in. long was kept at a temperature of about 1080° C. The mixture of tungstic oxide and carbon was of the ratio 10 to 1.5. This mixture was fed in at the top end of the tube, and from time to time was poked through, so that the material was in the hot portion about 30 min. The reduced material would then be forced into the cooled part of the tube (cooled by water). From time to time the reduced material was removed from the cold end of the tube. The product was quite dark or black. The first portion, however, was gray and lumpy. This dark portion analyzed:

	Per cent
Tungsten	95.2
Carbon	4.4

The dark color is thus seen to be due to excess carbon. The reducing action of the gases which come from the heated mass and pass through the tungstic oxide mixture plays an important part, as evidenced by the first reduction product being gray. That is, the first part of the charge, having no reducing gases passing through it, was properly regulated with respect to the tungstic oxide and carbon ratio. On the other hand, the later charges, being partially reduced with gas, had an excess of carbon. Although the carbon in this run was excessive, it could be easily regulated by reducing the carbon in the mix. The material was washed with water and showed 98.5 per cent tungsten. The washing as performed consisted of a crude panning, so that better results could be expected by a jig or table treatment. Mennicke[1] states that both carbon and partially oxidized tungsten can be removed by crushing and washing. The tendency to cake in the hot part of the tube could be decreased by using a larger tube. If necessary, the tube could be rotated to insure a proper feed, or a worm feed could be installed at the top, at the bottom, or both, as occasion demanded.

The possible advantages of using a continuous process such as the one suggested would be: Less heat loss, due to keeping the apparatus at a constant temperature; no unreduced oxides of tungsten; small chance of air coming in contact with the hot charge; and less wear and tear on the apparatus, since the greatest deterioration occurs on heating and cooling.

REDUCTION WITH GAS

Hartman[2] states that tungstic oxide is reduced to the metal with pure dry hydrogen at 1000° C.; Bosch[3] states that the reduction takes place with hydrogen at 600° C. under high pressures; Thomson[4] says that tungstic oxide heated at 600° to 800° C. in a stream of hydrogen for a long time is reduced to the metal. From these statements we were led to believe that the reduction temperature with gas at ordinary pressures might be lower than that required when carbon was used. This would cause less difficulty in maintaining the temperature and would save considerably on the wear and tear of the apparatus.

The following experiments were conducted to determine the temperature required for reduction with hydrogen:

Tungstic oxide was placed in a quartz tube, which in turn was placed inside an iron pipe fitted with a pyrometer, and closed in such a way that hydrogen could be passed through.

TABLE III

Time Heated Hrs.	Temperature Degrees C.	RESULTS
$1^1/_2$	800	Brown oxides resulted
$^1/_2$	900	Brown oxides resulted, with some black, shiny crystals
$1^1/_2$	1000	Resulting material was practically all brown with just a little gray at the end where the hydrogen was introduced. This gray might be due to the fact that the temperature might have been greater at that portion of the tube, the pyrometer being introduced at the other end

Reduction with hydrogen at 1080° C. for $1^1/_2$ hrs. gave a steel-gray product. This analyzed 99.4 per cent tungsten.

Reduction with gasoline gas at 1080° C. for 2 hrs. gave a dark gray (blackish) powder. This proved to be 98 per cent tungsten. It contained considerable carbon, due to hydrocarbons in the gas used.

It follows from Table III that reduction with hydrogen at ordinary pressures is not noticeably different from that with carbon. It may be that long heating with

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[1] *Loc. cit.*

[2] *Pahasapa Quarterly*, **5** (1916), 25.

[3] *Chem. Abs.*, **10** (1916), 1411.

[4] U. S. Patent 960,441.

large excess of hydrogen would reduce the oxide at lower temperatures. This treatment, however, is hardly applicable if the reduction process is to be used commercially. However, at temperatures over 1050° C. the reduction proceeds quickly and the product is a very pure tungsten powder. Producer gas might well be used in place of hydrogen for the reduction, as suggested by Thorpe.[1]

SUMMARY

1—The tungstic oxide used for reduction must be pure, dry, and in a state of fine division.

2—When reduced with carbon, the tungstic oxide should be thoroughly mixed with it.

3—At 650° to 850° C. tungstic oxide goes to a blue or purple oxide when heated with carbon; at 900° to 1050° C. a chocolate material is the result; and at temperatures above 1050° C. the gray powdered metallic tungsten results.

4—As the tungsten is easily oxidized, the reduced material must be cooled in a reducing atmosphere.

5—The ratio of tungstic oxide to carbon varies from 10 : 1 to 10 : 1.6, depending on the process used, the temperature of reduction, and the time involved.

6—Excess carbon can be partially removed by washing.

7—Fire-clay crucibles or iron tubes give satisfactory reduction with a product of over 98 per cent tungsten. Under the conditions of the test some oxides resulted at portions nearest the crucible cover and tube ends.

8—Fire-clay is not attacked by the charge at the temperature used. The iron tubes suffer considerable oxidation on the outside.

9—A continuous process could be arranged to get a tungsten powder free from oxides.

10—The time of reduction of small samples at 1100° C. is less than one hour.

11—The temperature of reduction with hydrogen at ordinary pressures is much the same as with carbon. The product is over 98 per cent tungsten.

ACKNOWLEDGMENT

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Bureau of Mines
Golden, Colorado

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[1] "Dictionary of Applied Chemistry," Vol. 5, 564.

SOLUBILITIES, SEPARATION, AND PURIFICATION OF ANTHRACENE, CARBAZOL AND PHENANTHRENE

By John Marshall Clark

Received September 30, 1918

GENERAL

Anthracene, carbazol, and phenanthrene are present in the oils derived from gas-house and coke-oven tars in the oil fraction known to the tar distiller under various names, such as "anthracene oil," "heavy oil," "dead oil," and "green oil." This oil is the fraction obtained in the distillation of tar between 290° and 380° C. When first distilled it is a reddish liquid with a green fluorescence. It soon becomes semisolid on cooling. Besides containing anthracene, carbazol, and phenanthrene, all of which are solid at ordinary temperatures, this fraction also contains varying percentages of about fifteen other hydrocarbons. Chrysogen, one of these substances, imparts the green color to this oil, and acridine, another, causes sneezing if inhaled in sufficient quantity. The amounts of these latter impurities are, however, small in comparison with the amounts of anthracene, carbazol, and phenanthrene present. No definite statements can be made as to the exact percentages of these substances in the tar as these figures vary with the kind of tar, its source, its method of distillation, etc. The following, however, are the analyses of the anthracene oil from representative American gas-house and coke-oven tars and are inserted here solely to give the reader a general idea of what to expect in the way of these oils. A few tests on the tars from which the oils are derived are also included.

The tests on the tars and oils in this paper were conducted after the methods of Church.[1] The percentage of pure anthracene was determined by the method of Luck, Meister, and Lucius,[2] which was later modified by Brüning[3] at Höchst-am-Main and became known as the Höchst test. The carbazol content was determined by a slight modification of the Kjeldahl method for the determination of nitrogen worked out by the writer and given below.

No very accurate method for the determination of phenanthrene could be found. The method of Kraemer and Spilker[4] was tried, but it was thought that the results were not dependable especially when the material examined contained less than 20 per cent of phenanthrene. The percentages of phenanthrene then as recorded in the following pages represent the difference between one hundred and the sum of the percentages of anthracene and carbazol. It will readily be seen that this will include in many cases a number of other hydrocarbons, and consequently the percentages of phenanthrene in many cases are probably high.

TABLE I

Tar Tests	Gas-House Tars	Coke-Oven Tar
Sp. Gr. at 15.5° C.	1.224	1.168
Free Carbon	22.3	6.91
Viscosity (Engler) 100 cc. at 100° C., seconds	64	36
Heavy Oil 290° to 380° C., per cent	16.2	23.0
Heavy Oil Tests		
Sp. Gr. at 15.5° C.	1.152	1.143
Phenols, per cent	3.1	1.7
Anthracene, per cent	1.8	1.5
Carbazol, per cent	0.7	0.6
Phenanthrene and other solid hydrocarbons, per cent	2.6	2.8

From this table one can readily see that even though the percentages of anthracene and carbazol are greater in the oil derived from gas-house tar than that derived from coke-oven tar, yet the actual amount, calculated back to the unit of tar, is less in the former than the latter. This, of course, is due to the difference in the percentage of oil obtained.

It is entirely possible that tars from other sources will show percentages varying from the above. The

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[1] This Journal, 3 (1911), 229.

[2] *Ber.*, 6, 1347.

[3] *Z. anal. Chem.*, 16, 181.

[4] Lunge, "Coal-Tar and Ammonia," 1916 Edition.

kind of coal used, the type of retort, and the method of firing are all factors that influence the quality of the tar. Even after the tar distiller receives it, it is subjected to more or less cracking depending on the conditions stated above; for instance, tars distilled by the continuous still process give oils lower in solid hydrocarbons than those distilled from the horizontal or vertical type of still.

In the recovery of anthracene, carbazol, and phenanthrene from the heavy oil, it is first necessary to allow the solids to separate out. This will take place to a large extent at ordinary temperatures but the operation can be made more complete and hastened by artificial cooling. The limpid creosote oil is then drained off from the anthracene "salts" thus obtained and the crystals centrifuged or pressed to free them from as much of the creosote oil as possible.

The percentages of hydrocarbons in the solid cake thus obtained will vary, but the sample used in the separation explained later is representative. It analyzed as follows:

	Per cent
Anthracene	30.1
Carbazol	22.0
Phenanthrene	47.9

A number of methods are now suggested to the research chemist for the purification of anthracene. His selection of a method is finally based on the product he has to purify and the means he has at his disposal to accomplish this purification, provided, of course, that all methods give equal results.

The following methods found in the literature seem the most likely ones:

Remy and Erhart[1] effect a purification of anthracene by crystallizing it from oleic acid.

The Farbenfabriken, formerly Frederick Baeyer & Co.,[2] use liquid sulfur dioxide to dissolve the impurities out from anthracene.

Welton[3] uses liquid anhydrous ammonia to dissolve out the impurities.

The Farbenfabriken[4] in another patent recommend the use of acetone as a solvent for the impurities of anthracene.

The Aktien Gesellschaft für Anilinfabrik[5] add potassium hydroxide to the melted crude anthracene and distill *in vacuo*. The purified anthracene containing phenanthrene passes over and the carbazol remains behind.

Wirth[6] separates anthracene by means of its easily soluble nitroso compound.

Catchpole[7] heats the impure anthracene cake to a temperature of not over 200° C. and thus "sweats" out the impurities from the anthracene.

Vesely and Votocek[8] find that concentrated sulfuric acid extracts all of the basic impurities of anthracene from a solution of crude anthracene in a solvent immiscible with the acid.

From the preceding one can readily see that the methods used were largely solvent methods. A search of the literature, however, revealed the fact that the solubilities of anthracene, carbazol, and phenanthrene had been determined in only a few solvents and at only a few temperatures.

Versmann,[1] Becchi,[2] and Findley[3] seem to have been about the only ones who recorded their researches in this field and a glance at the references will show how scant is the information they have left.

The writer's method of separation was based on a solvent method in so far as it was practical. Crude coal-tar solvent naphtha was used to remove the phenanthrene, and coal-tar bases (commonly called pyridine) were used to remove the carbazol from anthracene. It was found, however, that after a certain degree of purity had been obtained solvents could no longer be employed in the purification of anthracene and carbazol and then special chemical methods were introduced. Before using the solvent methods to advantage, however, it was necessary to determine the relative solubilities of pure anthracene, carbazol, and phenanthrene in several solvents and at different temperatures.

EXPERIMENTAL

Small quantities of anthracene, carbazol, and phenanthrene were prepared and used for the solubility tests. The methods used in the preparation of these small samples were to a large extent like the methods described later, except that very little attention was paid to yields in the preparation of these pure materials, as the amount of solvent used was more or less guesswork.

The anthracene prepared and used in the following solubility tests had a melting point of 212.7° C. and tested 99.8 per cent pure anthracene; the carbazol had a melting point of 236° C. and tested 99.94 per cent pure; and the phenanthrene had a melting point of 99.8° C.

The following tables show the tests of the solvents used and the solubilities of pure anthracene, carbazol, and phenanthrene in 100 parts of solvent. The specific gravities were determined by means of a pycnometer, and the distillation tests made in a standard Engler 250 cc. distillation flask.

Quite a number of the above solubilities are of interest only from an academic or scientific viewpoint. In the preparation of anthracene, carbazol, or phenanthrene on a commercial scale the manufacturer must select a solvent that is readily obtainable, that is cheap, and that will produce the best results. Toluol and benzol, for instance, would work admirably for separating phenanthrene from anthracene and carbazol, but no manufacturer would now think seriously of using them, especially when coal-tar naphtha will accomplish the same results. Similarly it is seen that acetone and pyridine could be used to separate anthracene from carbazol and phenanthrene, and for apparent reasons pyridine is given the preference.

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[1] German Patent 38,417.

[2] German Patent 68,474.

[3] English Patent 27,559.

[4] German Patent 78,861.

[5] German Patent 178,764.

[6] English Patent 14,462.

[7] English Patent 16,641.

[8] English Patent 27,596.

[1] *Jahresber.*, **1874**, 423.

[2] *Ber.*, 12, 1978.

[3] *J. Chem. Soc.*, **1902**, 221.

TABLE II—TESTS ON SOLVENTS USED FOR SOLUBILITY TESTS

NAME	Sp. Gr. at 15.5 ° C.	1st Drop ° C.	10 Per cent ° C.	20 Per cent ° C.	30 Per cent ° C.	40 Per cent ° C.	50 Per cent ° C.	60 Per cent ° C.	70 Per cent ° C.	80 Per cent ° C.	90 Per cent ° C.	Dry ° C.
Benzol, C. P.	0.880	79.8	80.0	80.1	80.1	80.2	80.2	80.3	80.4	80.4	80.5	80.6
Toluol, C. P.	0.870	110.0	110.0	110.0	110.0	110.1	110.2	110.2	110.2	110.3	110.3	110.4
Coal-Tar Solvent Naphtha Refined	0.865	142.0	145.0	146.0	147.0	149.0	150.0	153.0	155.0	160.0	166.0	175.0
Crude Coal-Tar Solvent Naphtha	0.893	140.0	152.0	153.0	155.0	157.0	160.0	162.0	169.0	174.0	179.0	192.0
Heavy Coal-Tar Naphtha	0.909	162.0	165.0	168.0	171.0	172.0	173.0	174.0	176.0	180.0	185.0	200.0
Chloroform, C. P.	1.495	59.5	60.4	60.5	60.6	60.7	60.9	61.0	61.4	61.8	62.0	63.5
Carbon Bisulfide, C. P.	1.270	45.2	45.7	46.2	46.2	46.3	46.4	46.4	46.5	46.6	47.0	49.0
Acetone	0.800	56.0	56.0	56.1	56.1	56.2	56.3	56.3	56.4	56.5	57.0	58.0
Light Pyridine[1]	0.952	115.0	125.0	131.0	132.0	133.0	135.0	137.0	143.0	145.0	150.0	171.0
Heavy Pyridine[1]	1.057	112.0	202.0	214.0	225.0	229.0	233.0	237.0	240.0	244.0	247.0	274.0
Hydrated Pyridine, $C_5H_5N.-3H_2O$ Carbon	1.050	93.5	94.0	94.2	94.6	94.8	95.0	95.2	95.4	95.6	96.0	98.0
Carbon Tetrachloride	1.610	74.0	75.5	75.8	76.0	76.1	76.2	76.2	76.3	76.4	76.5	76.7
Gasoline	0.742	61.0	90.0	100.0	111.0	118.0	128.0	135.0	140.0	150.0	164.0	180.0
Ether	0.720	34.8	35.0	35.1	35.2	35.3	35.3	35.4	36.0	37.1	40.2	40.8

[1] These are the bases derived from coal-tar oils by abstraction with sulfuric acid and liberation of the base with caustic soda. They probably contain but very little pyridine, C_5H_5N.

TABLE III—PARTS OF ANTHRACENE, CARBAZOL AND PHENANTHRENE SOLUBLE IN 100 PARTS OF SOLVENTS

	At 15.5° C.			At 30° C.			At 50° C.			At 80° C.			At 100° C.		
SOLVENT	Anth.	Carb.	Phen.	Anth.	Carb.	Phen.	Anth.	Carb.	Phen.	Anth.	Carb.	Phen.	Anth.	Carb.	Phen.
Benzol	1.04	0.72	16.72	2.10	1.01	40.10	...	5.05	..	...	...	...	...	...	
Toluol	0.53	0.42	13.80	1.90	0.78	29.10	3.10	1.60	..	7.88	2.90	...	12.20	4.78	Above the melting point of phenanthrene
C. P. Solvent Naphtha Refined	0.46	0.48	12.52	1.42	0.70	22.42	2.90	1.37	30.8	6.58	3.00	84.4	10.10	3.72	
Crude Coal-Tar Solvent Naphtha	0.50	0.54	15.30	1.71	0.94	31.80	3.25	1.70	74.2	7.20	3.84	243.0	8.82	7.00	
Heavy Coal-Tar Naphtha	0.32	0.48	11.94	1.35	0.75	21.30	3.10	1.52	60.3	7.65	3.63	193.0	10.53	4.70	
Chloroform	0.83	...	18.70	1.64	0.60	29.20	7.10	1.08	..	...	...	...	...	...	
Carbon Bisulfide	0.52	...	26.42	1.62	0.44	...	...	...	..	...	...	...	...	...	
Acetone	0.55	6.12	15.08	1.42	9.74	22.40	2.48	62.30	..	...	...	...	...	...	
Light Pyridine	0.85	12.45	25.54	2.15	16.90	38.00	4.10	26.74	78.9	11.22	66.80	241.0	16.72	...	
Heavy Pyridine	0.38	2.72	20.0	1.40	4.10	24.50	2.98	10.57	64.7	7.87	16.54	182.0	8.82	22.87	
Hydrated Pyridine	Nil	0.42	0.43	Nil	0.81	1.32	0.001	1.90	7.4	1.53	4.70	11.1	...	...	
Carbon Tetrachloride	0.67	0.09	7.40	1.15	0.11	11.24	1.30	0.30	..	...	...	...	...	...	
Gasoline	0.12	0.11	4.53	0.37	0.12	6.30	0.76	0.16	..	...	...	...	...	...	
Ether	0.70	2.54	8.93	1.03	2.90	15.24	...	...	..	...	...	...	...	...	

Briefly then, the method finally adopted as giving the best results was to use crude coal-tar solvent naphtha and pyridine as the solvents, to heat the crude anthracene cake in the selected solvent until practically everything passed into solution, and to filter at a lower temperature at which it was found convenient to work and the best results were obtained. It may seem unnecessary perhaps to some to heat beyond the point of filtration. However, this was found necessary in actual practice both for obtaining a whiter product and better results from the use of the solvent.

After filtering, the solvent was distilled off, recovered, and the crystallized material, as well as the residue from the distillation, subjected to the action of solvents again. By altering the solvents and repeating the process, the hydrocarbons were obtained in a degree of purity that will permit of their use in dye manufacture.

The following diagram illustrates the process used on one of the final runs. It shows the amount and purity of the product at the start and shows how much and what kind of solvents were used in the purification and separation.

This diagram illustrates all the steps that are necessary for the preparation of anthracene and carbazol of a purity sufficient for use in dye manufacture, as well as the steps necessary in the preparation of the pure materials. Anthracene and carbazol of from 85 to 90 per cent purity seem to work very well for use in the preparation of most dye intermediates. Phenanthrene does not play a very important part in the arts, but as it forms the main impurity in anthracene and carbazol it is given prominence in this paper.

A temperature of 30° C. seems to be a very good temperature at which to carry out the crystallization. It is generally just a little above room temperature and is easily maintained by using steam-jacketed kettles.

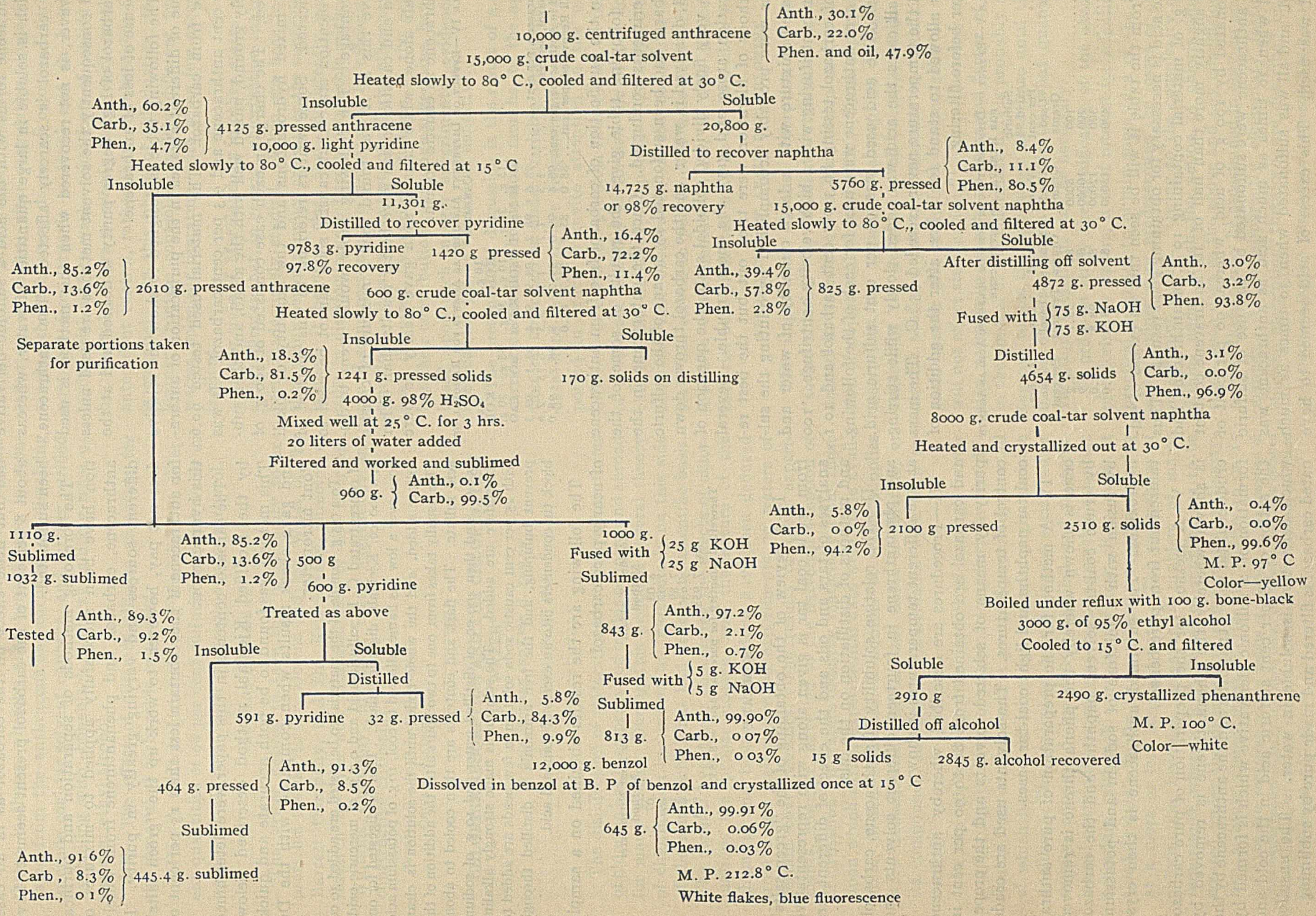
In one or more places in the scheme depicted there may seem to be a discrepancy in the phenanthrene figures. As the phenanthrene is calculated by difference it is probable that some unexpressed solvent remained behind, thus introducing an error in the phenanthrene content.

The reader will readily see from the experimental data that it is impossible to purify anthracene and carbazol by strictly solvent methods. Once a mixture of 90 per cent anthracene and 10 per cent carbazol is obtained, or *vice versa*, purification by solvent methods is of no avail. Mixed crystals of these substances in this proportion are found in the filtrate on evaporation as well as in the crystallized material. Phenanthrene, owing to its far greater solubility in coal-tar solvent naphtha, can be separated, or nearly so, from anthracene and carbazol in the purification of the latter substances. In the purification of phenanthrene, however, it is easier to take out the carbazol with alkali and then the anthracene by the use of solvents.

The complete purification of anthracene and carbazol is only accomplished by special chemical methods. The anthracene is separated from carbazol by subliming or distilling after fusion with alkali. The carbazol forms the alkali compound, remains behind, and the anthracene distills over. The carbazol can then be set free from its alkali derivative by the use of mineral acid, but the material thus liberated usually contains anthracene in such large percentages that this is not considered good material for use in making pure carbazol. It is, however, returned to the process and worked along with other inferior residues.

Carbazol, on the other hand, is purified from anthracene by means of sulfuric acid of 98 per cent purity or by any other convenient strength that will sulfonate anthracene in the cold. At ordinary temperatures

SEPARATION AND PURIFICATION OF ANTHRACENE, CARBAZOL, AND PHENANTHRENE



anthracene forms with the acid a sulfonic derivative which is soluble in large quantities of water, whereas the carbazol is scarcely affected. The anthracene, however, is not recovered when this method is used and consequently the solvent methods are used unless a carbazol of high degree purity is desired and at the expense of loss of anthracene.

The following table is designed to show the relative value of different alkalies in the purification of anthracene from carbazol. The material used tested 90.6 per cent anthracene and 9.3 per cent carbazol. It was finely ground, mixed well with the alkali, and then sublimed. The charge in each case consisted of 200 g. of the mixed hydrocarbons and the quantity of alkali indicated. Some writers referring to this method of purification state that caustic soda cannot be used to advantage. The following table would seem to disprove this as it was found that a mixture of caustic soda and caustic potash gave better results than either alkali alone, while caustic soda gave nearly as pure anthracene as caustic potash.

TABLE IV—EFFECT OF DIFFERENT ALKALIES AS AGENTS FOR REMOVAL OF CARBAZOL

	15 g. KOH	20 g. NaOH	10 g. KOH 10 g. NaOH	30 g. K_2Co_3	35 g. CaO	8 g. KOH 20 g. CaO
Anthracene, per cent	98.6	98.2	98.9	96.4	93.1	97.3
Carbazol, per cent	1.3	1.7	1.1	3.5	6.75	2.6
Yield in Anthracene, per cent	98.4	99.0	99.2	97.8	96.2	98.0
Alkali Recovered, per cent	88.0	85.0	83.7	82.0	...	..

In the purification of carbazol free from anthracene the following table gives the results of some of the experiments conducted. Once the anthracene in the carbazol had been sulfonated by means of the sulfuric acid, dissolved in water, and the carbazol thrown down in a very finely divided colloidal state, the question of filtration arose and gave the most trouble. Several methods of filtration were tried out but the best results were probably accomplished by diluting the sulfonated mixture with a large quantity of water and then centrifuging with a high velocity centrifuge. 100 g. of carbazol testing 89.3 per cent carbazol and 10.1 per cent anthracene were used for each of the following runs. The acid used was 98 per cent sulfuric acid. In all cases the acid was added slowly while stirring and the temperature never exceeded 35° C. The mass was allowed to stand for 4 hrs. after the addition of water before filtering.

TABLE V—EFFECT OF DIFFERENT QUANTITIES OF SULFURIC ACID AS AGENTS FOR REMOVAL OF ANTHRACENE

RUN No.	Sulfuric Acid 98 Per cent Used Grams	Water Used Grams	Dried Sample Grams	Carbazol Per cent	Anthracene Per cent
1	100	8000	86	95.7	4.2
2	200	10000	84	98.4	0.9
3	300	12000	83	98.8	0.0
4	400	15000	83	98.9	0.0

From the table it will be seen that an excess of sulfuric acid is necessary for obtaining good results. Thus 100 g. of material containing 10 g. of anthracene had but slightly more than half of its anthracene content sulfonated by 100 g. of acid, whereas 90 per cent of the anthracene were sulfonated by the use of sulfuric acid when 20 times as much acid as anthracene was used, and all was sulfonated when 30 times as much acid was used. This excess of acid seemed to have had but little effect on the carbazol as in all cases about 8 per cent of the carbazol present seems to have been sulfonated.

The foregoing methods of separation and purification have been successfully applied to mixtures of anthracene, carbazol, and phenanthrene from widely different sources and varying greatly in purity. It does not pay, however, to work up the "green salts" for anthracene if they contain less than 15 per cent of this hydrocarbon.

The carbazol contents in this paper were determined by the modified Kjeldahl method described below. This method was found to be both accurate and quick, and gave check results when compared with the Du Pont nitrometer.

To a 0.5 g. sample of the material to be tested are added 30 cc. of concentrated C. P. sulfuric acid and 0.7 g. of mercuric oxide in a 500 cc. Kjeldahl digestion flask. This is digested for one hour over a low gas flame, allowed to cool, 10 g. of potassium acid sulfate added, and the whole boiled until the solution is clear. This usually takes from one to two hours after the addition of the acid sulfate. The flask and contents are then cooled to about 35° C., and then 200 cc. of distilled water and 10 g. of sodium thiosulfate are added. The solution is made strongly alkaline with 25 per cent caustic soda solution, a few beads are added to prevent bumping, and the free ammonia is distilled through block tin condensers into an excess of standard acid.

The following are the results obtained on a sample of nearly pure carbazol:

Modified Kjeldahl Method	Du Pont Nitrometer Method
8.03	8.07
7.97	7.89
7.89	7.84
7.93	7.97
Av. 7.955	7.943

Theoretical quantity for pure carbazol = 8.383.

SUMMARY

I—A review of the obtaining of the "green salts" from crude coal tar is given along with representative analyses of tars and oils and the effect of different tars and methods of distillation on the oils.

II—The relative solubility of anthracene, carbazol, and phenanthrene in fourteen different solvents and at five different temperatures is shown.

III—Procedures are described whereby anthracene and carbazol are obtained from 80 to 90 per cent in purity by means of selected solvents and the proper control of temperatures. The solvents used are crude coal-tar naphtha and light coal-tar bases.

IV—A method for the preparation of pure anthracene is shown whereby the phenanthrene is removed by crude coal-tar solvent naphtha and the carbazol by fusion with a mixture of sodium and potassium hydroxides. The sublimed anthracene is then crystallized out from pure benzol.

V—A method for the preparation of pure carbazol is shown whereby the phenanthrene is removed by crude coal-tar solvent naphtha and the anthracene by the formation of a sulfonic derivative which is formed by the action of 98 per cent sulfuric acid in the cold and which derivative is soluble in water. The unsulfonated carbazol is filtered and made pure by subliming.

VI—A method for the preparation of pure phenanthrene is shown whereby the phenanthrene is separated from the anthracene and carbazol by dissolving in crude coal-tar solvent naphtha, and further purified by boiling with boneblack and crystallizing from 95 per cent ethyl alcohol.

VII—The effect of different alkalies as agents for the removal of carbazol is tabulated.

VIII—A table is given showing the effect of different quantities of 98 per cent sulfuric acid and water as agents for the removal of anthracene from carbazol.

ACKNOWLEDGMENT

The writer desires to take this opportunity to express his thanks to Dr. Downs and Mr. Weiss, of The Barrett Company, and Dr. Kritchevsky, director of research in dyes and intermediates of the Sherwin-Williams Company, for their many suggestions and constructive criticisms.

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Chicago, Illinois

CHLORINE ABSORPTION AND THE CHLORINATION OF WATER[1]

By Abel Wolman and Linn H. Enslow

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INTRODUCTORY

The disinfection of waters by means of various forms of chlorine has been practiced in this country and abroad for many years. During this period a general theory of chlorination has grown up, particularly on this side of the water, which has had little or no scientific basis. The general hypothesis concerning the effects of chlorination, the proper dosage, and the nature of the chemical and biological reactions have been deduced from a few well-controlled experiments on waters of certain characteristics. The results of these experiments, however, have led to the universal adoption of chlorination for waters differing materially from those upon which earlier experimental data were made available. When, therefore, a number of water supplies were treated with standardized doses of chlorine, or its compounds, failures in performance were soon recorded.

In the supervision and control of a single water supply, the problem of chlorination offers far less difficulty than in the case of a group of water supplies, all of which have distinctive and disconcertingly variable qualities. The control of disinfection of a city water supply, supported by daily chemical and bacteriological examinations, may at least approach a scientific procedure, although surprisingly few cities even at this late date actually do more than a superficial dosing at a more or less constant rate. The supervision of chlorination becomes, however, a problem of major importance where a large series of supplies are to be treated under the direction of some central authority, like a State Department of Health. With 10 or 15 water supplies—inadequately sampled, some in the raw state, some just after coagulation, some filtered, ranging through every degree of color and turbidity, now free from organic material and an hour later loaded with surface wash—what form of control should be adopted? Here a speedy, safe, easy method of antecedent control, rather than of subsequent failure, is essential. On this phase of chlorination, the preliminary routine control of widely different types of waters, scientific literature, with some few exceptions, is silent.

In the state of Maryland, as in other states, experience indicates that, in general, chlorination control has been inadequately studied. When we bear in mind that a number of supplies are under the supervision of laymen, it becomes clear that consistently good results in disinfection are hardly attainable without the use of some presumptive indicator of an efficient chlorine dose. Presumptive tests of chlorine efficiency have been discussed by various students of the problem; but their contributions, although suggestive, have been based upon such meager experimental evidence that they cannot yet be considered definitive.

The present brief discussion is the result of a study, carried on during the past 18 months, of the application of chlorinators under variable conditions. The data here set forth are fragmentary. They are reported in order to invite attention to the extreme intricacy of the whole problem rather than as the basis of a formula designed to furnish the proper doses of chlorine and its allied compounds. It may be stated, however, that observation of the conditions in this state has served to point out a wide field for further intensive experimentation and, in this respect, the material here presented may be of some little value.

ABSORPTION OF AVAILABLE CHLORINE

The importance of the absorption of so-called "active chlorine" by different waters is somewhat ill-defined in its relation to disinfection or the elimination of objectional bacterial life. Some experimenters assert that the amount of absorption discloses little concerning the destruction of bacteria, while others assume that the chlorine consumed in "oxidizing organic matter and sometimes ferrous salts or sulfides will not effect sterilization."[1] Since the latter assumption necessarily permits an increased factor of safety in the control of the chlorination, it is probably advantageous to use the hypothesis as a base until the collection of adequate data indicates what quantitative variations therefrom may be necessary.

In order to study the significance of the absorption of chlorine by waters, it is of interest for scientific and practical purposes to obtain some idea of the factors which influence or predetermine the losses of chlorine in different waters. Owing to the complexity of conditions under which the action of chlorination proceeds, such data as the above and any conclusions pertaining thereto may be ascertained in only an empirical manner. A few apparently elementary features of chlorine absorption, therefore, are described briefly in

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[1] The data submitted are the results of a study of the question of chlorination control in Maryland, upon which the writers have been detailed under the general direction of Mr. R. B. Morse, Chief Engineer, Maryland State Department of Health.

[1] Dakin and Dunham, "Handbook of Antiseptics," 1918, p. 106.

order to establish at least some salient characteristics of the phenomenon of the disappearance of the active agency in chlorination.

THE RATE OF CHLORINE ABSORPTION—A few experiments were tried to determine the velocity of absorption of available chlorine by the same water during varying time intervals. The data were collected in order to compare with similar work reported by Race.[1] The results are set forth in Table I. A comparison of these findings with the values reported by Race indicates that K, the velocity constant, in general, decreases with the time of contact. These values are in agreement with the conclusions noted by Race. It should be pointed out, however, that the value of K approaches a constant for different time intervals in those waters whose organic content is low. It appears, therefore, that the rate of chlorine absorption deviates from the ideal monomolecular law of chemical reaction in an increasing degree with waters of increased organic content. In other words, the monomolecular law with K constant is fairly well typified in those few waters which have only slight organic content, such as well and filtered waters, Nos. 13, 15 and 17. This is to be expected, since it is only in these latter waters that the compounds acted upon are probably of such simple chemical structure as to result in a constant reaction velocity.

TABLE I—ABSORPTION OF CHLORINE BY WATERS AT 20° C. VARIATIONS IN K WITH TIME

SAMPLE		Values of $K = \frac{1}{t_2 - t_1} \log \frac{N_1}{N_2}$ for time intervals of 5 min.	30 min.	60 min.
1	Surface	0.052	0.009	0.005
2	Surface	0.069	0.012	0.006
3	Surface	0.032	0.013	0.007
4	Surface	0.041	0.013	...
5	Surface	0.082	0.018	...
6	Surface	0.066	0.017	0.009
7	Surface	0.071	0.013	0.013
8	Surface	0.082	0.023	0.015
9	Surface	0.032	0.011	0.007
10	Surface	0.099	0.026	...
11	Surface	0.036	0.015	...
12	Surface	0.017	0.007	...
13	Filtered	0.007	0.004	...
14	Well	0.014	0.005	0.003
15	Well	0.007	0.008	0.006
16	Well	0.013	0.003	0.002
17	Well	0.009	0.009	...
18	Surface	0.104	0.018	0.010
19	Surface	0.036	0.007	...
20	Surface	0.044	0.004	...
21	Surface	0.026	0.014	0.010
22	Surface	0.120	0.023	0.014

TABLE Ia—SUMMARY OF DATA IN TABLE I

Initial Chlorine Absorbed in 5 min.	Ratio K_5/K_{30}	Ratio K_5/K_{60}
0.08	1.8	1.1
0.08	1.1	...
0.10	1.0	..
0.14	4.3	6.5
0.15	2.8	3.3
0.18	2.4	..
0.26	1.8	1.3
0.31	2.5	4.6
0.31	2.9	4.6
0.34	2.8	..
0.34	5.1	..
0.38	3.2	..
0.40	11.0	..
0.45	5.9	10.4
0.53	3.9	7.3
0.55	5.6	11.5
0.56	5.5	5.5
0.61	4.6	..
0.61	3.5	5.5
0.68	3.8	..
0.70	5.8	10.4
0.75	5.2	8.6

COLOR AND THE RATE OF CHLORINE ABSORPTION—The use of color readings as a presumptive indicator of the amount of chlorine which would be absorbed by a water in a given period has been suggested as a convenient procedure for routine operation of disinfectant plants. To be of any value, such readings should be the result of a long series of correlated experimental observations. Such continuous series have not been developed, it is believed, for many individual water supplies, while still less has been done in the way of comparative readings on different water supplies. Data upon this question are now being collected in this department. They are not reported in this paper on account of their insufficient number, but the evidence from the observations now available would seem to indicate that for the *same* water supply, changes in color are not necessarily concomitant with variations in chlorine absorption during a constant time interval, while for different water supplies the same conclusion is indicated as far as interdependent chlorine absorptions are concerned. It would appear, from the evidence now at hand, that color readings in different water supplies cannot be adapted to the prediction of chlorine absorption readings, because of the absence of any adequate conversion factor.

TURBIDITY AND THE RATE OF CHLORINE ABSORPTION—In order to study the variation of chlorine absorption in a surface water within different ranges of turbidity, a series of 350 samples of the Potomac River water at Luke, Md., were examined during June and July 1918. A study of the turbidity readings and the chlorine absorption tests indicates practically no correlation whatever between these two phenomena, although the turbidities ranged from 0 to 90 parts per million. The Potomac River water at the above station offers an interesting illustration of the necessity for guarding against unwarranted correlations between the physical property of a water and its biochemical conduct. In the case of the above water, the chlorine absorption values (during five minutes) showed no increase whatever with increases of turbidity, but rather a slight decrease. That the absorption remained almost constant and even decreased, in a degree, with an apparent physical degradation of the water is probably explained by the fact that the Potomac River at the point under discussion contains considerable oxidizable mine wastes. Sudden rainfalls create dilutions of these wastes, but at the same time raise the turbidity readings on the river. It comes about, therefore, that the increased muddiness in the water is in reality accompanied by a reduction in oxidizable material, without a consequent increase in chlorine absorption values. The situation is somewhat analogous to the reductions in alkalinity frequently observed with rises in turbidity. It is clear from the above situation that the direct variation of dosage with increase of turbidity would have been fallacious and contrary to the demand of the water. When the attempt is made to correlate turbidities of *different* waters with their corresponding chlorine absorptions, even less success is experienced. This situation is to be expected in different supplies, because of the variance in character and degree of watershed pollution. It may be postulated, as a preliminary conclusion, that turbidity readings are not a

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[1] "Some Aspects of Chlorination," *J. Am. Water Works Assoc.*, June 1916.

safe index of chlorine absorption for different water supplies, but may be adapted, with sufficient precautionary measures, to use for an individual supply. Even in the latter case, the conversion of turbidity to chlorine absorption is accomplished only after long studies of widely varying phases of the same supply.

OXYGEN CONSUMED AND THE RATE OF CHLORINE ABSORPTION—Inasmuch as the oxygen-consumed values of waters represent approximately the oxidizable compounds present in such supplies, it would seem that this chemical index should bear some relation to the complex action of chlorine absorption, of which some portion at least partakes of the nature of an oxidation. In order to study this phase of absorption, a series of widely varying waters, of surface and underground types and of different ranges of pollution, were examined during portions of 1917 and 1918. In all of these waters the oxygen consumed and the chlorine absorbed (5 min.) values were obtained. These readings are graphically shown on Chart 1, where the individual and average values have been plotted, in order to permit of the construction of an empirical curve. The data there shown apparently disclose a fairly close variation of chlorine absorption with the oxygen-consumed values of different supplies. This correlation, it should be emphasized, is independent of the source or nature of the water, since the 45 waters tabulated include those from raw surface streams, deep wells, and filtered supplies.

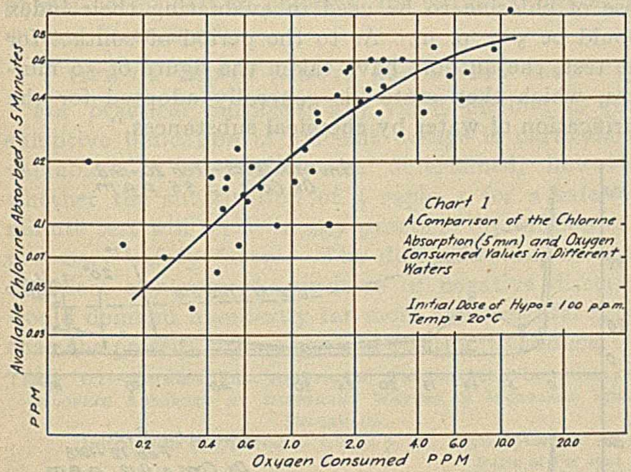
Chart 1
A Comparison of the Chlorine Absorption (5 min) and Oxygen Consumed Values in Different Waters

TABLE II—A COMPARISON BETWEEN CHLORINE ABSORPTION INTERVALS AND EQUAL OXYGEN-CONSUMED INTERVALS

Oxygen Consumed		Chlorine Absorbed	
Reading	Interval	Reading	Interval
0.5	...	0.117	...
1.0	0.5	0.211	0.094
1.5	0.5	0.290	0.079
2.0	0.5	0.350	0.060
2.5	0.5	0.402	0.052
3.0	0.5	0.449	0.047
3.5	0.5	0.488	0.039
4.0	0.5	0.520	0.032
4.5	0.5	0.550	0.030
5.0	0.5	0.577	0.027
5.5	0.5	0.600	0.023
6.0	0.5	0.620	0.020
6.5	0.5	0.635	0.015
7.0	0.5	0.652	0.017

The empirical curve indicates at once that the amount of chlorine absorbed in a definite time interval does not increase in direct proportion with the increase in pollution of the water (as measured by the oxygen-consumed test), but that the 5 minute rate of chlorine absorption shows a decreasing acceleration with increases in pollution. In other words, increases in oxygen-consumed values appear to result in *relative* decreases in the intervals between successive chlorine absorption values. This phenomenon is made clearer by reference to Table II, wherein are compared certain values obtained from the empirical curve shown in Chart 1.

The apparent correlation discussed above has considerable practical importance aside from its use in the chlorination of water supplies. Its probable existence may result in the development of an extremely rapid presumptive indicator of the quality of a water, namely, its chlorine absorption in a definite time interval. It has been found comparatively simple, in this laboratory, for instance, to differentiate between an underground supply of good quality and a comparatively poor surface supply, simply by means of a chlorine absorption test made in 5 minutes. The information gained would seem to be capable of wider application to the entire field of water treatment. As a rapid diagnostic index of changes in quality of water supplies, the chlorine absorption test appears to offer a fruitful field for investigative effort.

CHLORINE ABSORPTION AND EFFECTIVE DISINFECTION DOSAGE

The practical effectiveness of any chlorine treatment is necessarily measured and conditioned by its ability to eliminate the significant bacterial life in the water. The preliminary determination of a dose which may be subsequently found to be effective has been the primary objective of past investigations in this field. In practically all of these methods of presumptive testing for effective dosage, chlorine absorption tests have played an important rôle. It is of interest, therefore, at this point to review briefly several of the methods of chlorine control now in use and to discuss the principles underlying their application.

American practice in the chlorination of water supplies has always been sharply differentiated from the foreign. In general, the foreign sanitarians have employed chlorine doses appreciably higher than those in use on this continent. This policy has been the resultant of a conservative conception of the whole question of chlorination and has therefore left its impress upon the modern systems of chlorination control. A study of the various methods of presumptive tests for the effective doses discloses the common assumption, independently promulgated, that the chlorine absorption in definite intervals bears some definite but apparently unknown relation to disinfection accomplishment. This definite relationship is, however, the subject of a wide difference of opinion among individual sanitarians, with always the sharp demarcation between the foreign and domestic viewpoints.

The principle underlying practically all of the chlorination control procedures is that of measuring the amount of available chlorine absorbed by the water to be disinfected in a given period of time. To this amount a factor of safety is usually added, giving a resultant so-called effective chlorine index. It is clear that the important element in the above procedure is the time element. The time interval taken for the measurement of the chlorine absorption is dependent upon the consideration of the death rate of the bacteria under the particular conditions. A dose measured in the light of the above principle is a safe dose only if the time interval used in its evaluation is amply sufficient to provide for adequate bacterial destruction. The problem of measurement of chlorine dosage resolves itself, therefore, into the question, "What is the safe time interval for the chlorine absorption test?"

The literature of chlorination suggests various answers to this question. Adams,[1] in his discussion of the chlorination of the water for Toronto, Canada, seems to assume that 3 minutes (plus a factor of safety) is a sufficient time interval for such a test. The basis for his criterion is not apparent. He states, however, that "by conducting a series of tests it was determined that Color No. 2 represented a surplus of chlorine in the finished water that would guarantee efficiency in bacterial destruction at all times, and in the great majority of cases would not give taste or odor, and under no circumstances a bad taste or odor." Color No. 2 was equivalent to the intensity of color existing with a definite excess of available chlorine.

That such a short time interval as the above is not universally applicable is evidenced by a survey of the data reported by Race.[2] It would appear from a number of the experiments there cited that effective sterilization or even approximately fair destruction is frequently not obtained even after a 60 minute interval. The application of a 3 minute absorption test to such a condition would demand, of course, an auxiliary factor of safety of high proportions in order to eliminate the danger of ineffective dosage.

Dienert,[3] of the city of Paris, France, approaches this problem in the conservative manner suggested in the preceding statement. He not only stipulates factors of safety abnormally high in comparison with American practice, but uses in addition a chlorine absorption time interval of 15 minutes. His procedure of presumptive testing is of sufficient interest to quote at length in this discussion. His statements follow:

> For the treatment of water we use always a quantity of available chlorine equal to that absorbed in a quarter of an hour increased by 0.5 p. p. m. We estimate that to sterilize a clear water with a quantity of chlorine determined as we have just said, 3 hours contact are necessary. If, for certain reasons, we are obliged to distribute water before this delay, we must increase the quantity of chlorine and bring it up to 1.00 instead of 0.5 p. p. m.
>
> Thus, let us take a water whose absorption of available chlorine in a quarter of an hour is equal to 0.2 p. p. m. If the water must be distributed in a very short time we would add 1.2 p. p. m. in order to sterilize it. If we should store the water longer than 3 hours, we would use only 0.2 + 0.5 = 0.7 p. p. m. of available chlorine.
>
> We have established, in following the bacterial content of river or turbid waters treated with doses of free chlorine of from 1.00 to 1.5 p. p. m., that at certain moments *B. coli* was not destroyed. Safety in treatment demands the use of a dose of free chlorine a little higher than the doses given above.

Professor Santoliquido,[1] of Italy, adds to the general theory by stating that "the bactericidal action of chlorine is not instantaneous for any particular bacterium; in order that the action should result, there is always necessary a contact period, which, at a minimum, must be from 10 to 20 minutes."

Costa and Pecker[2] modify somewhat the system of presumptive test for chlorine dosage by eliminating the factor of safety and using their so-called "chlorine index." The index appears to differ but slightly, in its evaluation, from the usual chlorine absorption tests reported by other authors and in our own discussion. They establish as a principle or hypothesis that the useful dose for the purification of water is determined by the total quantity of chlorine fixed by the water in a given time and under definite conditions. They have determined, as a result of experience, that the initial dose of chlorine to be used in evaluating their index should be 5 p. p. m. As to the period of contact for the test, the authors have taken the figure of 30 minutes, which they state "is generally adopted for the purification of water by chemical substances."

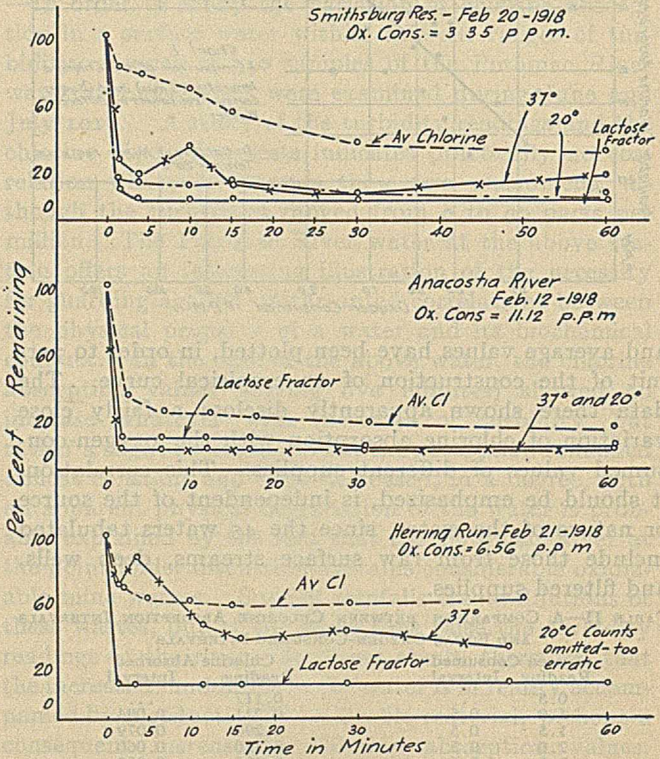

Chart 2—A Comparison of the Rates of Chlorine Absorption and Bacterial Destruction

These authors declare further, that they have been able to decide after more than 2 years' experimental work that the sterilization of water is not very often obtained if the quantity of chlorine used does not reach the figure fixed by the index, and that these latter figures give quantities sufficient for purification.

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[1] "Water Chlorination Experiences at Toronto, Canada," *Am. J. Pub. Health*, August 1916.

[2] "Some Aspects of Chlorination," *J. Am. Water Works Assoc.*, June 1916; "Chlorination and Chloramine," *Ibid.*, March 1918.

[3] "New Perfections in the Chlorination of Waters," *La Technique Sanitaire et Municipale*, February 1917.

[1] "Note on the Purification of Potable Water by Calcium Hypochlorite," Office International D'Hygiene Publique, May 1918.

[2] "The Determination of the Useful Dose of Chlorine for the Purification of Water: The Chlorine Index," *Compt. rend.*, February 1918.

The foregoing discussion seems to indicate the absence of any general agreement either as to the necessary time interval for the chlorine absorption test or the relative scale of factor of safety. The evidence as to the velocity of bacterial destruction under widely varying conditions is far from complete. If the rates of disinfection on Chart 2 (experimental data) are approximately as shown, it would seem that a 30 minute absorption plus a high factor of safety is hardly necessary. It is doubtful, too, whether such factors of safety as 0.5 to 1.00 can be universally employed under such conditions as exist in Maryland, where frequently the period of contact before consumption is so brief as to preclude a dose which would result in such excessive amounts of free chlorine at the tap.

A general survey of this phase of chlorination discloses a need for additional data regarding the velocities of disinfection under actual operating conditions. That the conceptions of this phase are inadequately developed is evidenced by the wide discrepancy in the phenol coefficients of chlorine, for example, quoted in current literature.[1]

FIVE OR THIRTY MINUTE ABSORPTION TEST?

For practical purposes, any rapid method of presumptive indication of efficient dosage is particularly valuable. It remains to be determined, however, whether the substitution of a rapid 5 for a safer 30 minute test will result in any practical diminution of a necessary safety factor. The demonstration of such an effect either in the positive or negative direction would demand manifestly far more experimental proof than the present writers are in a position to adduce.

TABLE III—SHOWING THE ADDITIONAL PERCENTAGES OF AVAILABLE CHLORINE ABSORBED BY DIFFERENT WATERS IN INCREASED TIME INTERVALS

Initial Dose of Chlorine = 1.00 p. p. m. Temperature 20° C.

		Per cent of Initial —Chlorine Absorbed in—			Ratio of Per cent —Chlorine Absorbed—	
	SAMPLE	5 min.	30 min.	60 min.	30 min. to 5 min.	60 min. to 5 min.
1	Surface........	45	47	50	1.04	1.12
2	Surface........	55	57	58	1.04	1.06
3	Surface........	31	60	62	1.95	2.00
4	Surface........	38	60	..	1.59	..
5	Surface........	61	71	..	1.17	..
6	Surface........	53	70	72	1.32	1.36
7	Surface........	56	61	84	1.09	1.50
8	Surface........	61	79	88	1.21	1.44
9	Surface........	31	53	63	1.71	2.02
10	Surface........	68	84	..	1.24	..
11	Surface........	34	59	..	1.74	..
12	Surface........	18	39	..	2.15	..
13	Filtered.......	08	25	..	3.22	..
14	Well...........	15	30	38	2.00	2.53
15	Well...........	08	42	56	5.25	7.00
16	Well...........	14	18	24	1.29	1.71
17	Well...........	10	45	..	4.50	..
18	Surface........	70	72	75	1.03	1.08
19	Surface........	34	37	..	1.09	..
20	Surface........	40	40	..	1.00	..
21	Surface........	26	64	75	2.48	2.90
22	Surface........	75	80	85	1.07	1.14

It is of interest, however, in connection with this problem, to refer to the experimental data shown in Table III and Chart 3. These experiments[2] were designed to answer in a preliminary manner the question as to the effect of increased time intervals upon the total amounts of available chlorine absorbed by different waters. In other words, what additional information is gained by extending absorption tests from 5 to 30 or 60 minutes? Chart 3, with its few empirical values, seems to suggest that the importance of increasing the period of test decreases materially with the increased values of the initial 5 minute absorptions. The evidence in Table III would appear to point to the conclusions that increased safety in dosage is occasioned by the 30 minute test in those waters where the factor of safety is least essential, whereas little additional safety is gained in waters of higher initial absorption or in those where it is most necessary.

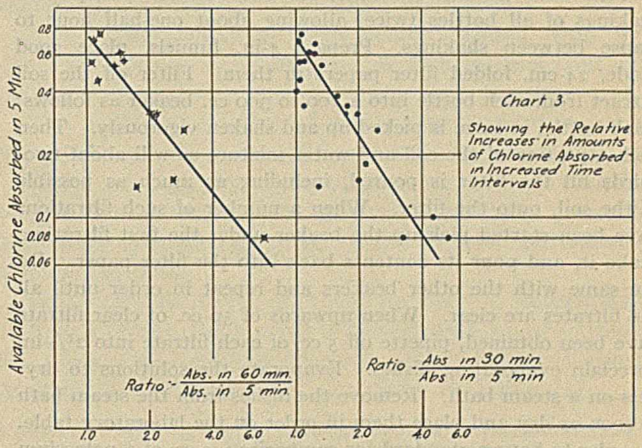

Chart 3

Showing the Relative Increases in Amounts of Chlorine Absorbed in Increased Time Intervals

If the 5 minute chlorine absorption test is at all indicative of the pollute content of a water, then the evaluation of a 30 minute test seems to add but little necessary information as to effective dosage. It would hardly be advantageous to use a 30 minute test, in preference to a 5, when the former increases greatly the dosages for good waters and affects but little those of poorer waters. The addition of a constant factor of safety as, for instance, 0.2 to the 5 minute absorption value would apparently accomplish the same result in the routine control of chlorination as the use of a longer absorption time interval.

STATE OF MARYLAND
DEPARTMENT OF HEALTH
BALTIMORE

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[1] Rideal, *J. Roy. San. Inst.*, 31 (1910), 33–45, gives 2.2, while Schneider, "Bacteriological Methods—Food and Drugs," p. 260, gives 12.5.

[2] The determinations were all made according to the 1917 A. P. H. A. Standard Method of Water Analysis. The oxygen-consumed readings were obtained in acid digestion, with a period of digestion of 30 minutes at a boiling temperature. No corrections for oxidizable mineral substances were applied to the oxygen-consumed values, since these latter were to be used to represent the *total* oxygen demand of the water supply. In the measurement of available chlorine in the different experiments the temperature used was 20° C.

ACCURATE DETERMINATION OF SOIL NITRATES BY PHENOL DISULFONIC ACID METHOD

By H. A. NOYES

Received July 15, 1918

Nitrates play such an important rôle in plant nutrition and the amounts present in the soil are so dependent on bacterial activities that frequent determinations of soil nitrates are important in soil fertility investigations. The two general methods used for the determination of nitrates are the reduction and the colorimetric methods. Both methods have been criticized by various investigators. The present paper is a report of work to determine how and to what extent the different errors in the colorimetric (phenol disulfonic acid) method can be overcome in soil work.

The more important points studied in connection with the method were: first, the nature of the soil and the amount of nitrates contained; second, the method of extracting nitrates; third, the effect of chlorides on the nitrate determination; fourth, the method of obtaining clear, colorless soil extracts; fifth, the removal of interfering substances; sixth, the size of the aliquot; seventh, the evaporation of the aliquot and the adding of reagents; eighth, the colorimeter and how to use it; and ninth, the method of expressing results.

MODIFIED METHOD

Place 50 g. of soil in salt mouth bottles, add 200 cc. of distilled water to each bottle, stopper each bottle and shake it vigorously in turn with the other bottles, for one minute. Repeat the shakings of all bottles twice, allowing about one-half hour to elapse between shakings. Prepare 4-in. funnels, place good grade, 24-cm. folded filter papers in them. Filter off the soil extract from each bottle into a 200 to 300 cc. beaker as follows: Each bottle, in turn, is picked up and shaken vigorously. Then such a portion of the soil and water mixture as will about two-thirds fill the filter is poured, including as much as possible of the soil, onto the filter. When a number of such filtrations have been started pick up the beaker under the first filtration, shake it, and pour its contents back into the filter paper. Do the same with the other beakers and repeat in order until all the filtrates are clear. When upwards of 50 cc. of clear filtrate have been obtained, pipette off 5 cc. of each filtrate into $2^1/_2$-in. porcelain evaporating dishes. Evaporate the solutions to dryness on a steam bath. Remove the dishes from the steam bath as soon as dry and place them in order on the laboratory table. In order to have a standard for comparison, 5 cc. of a potassium nitrate solution containing 0.0001 g. of nitrate per cc. are placed in an evaporating dish and treated as one of the soils undergoing the test. *When the dishes are cool* 1 cc. of the phenol disulfonic acid solution prepared according to Chamot, Pratt and Redfield[6][*] is added to each dish. Add the phenol disulfonic acid drop by drop in a ring about the dish and let these drops spread down over the dry residue. Rotate each dish so as to make sure that the acid will come in contact with all the residue and react with all the nitrates present. Allow the dishes to stand about 15 min. and then add down the side of each dish, so as not to have the water and acid mix too rapidly, approximately 15 cc. of *cold* distilled water. Now, by means of a wash bottle having a fine jet, add dilute (4 to 8 per cent) ammonium hydroxide solution until the yellow color is permanent. The fine jet of ammonium hydroxide solution is played over and through the solution in such a way as to prevent violent local heat reactions between the acid and the salts present. The standard is washed out into one of the cylinders for a Schreiner[16] colorimeter and made up to the 100 mm. mark. Each division of this standard gives an easily discernible change in the nitrate color. The standard, after shaking, is placed in the right-hand side of the colorimeter. The solutions to be tested are then made up directly in the other colorimeter tube to the 100 mm. mark providing they are not over two-thirds as strong as the standard. The unknown is set at the 100 mm. mark in the left-hand side of the colorimeter and the standard is pushed up until the colors are the same. Five readings are made and the average of these is recorded.

There are occasions when some variations are advisable in the method given above.

QUANTITY OF SOIL—It is customary to use 100 g. of field soil for nitrification tests and when this is done the 100 g. of soil are put with 400 cc. of distilled water.

COLORED SOIL EXTRACTS—If the soil gives a colored water extract, or contains soluble iron, 5 g. of calcium hydroxide are added to the soil just previous to the addition of the 200 cc. of distilled water. Some mucks and manures require the addition of more than 5 g. of calcium hydroxide.

LOW NITRATE CONTENTS—If the soils contain less than 100 lbs. of nitrate per million pounds of soil, 20 cc. aliquots of the water extract are taken for the determination. This makes one division on the colorimeter with the standard equal 1.0 part nitrate per million parts of soil.

DILUTION OF STANDARD—If the soils contain but little nitrate (less than 5 parts per million) the standard is diluted one-half to increase the accuracy of the determinations.

HIGH NITRATE CONTENTS—If the solution being tested is much over one-half as strong as the standard it is diluted as follows: A tall, slender cylinder is graduated in multiples of the volume of solution necessary to fill a colorimeter tube to the 100 mm. mark. The unknown is washed directly into this cylinder and diluted with weak (0.25 to 0.5 per cent) ammonium hydroxide until the yellow color is approximately as weak as desired. The volume is then brought to the next multiple of that used in the colorimeter, the whole mixed, and the colorimeter tube filled to the 100 mm. mark and read in terms of the standard. If it is necessary to dilute the unknown more than eight times a smaller aliquot of the soil extract is worked.

THE NATURE OF SOILS AND SOIL NITRATES CONTAINED

Soils may be classified with respect to the difficulties encountered in the determination of nitrates, as follows: (1) light, medium, dark, or black sands, loams, clays, and peats; (2) those containing low, medium, or high concentrations of soluble salts; (3) those acid, neutral, or alkaline in reaction; (4) those aërated and moist, unaërated and water-logged.

The physical nature of the soil, sand, silt, peat, or clay often determines the ease with which a clear water extract can be obtained. A high concentration of soluble salts sometimes means a high concentration of nitrates[7] and the larger the amount of soluble salts present the greater the care that has to be taken to prevent heat reactions causing losses of nitrates. Many acid soils and some sweet soils contain water-soluble organic matter. The color given by the organic matter interferes with the accuracy of the determinations made. Unaërated and water-logged soils may contain substances which interfere with the determination of nitrates.

EXTRACTION OF NITRATES FROM SOILS

No uniformity exists among different workers as to the amount of water to put with a gram of soil to extract its nitrates. Allen and Bonazzi[2] give a table in which they calculate that all the nitrates present in the soil are not extracted when 100 g. of soil are put with 500 cc. of water. They express the belief that nitrates are absorbed by soils. Noyes[13] when working on the absorption of different radicals by

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[*] Numbers refer to corresponding number in References, p. 218.

soils and decaying leaves found no absorption of nitrates but obtained nitrates from all the materials worked with. Since the nitrates of all the metals are soluble and soils contain enough soluble metallic elements to go with all the nitrates present, the work reported in Tables I and II was carried out on soils of different organic content.

TABLE I—EXTRACTION OF NITRATES FROM SOILS WITH VARYING AMOUNTS OF WATER

		COLORIMETER READINGS IN MILLIMETERS		
SOIL	Nitrate Content Parts per Million	From 50 g. Soil and 100 cc. of Water Mm.	From 50 g. Soil and 200 cc. of Water Mm.	From 50 g. Soil and 400 cc. of Water Mm.
White Sand	64	16.5	8.0	4.0
Greenhouse Loam	208	27.0	13.0	7.0
Black Sand	276	22.0	11.5	5.5
Muck	960	30.0	15.0	7.5
AVERAGE		24.0	12.0	6.0

TABLE II—DETERMINATION OF NITRATES ADDED TO SOILS

	Colorimeter Readings Mm.	Parts of Nitrate per Million Parts of Soil	Error as Parts Nitrate per Million Parts of Soil	Divisions (in mm.) on Colorimeter Error Equals
White Sand				
Soil alone	0+	0	0	0.0
100 parts nitrate per million parts soil added	12.2	98	—2	—0.3
200 parts nitrate per million parts soil added	24.0	192	—8	—1.0
Greenhouse Silt Loam[1] IV				
Soil alone	16.2	518	?	?
100 parts nitrate per million parts soil added	19.4	621	+3	+0.1
200 parts nitrate per million parts soil added	22.4	717	—1	0.0
Black Sand IV				
Soil alone	10.0	320	?	?
100 parts nitrate per million parts soil added	13.3	426	+6	+0.2
200 parts nitrate per million parts soil added	16.5	528	+8	+0.3
Muck[2] IV				
Soil alone	29.8	954	?	?
100 parts nitrate per million parts soil added	33.1	1059	+5	+0.02
200 parts nitrate per million parts soil added	36.3	1162	+8	+0.03
AVERAGE OF ERRORS			—2	—0.1

[1] Five cc. aliquots evaporated in each case. Roman numerals denote number of times solution was diluted for reading. Changes in reading due to added nitrate depend on number of times solutions were diluted just before reading.

[2] This is the only case in which the sample was the same as that used in Table I.

The tables show that water in the ratio of 2 parts of water to one part of soil was as efficient in extracting nitrates as 8 parts of water to one part of soil; and that nitrates added to soils are recovered when the nitrates are determined in the water extracts of the soils.

EFFECT OF CHLORIDES ON NITRATE DETERMINATIONS

Most investigators have recognized that chlorides when present cause a loss of nitrates by reacting with the phenol disulfonic acid reagent when it is added to the dry residue. Schreiner and Failyer,[17] Stewart and Greaves,[19] besides others, advocate the removal of chlorides with silver sulfate. Lipman and Sharp[11] object to the precipitation of chlorides by silver sulfate for they have found sulfates to cause losses of nitrates. Gericke[8] has found that the losses of nitrates due to the presence of chlorides are overcome by adding the phenol disulfonic acid reagent directly to the aqueous extract when it is partially evaporated. Phelps and Shoub[14] evaporated nitrate solutions containing 5 parts of nitrate per million to dryness. They then added 0.5, 1.0, and 2.0 cc. of distilled water before adding the phenol disulfonic acid reagent and lost nitrates where the water was added. They conclude from these results that the volume must be reduced to a minimum, *i. e.*, the reagent must be added to the dry residue for best results.

The principal reactions taking place when nitrates are lost are undoubtedly the following:

$$(1)\quad NaCl + H_2SO_4 \longrightarrow HCl + NaHSO_4$$
$$(2)\quad NaNO_3 + H_2SO_4 \longrightarrow HNO_3 + NaHSO_4$$
$$(3)\quad 4HNO_3 + \text{heat} \longrightarrow 4NO_2 + 2H_2O + O_2$$
$$(4)\quad HNO_3 + 3HCl \longrightarrow 2H_2O + Cl_2 + NOCl$$

The modified method, given above, is intended to overcome the losses due to chlorides by keeping the temperatures of the systems below that at which the above rapid reactions take place readily.

A small aliquot gives little material to make aqua regia and thus avoids losses from that source.

The phenol disulfonic acid reagent added drop by drop to different parts of the *cold* dish insures contact with all the residue and prevents high temperatures.

The addition of 15 cc. of *cold* water keeps down the temperatures which would favor vitiating reactions.

Slow and scattered additions from a wash bottle of the weak ammonium hydroxide solution prevent high local temperatures due to the heat of neutralization of the acid.

To study the effect of chlorides on the determination of nitrates, the results obtained with 2 and 3 times the quantity of sodium chloride, which Hilgard[9] gives as toxic to the sugar beet, are given in Table III.

TABLE III—EFFECT OF SODIUM CHLORIDE ON NITRATE DETERMINATIONS

	Colorimeter Readings in Mm.	Parts of Nitrate per Million Parts of Soil	Error as Parts Nitrate per Million Parts of Soil	Divisions (in mm.) on Colorimeter Error Equals
White Sand				
No sodium chloride added	24.0	192	..	...
16,600 parts sodium chloride per million parts soil added[1]	23.2	186	—6	—0.8
24,900 parts sodium chloride per million parts soil added[1]	22.7	182	—10	—1.3
Greenhouse Silt Loam IV([2])				
No sodium chloride added	22.4	717	..	...
16,600 parts sodium chloride per million parts soil added	22.1	707	—10	—0.3
24,900 parts sodium chloride per million parts soil added	22.3	714	—3	—0.1
Black Sand IV				
No sodium chloride added	16.5	528	..	...
16,600 parts sodium chloride per million parts soil added	16.5	528	0	0
24,900 parts sodium chloride per million parts soil added	16.3	522	0	0
Muck IV				
No sodium chloride added	36.3	1162	..	...
16,600 parts sodium chloride per million parts soil added	36.3	1162	0	0
24,900 parts sodium chloride per million parts soil added	36.3	1162	0	0
Average, no sodium chloride added	24.8	649	..	...
Average, all	24.6	647	—4	—0.3

[1] The sodium chloride was added in all cases to the soil at the same time as the 200 cc. of distilled water.

[2] Five cc. aliquots evaporated in each case. Roman numerals denote number of times colored solution was diluted for reading.

From the results in Table III it is seen that sodium chloride in amounts as high as 24,900 parts per million may be present when nitrates are determined by this method without influencing the accuracy of the results.

THE OBTAINING OF CLEAR, COLORLESS SOIL EXTRACTS

Stewart and Greaves,[18] Hill,[10] Chamot, Pratt, and Redfield[5,6] have all used either potassium alum crystals or aluminum cream to clarify nitrate solutions. Lipman and Sharp[11] find potassium alum, aluminum cream, and boneblack to cause changes in the nitrate content of the soil extracts and advocate calcium oxide as the precipitant to use. Potter and Snyder[15] have followed up the work of Lipman and Sharp using both calcium carbonate and calcium oxide as precipitants. They believe that calcium carbonate is the more satisfactory.

In humus work it is always recognized that calcium forms insoluble compounds known as calcium humates. In this laboratory calcium compounds have been used to precipitate water-soluble organic substances which color the solutions. In preliminary tests calcium carbonate was more efficient than calcium oxide. It is known that calcium oxide does not slake well in the presence of large quantities of water and so calcium hydroxide and calcium carbonate were compared as precipitants. The calcium hydroxide was made from calcium oxide by adding distilled water to the lumps of calcium oxide until they yielded a fine white powder.

The method of filtration described in the procedure removes all silt, clay, and suspended matter making the calcium hydroxide unnecessary for the removal of these substances.

Table IV gives the relative efficiency of freshly prepared calcium hydroxide and carbonate for precipitating colored soluble organic matter from water extracts of two soils and manure when added to the material just before the 200 cc. of distilled water were added.

TABLE IV—COMPARISON OF CALCIUM HYDRATE AND CALCIUM CARBONATE FOR REMOVING SOLUBLE ORGANIC COLORS FROM SOIL EXTRACTS

	Comparative Colors of Soluble Organic Material as Measured by Colorimeter Readings
Manure, sweet[1]	
Water extract alone	1.00
Water and calcium carbonate[1] extract	0.56 and 1.00 Av. 0.78
Water and calcium hydroxide[1] extract	0.10 and 0.11 Av. 0.11
Hudson Peat, acid	
Water extract alone	1.00
Water and calcium carbonate extract	1.78
Water and calcium hydroxide extract	0.61
Water, calcium carbonate and hydroxide extract	0.95
Water and 10 g. calcium hydroxide extract	0.25
Water and 15 g. calcium hydroxide extract	0.25
Greenhouse Soil, sweet	
Water extract alone	1.00
Water and calcium carbonate extract	1.19
Water and calcium hydroxide extract	0.29
Water, calcium carbonate and hydroxide extract	0.29

[1] Five grams used unless otherwise noted.

The results reported in Table IV show 5 g. of calcium hydroxide to be a much more efficient precipitant of the water-soluble organic matter than the calcium carbonate.

It was considered advisable to see what effects calcium carbonate and calcium hydroxide had on the determination of nitrates in a well fertilized silt loam, an acid black sand, a partially decayed sample of horse manure, a sweet muck, a very acid muck, a soil containing soluble iron, and a rich greenhouse soil. It was considered that if it could be shown that the interfering color was removed from these soils by either reagent and that the reagent did not affect the nitrate content of the soil a big difficulty in the determination of soil nitrates on soils that yield colored extracts would be overcome. To obtain data nitrates were determined on the selected soils both with and without precipitants and with a known amount of added nitrate. The results of these tests and a test on a clay loam, showing that a precipitant is not needed to remove the silt and clay when the modified method is used, are given in Table V.

With the silty clay loam which gives a colorless extract the method of filtering has taken care of the silt and clay and all three determinations give 60 parts of nitrate per million pounds of soil. This is confirmatory of the statement of Gericke[8] that, "The use of calcium oxide and also calcium carbonate for the clarification of aqueous extracts, especially from soils, is recommended as a precipitant that is both efficient and non-interfering in the nitrate determinations."

The silt loam gave a water extract slightly colored; calcium carbonate caused the solution to be much more colored, while calcium hydroxide removed the color. The hydroxide was superior to the carbonate.

With the acid black sand the hydroxide and the carbonate yielded very similar results to those obtained on the silt loam.

The horse manure gave a highly colored extract. The calcium carbonate while not giving a strong colored water extract still gave an extract which yielded more color after evaporation and treatment with the phenol disulfonic acid reagent than the water extract by itself did. The calcium hydroxide did not entirely remove the color but gave results that were close to correct when we consider that one millimeter difference in the colorimeter reading was equivalent to 32 parts of nitrate.

In the case of sweet muck the calcium carbonate gave very high results for the added nitrate. The lower results with calcium hydroxide showed the removal of water-soluble organic matter and nearly the correct result for the added nitrate.

With the acid muck instead of adding nitrate, one and two additional applications of the calcium hydroxide were used with this soil, since it was found that the colorimeter readings were showing that the calcium carbonate and water extracts were much higher than the water extract and that the amount of calcium hydroxide used had only taken out a part of the color (Table IV). The additional applications of calcium hydroxide reduced the color slightly more but gave the same nitrate results. The water, calcium carbonate, and calcium hydroxide extract lies between the calcium carbonate alone and the water extract.

The greenhouse soil had been heavily manured and fertilized for at least two years. The calcium carbonate extracted more color than the water alone while the calcium hydroxide gave an extract containing much less color than the water extract (Table IV). Diluting the solutions 32 times before reading removed the interference of the colored extracts since the nitrate determinations agreed exactly when read by the precision method to be described later.

The results obtained show that calcium hydroxide should be used to prevent the water-soluble organic

Table V—Comparison of Calcium Hydrate and Calcium Carbonate for Clarifying Water Extracts of Soils

	Colorimeter Readings Mm.	Difference in Readings Due to Clarifying Agents	Difference in Readings Due to Clarifying Agents and Added Nitrates	Nitrates per Million Parts of Soil	Effects of Clarifying Agents on Parts Nitrate per Million Parts of Soil	Effects of Added Nitrate on Parts Nitrate per Million Parts of Soil
Silty Clay Loam						
Water extract	15	..	..	60	..	...
Water[1] and calcium carbonate[2] extract	15	0	..	60	0	...
Water and calcium hydroxide[3] extract	15+	0+	..	60	0	...
Silt Loam. Conn. Valley Onion Soil						
Water extract	12	..	..	48	...	...
Water and calcium carbonate extract	45	+33	..	180	+132	...
Water and calcium hydroxide extract	11	— 1	..	44	— 4	...
Water, added nitrate[4] and calcium carbonate extract	65	..	+20	260	+132	+ 80
Water, added nitrate and calcium hydroxide extract	29	..	+18	116	— 4	+ 72
Black Sand, Acid II(*a*)						
Water extract	30	..	..	240	...	...
Water and calcium carbonate extract	47	+17	..	376	+136	...
Water and calcium hydroxide extract	30	0	..	240	0	...
Water, added nitrate and calcium carbonate extract	59	..	+12	472	+136	+ 96
Water, added nitrate and calcium hydroxide extract	38.5	..	+ 8.5	308	0	+ 68
Horse Manure VIII						
Water extract	65	..	..	2,082	...	...
Water and calcium carbonate extract	75	+10	..	2,400	+320	...
Water and calcium hydroxide extract	40	—25	..	1,280	—800	...
Water, added nitrate and calcium carbonate extract	70.5	..	— 4.5	2,256	+320	—144
Water, added nitrate and calcium hydroxide extract	42+	..	+ 2.0	1,344	—800	+ 64
Muck, Sweet IV						
Water extract	56	..	..	896	...	...
Water and calcium carbonate extract	45	—11	..	720	—186	...
Water and calcium hydroxide extract	55+	—1	..	880+	— 16	...
Water, added nitrate and calcium carbonate extract	62	..	+17	992	—186	+272
Water, added nitrate and calcium hydroxide extract	59	..	+ 4	944	— 16	+ 64
Sand Containing Soluble Iron II						
Water extract	2	..	..	16	...	...
Water and calcium carbonate extract[5]	10	+ 8	..	80	+ 64	...
Water and calcium hydroxide extract	18	+16	..	144	+128	...
Water, added nitrate and calcium carbonate extract[5]	19	..	+ 9	152	+ 64	+ 72
Water, added nitrate and calcium hydroxide extract	26	..	+ 8	208	+128	+ 64
Muck, Acid II						
Water extract	14	..	..	112	...	...
Water and calcium carbonate extract	52	+38	..	416	+304	...
Water and calcium hydroxide extract	10	— 4	..	80	— 32	...
Water, calcium carbonate and calcium hydroxide extract	41	+27	..	328	216	...
Water and calcium hydroxide (10 g.) extract	10	— 4	..	80	— 32	...
Water and calcium hydroxide (15 g.) extract	10	— 4	..	80	— 32	...
Greenhouse Soil XXXII						
Water extract	61	..	..	7808	...	...
Water and calcium carbonate extract	61	0	..	7808	0	...
Water and calcium hydroxide extract	61	0	..	7808	0	...
Water, calcium carbonate and calcium hydroxide extract	61	0	..	7808	0	...

(*a*) Roman numerals state number of times solution made from 5 cc. aliquot was diluted for reading.

[1] Fifty grams air-dry soil and 200 cc. of water in each case.

[2] Six grams precipitated calcium carbonate added to each 50 g. soil before the 200 cc. of distilled water.

[3] Six grams precipitated calcium hydroxide added to each 50 g. soil before the 200 cc. of distilled water.

[4] Nitrate added to increase the nitrate content 68 parts per million parts of soil.

[5] Solutions filtered before reading to get rid of precipitated iron compounds.

matter appearing in the water extract of soils from affecting the nitrate determination. The method of filtering gives clear extracts free from clay.

REMOVAL OF INTERFERING SUBSTANCES

In Table V we have the results obtained by comparing, on one soil, calcium carbonate and calcium hydroxide as precipitants of water-soluble iron. The hydroxide was found by chemical tests to have removed all the water-soluble iron while the carbonate only removed a portion of it. It is to be noted that the presence of soluble iron in the solution used for the nitrate determination not only interfered with the reading due to presence of precipitated iron oxide and hydroxides but caused a loss of nitrates as well. Phelps and Shoub[14] remove iron and manganese from water by boiling with sodium hydroxide, while our results lead us to believe that if calcium hydroxide is added to the soil at the same time the water used for extraction is added, extracts are obtained which are free from soluble substances that may be precipitated on the subsequent neutralization of the solution with ammonium hydroxide.

SIZE OF ALIQUOT

Stewart and Greaves[18] advocate a 50 cc. aliquot or other convenient quantity, while Allen[1] uses 250 cc. of the soil extract which represents 50 g. of soil. The standard decided on in this laboratory contains only 0.5 mg. of nitrate. We use the small aliquot of extract for two reasons:

1—To keep down the quantity of soluble salts in the residue which come in contact with the sulfuric acid reagent.

2—To avoid the necessity of diluting solution just before reading.

As mentioned previously, a 20 cc. aliquot of the water extract is desirable where the nitrogen content is under 100 parts per million. In cases of very high concentrations of nitrates less than 5 cc. aliquots have been successfully used provided they were procured with accurately calibrated pipettes.

EVAPORATION OF ALIQUOT AND ADDING OF REAGENTS

The aliquot is evaporated to dryness on the steam bath, removed, cooled, and when cold the residue is treated with 1 cc. of phenol disulfonic acid made according to the directions of Chamot, Pratt, and Redfield.[6] The time for and the method of adding reagents are given in detail under the directions for carrying out the modified method.

THE COLORIMETER AND HOW TO USE IT

No uniformity exists in the colorimeters used in different laboratories. In ten of the articles listed in the bibliography attached no mention is made of the make of colorimeter used. The colorimeters mentioned were Schreiner's, Sargent-Kennicott, Lovibond's, and Duboscq's.

The monocular telescope, the verniers, and the prism glass tubes of the Duboscq colorimeter are features desired. The small length of the columns of liquid used make this colorimeter undesirable for use in reading soil nitrates for any small volume error is too large a per cent of the total aliquot read.

Lovibond's tintometer is accurate but expensive. To use this tintometer advantageously with soils it would be necessary to use one or perhaps two colors standardized to specific nitrate contents and make dilutions to correspond to these colors. Tubes for such dilutions and the making of dilutions to exactly check specific standards would not be applicable to the conditions under which the major portion of the soil nitrate work is done.

The Campbell-Hurley[4] colorimeter has the monocular telescope, compares long columns of liquid, and gets results in terms of cubic centimeters of standard equivalent to a larger number of cubic centimeters of the unknown. It was not the one chosen for it is too easily broken in the routine laboratory.

Schreiner[16,17] has improved on the Whitson[20] colorimeter which works on the same principle as the Campbell-Hurley apparatus. The Schreiner, commonly known as the Bureau of Soils colorimeter, when properly made, seems adapted to soil nitrate determinations in both agronomical and chemical laboratories. The advantages of this apparatus are that it is a simple camera of wood, all working parts can be handled individually, and the solutions come in contact with glass only. Tubes meeting the following requirements have been found satisfactory and can be obtained under the following specifications. Tubes are to be of clear glass having flat bottoms, inside and out, of same thickness. Graduations are to be in millimeters, zero being the level of the top of the glass bottom. Bore of all tubes should be exactly the same. Tubes meeting these specifications will each hold the same amount when filled to equal heights.

READING OF COLORIMETER

In the procedure given it was advocated that the unknown be diluted until it is less than two-thirds as strong as the standard. This is based on experience in reading nitrates where it was found that when the unknown and standard are almost the same strength we are not sure of the reading to within 3 or 4 mm., while if the standard is, for example, 4 times as strong as the unknown, the slightest movement of the standard up or down makes a sharp change in the color comparison. The following figures show how closely five readings on the same solutions agree.

TABLE VI—REPRESENTATIVE COLORIMETER READINGS

Individual Readings					Average
16.0	16.0	16.0	16.5	16.5	16.2
19.0	20.0	19.0	20.0	19.0	19.4
23.0	22.5	22.5	22.5	22.0	22.4
10.5	9.5	10.0	10.0	10.0	10.0
13.5	13.5	13.0	13.0	13.5	13.3
30.0	30.0	29.0	29.5	30.5	29.8
36.0	37.0	35.0	37.0	36.5	36.3
37.5	35.5	36.0	36.5	36.0	36.3
60.0	62.0	61.0	60.5	62.5	61.2

SUMMARY

1—The phenol disulfonic acid method for nitrates is adapted to the accurate determination of soil nitrates in large as well as in small amounts.

2—Nitrates are completely extracted from soil by water, and nitrates added to soils were completely recovered in addition to those present in the soil.

3—Chlorides have no effect on nitrate determinations made by the phenol disulfonic acid method when the precautions outlined are taken.

4—Clear soil extracts always result when solutions are properly filtered through paper filters.

5—Calcium hydroxide has been found to be the best precipitant of colored water-soluble organic matter.

6—Calcium hydroxide removes interfering inorganic substances such as water-soluble iron.

7—The use of small aliquots of the water extract reduces the amounts of interfering salts, prevents heat reactions with the sulfuric acid, and thereby increases the accuracy of the determination.

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REFERENCES

1—E. R. Allen. THIS JOURNAL, 6 (1915), 521.
2—E. R. Allen and A. Bonazzi. Ohio Agricultural Experiment Station, Technical Series, *Bulletin* 7 (1915).
3—H. V. Arny and C. H. Ring. THIS JOURNAL, 8 (1916), 312.
4—J. A. Campbell. *J. Am. Chem. Soc.*, 33 (1911), 1113.
5—Chamot, Pratt, and Redfield. *Ibid.*, 33 (1911), 366.
6—Chamot, Pratt, and Redfield. *Ibid.*, 33 (1911), 381.
7—S. D. Conner. *J. Am. Soc. Agron.*, 9 (1917), 299.
8—W. F. Gericke. THIS JOURNAL, 9 (1917), 585.
9—E. W. Hilgard. "Soils," 1906 Ed., 467.
10—H. H. Hill. *Report of Virginia Polytechnic Institute Agricultural Experiment Station*, **1911–1912**, 133.
11—C. B. Lipman and L. T. Sharp. *University of California Publications in Agricultural Science*, 1 (1912), 21.
12—M. Nichols. THIS JOURNAL, 9 (1917), 586.
13—H. A. Noyes. *Ibid.*, 6 (1914), 574.
14—E. B. Phelps and H. L. Shoub. *Ibid.*, 9 (1917), 767.
15—R. S. Potter and R. S. Snyder. Iowa Agricultural Experiment Station, *Research Bulletin* 24 (1915), 340.
16—O. Schreiner. *J. Am. Chem. Soc.*, 27 (1905), 1192.
17—O. Schreiner and G. H. Failyer. U. S. Dept. Agriculture, Bureau of Soils, *Bulletin* 31 (1906).
18—R. Stewart and J. E. Greaves. Utah Experiment Station, *Bulletin* 106 (1906).
19—R. Stewart and J. H. Greaves. *J. Am. Chem. Soc.*, 32 (1910), 756.
20—A. R. Whitson. Wisconsin Agricultural Experiment Station, *Bulletin* 85 (1901).

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THE EFFECT OF FERTILIZERS ON THE COMPOSITION OF HOPS

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INTRODUCTION

It is well recognized that the effect of fertilizers on the total yield of crop per unit of land can be readily interpreted, usually in favor of the fertilizers employed. It is equally well recognized that a study of some one of the principal constituents of the crop, as influenced by the fertilizers, does not reveal such easily interpreted results. In fact, the results obtained from such a study are usually of such a heterogeneous character as to preclude any positive conclusions. The major portion of the vast amount of work done on the effect of fertilizers deals with results of yield per unit of land, a small portion deals with effects on the quality of the crop, and a very small remainder deals with the effect on some one or more constituents of the crop.

The material presented here has to do largely with the effect of systematic fertilization over a period of years on some of the principal constituents of hops grown on experimental plots in the Sacramento Valley, California. The numerous other factors that influence yield and quality have of necessity been more or less ignored, mainly because at present there are no known methods of measuring the effect of these factors. Furthermore, these factors become more or less conflicting especially when the investigation covers a long-time experiment.

A search of the literature shows that no work on fertilizer experiments on hops has been directed toward the increase or improvement of the principal economic constituents.

DESCRIPTION OF THE FERTILIZER PLOTS

The plots to be fertilized were laid out in the spring of 1913 at Wheatland, California. Two one-acre plots were selected and labeled J. R. field and No. 1 field, respectively. The former is located on upland, or, as it is known locally, "red land;" the latter on a sandy loam, formerly the bed of Bear River, and is sedimentary in character.

The J. R. field was laid out as follows: One acre of red land was selected which lies close to a slough and laid out into plots such that each plot contained four rows of hops of one hundred hills each. The rows run from east to west and the numbered plots from south to north. The general slope of the field is from south to north and Plot 1 is at the best end of the field, while Plot 15 is very near the slough. The field was not irrigated.

TABLE I—PLOT NUMBERS AND PLAN OF FERTILIZATION

PLOT NO.	FERTILIZER	Rate per Acre Lbs.	Dealer's Analysis Per cent
1.....	Sulfate of Potash	270	K_2O, 50
	Acid Phosphate	500	P_2O_5, 17 to 18
2.....	Nitrate of Soda	240	N, about 16
3.....	Check		
4.....	Acid Phosphate	500	P_2O_5, 17 to 18
5.....	Sulfate of Potash	270	K_2O, 50
6.....	Check		
	Acid Phosphate	500	P_2O_5, 17 to 18
7.....	Nitrate of Soda	240	N, about 16
	Sulfate of Potash	270	K_2O, 50
	Acid Phosphate	500	P_2O_5, 17 to 18
8.....	Nitrate of Soda	240	N, about 16
	Lime	750	Hydrated pure lime, about 74
9.....	Check		
	Sulfate of Potash	270	K_2O, 50
10.....	Acid Phosphate	500	P_2O_5, 17 to 18
	Lime	750	Hydrated pure lime, about 74
11.....	Lime	750	Hydrated pure lime, about 74
12.....	Check		
13.....	Rotted Barnyard Manure	2000	
14.....	Check		
15.....	Complete Hop Fertilizer	500	Phosphoric acid (basic bone superphosphate), 10 Available phosphoric acid soluble and available), 7.5 Equal to bone phosphate of lime, 21.80 Sulfate of potash, 9.25 Nitrogen from bone and blood, 2 to 4 Nitrogen from nitrate, 2 Nitrogen estimated as ammonia, 3.64

The No. 1 field was selected and laid out in the old bed of Bear River and arrangements made for irrigation. This field is about one mile distant from the J. R. field. Each plot contains three rows of hops of one hundred hills each, the rows running from south to north and the numbered plots from east to west. The soil varies somewhat, being poorest at the east end of the field. In both fields the rows are 7 ft. apart and the hops 6$^1/_2$ ft. apart in the row.

The numbered plots and the amount of fertilizer applied per acre are given in Table I. The analyses on the dealer's tags are included in this table.

EXPERIMENTAL WORK

The hops for experimental purposes were picked each year from Row 2 in each plot of each field. By picking the inner row of each plot a representative sample was obtained, and all danger of influence of the fertilizer of the neighboring plots eliminated. The crops of 1914, 1915, and 1916 were dried, sulfured in the usual manner, and then sent to Washington, D. C., for analysis. The analyses were made approximately one hundred days after the hops were picked. The picking was done each year on the same date, the last week in August.

On receipt in Washington, D. C., the hops were stored in a dry laboratory until analyzed. The following determinations were made on each sample: moisture, determined only in order to have a comparable working basis; soft resins, hard resins, total resins, soluble ash, insoluble ash, and total ash. The moisture was determined by drying over sulfuric acid; the soft and hard resins by a method formerly found satisfactory;[1] the soluble and insoluble ash by the Optional Official Method in *Bulletin* 107 of the Bureau of Chemistry.[2]

RESINS IN HOPS FROM THE FERTILIZED PLOTS

The experiment brings out clearly the difficulties encountered when a correlation is sought between fertilizer applied and percentage of yield of hop constituents. The results of the resin determinations from the J. R. field are presented in Table II.

The percentage of soft resins in the hops from year to year shows no cumulative effect of the fertilizers, neither do the results indicate any special benefit from the fertilizers applied. The percentage of yield of hard resins varies in like manner as do also the total resins.

Taking each plot as an individual, with one exception that of Plot 2, no continuity is noted in the results year by year. The yield of resins is found to vary from year to year with as much irregularity in the fertilized plots as it does in the check plots. Such a seasonal variation has been found to be true in the case of hops from other sections. The check plots yield the same varying results. Taken generally, the check plots yield as high or higher a percentage of resins than do the fertilized plots. This result is no doubt due to the fact that the fertilizer tends to produce a high vegetative yield with a corresponding diminution in the percentage of the resins present.

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[1] G. A. Russell, "The Resins in Hops from Various Geographic Localities," THIS JOURNAL, 7 (1915), 1033.

[2] "Official and Provisional Methods of Analysis," U. S. Department of Agriculture, Bureau of Chemistry, *Bulletin* 107 (revised), 238.

TABLE II—YIELD OF RESINS IN THE HOPS FROM THE J. R. FIELD, FROM 1914 TO 1916, INCLUSIVE

	SOFT RESINS				HARD RESINS				TOTAL RESINS			
PLOT No.	1914 Per cent	1915 Per cent	1916 Per cent	Three-Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three-Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three-Year Average Per cent
1	9.02	6.09	14.78	9.96	4.70	5.38	4.35	4.81	13.72	11.47	19.13	14.77
2	12.23	14.25	12.79	13.09	4.06	2.17	3.54	3.26	16.29	16.42	16.33	16.34
3	10.00	11.33	16.85	12.73	4.79	4.03	2.48	3.77	14.79	15.36	19.33	16.49
4	13.30	6.56	16.88	13.25	5.97	5.66	2.11	4.58	19.27	12.22	18.99	16.82
5	14.40	12.16	13.94	13.50	4.03	3.44	2.58	3.35	18.43	15.60	16.52	16.85
6	12.91	9.59	9.37	10.62	3.81	3.76	3.47	3.68	16.72	13.35	12.84	14.30
7	11.41	7.00	16.45	11.62	3.88	6.33	2.00	4.07	15.29	13.33	18.45	15.69
8	10.00	4.00	10.20	8.07	3.95	3.38	2.82	3.38	13.95	7.38	13.02	11.45
9	13.66	14.32	12.21	13.40	4.06	2.98	3.08	3.38	17.72	17.30	15.29	16.77
10	12.90	...	11.89	12.39	2.49	..	2.30	2.54	15.69	...	14.29	14.99
11	12.70	12.58	16.80	14.03	4.08	4.00	2.25	3.44	16.78	16.58	19.05	17.47
12	12.22	15.50	12.79	13.50	3.79	4.52	3.16	3.82	16.01	20.02	15.95	17.32
13	11.65	10.38	9.00	10.34	3.39	3.61	3.33	3.44	15.04	13.99	12.33	13.78
14	11.97	15.04	10.31	12.44	3.27	5.87	3.12	4.09	15.24	20.91	13.43	16.52
15	10.62	16.82	11.47	12.97	3.53	2.18	2.79	2.83	14.15	19.00	14.26	15.80
YEARLY AVERAGE	11.93	11.11	13.05	...	4.01	4.09	2.89	..	15.93	15.21	15.94	...

AVERAGE PERCENTAGE OF YIELD IN CHECK PLOTS

Year	Soft Resins	Hard Resins	Total Resins
1914	12.172	3.944	16.092
1915	13.156	4.232	17.388
1916	12.306	3.062	15.368

TABLE III—YIELD OF RESINS IN THE HOPS FROM THE No. 1 FIELD, FROM 1914 TO 1916, INCLUSIVE

	SOFT RESINS				HARD RESINS				TOTAL RESINS			
PLOT No.	1914 Per cent	1915 Per cent	1916 Per cent	Three-Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three-Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three-Year Average Per cent
1	15.70	8.91	11.05	11.88	3.88	1.77	2.24	2.63	19.58	10.68	13.29	14.51
2	16.12	8.52	10.10	11.58	3.21	2.23	2.81	2.75	19.33	10.75	12.91	14.33
3	14.58	10.61	12.06	12.41	3.31	4.68	2.91	3.63	17.89	15.29	14.97	16.04
4	15.62	14.78	10.90	13.76	4.62	3.21	3.02	3.61	20.24	17.99	13.92	17.37
5	10.58	12.94	12.19	11.90	3.47	2.11	2.14	2.57	14.05	15.05	14.33	14.47
6	12.23	9.51	10.87	10.87	3.13	4.43	3.49	3.35	15.36	13.94	14.36	14.22
7	16.48	7.48	10.00	11.32	2.65	5.33	3.33	3.77	19.13	12.81	13.33	15.09
8	12.89	8.68	10.10	10.55	3.39	6.13	3.33	4.28	16.28	14.81	13.43	14.83
9	13.02	13.89	10.87	12.59	5.28	5.10	3.57	4.65	18.30	18.99	14.44	17.24
10	12.17	10.09	12.83	11.53	3.99	4.06	3.81	3.95	16.16	14.15	16.14	15.48
11	13.51	11.19	14.12	12.94	2.48	3.91	3.11	3.16	15.99	15.10	17.23	16.10
12	13.08	12.22	11.63	12.31	3.70	3.60	3.66	3.65	16.78	15.82	15.29	15.96
13	14.55	14.65	9.57	12.92	3.72	3.21	5.44	4.12	18.27	17.86	15.01	17.04
14	15.05	14.94	11.30	13.76	2.37	2.86	3.68	2.97	17.42	17.80	14.98	16.73
15	11.82	11.59	10.65	11.35	3.09	3.16	4.11	3.45	14.91	14.75	14.76	14.80
YEARLY AVERAGE	13.80	11.33	11.18	...	3.49	3.71	3.37	..	17.29	15.04	14.55	...

AVERAGE PERCENTAGE OF YIELD IN CHECK PLOTS

Year	Soft Resins	Hard Resins	Total Resins
1914	13.59	3.56	17.15
1915	12.23	4.13	16.37
1916	11.34	3.46	14.81

In other words, the plant working under the stimulus of the fertilizer produces many cones but does not produce a corresponding amount of resins. The ratio of yield of cones to percentage of resins does not remain constant.

The results of the analyses of the hops from the J. R. field show in the aggregate that the application of the various fertilizers did not increase the percentage of soft or hard resins, neither did these applications cause any marked diminution in the percentage of yield of resins.

The percentage of yield of resins in the hops from the No. 1 field is given in Table III.

The yield of resins from this irrigated field shows seasonal variations similar to those of the J. R. field. There is, however, a difference in the yearly averages. A marked diminution is apparent in the yearly average percentage of yield of soft and total resins in all the plots. The percentage of hard resins does not diminish but varies with the year. Here it is clearly demonstrated that the various fertilizers produce vegetative matter but do not produce a corresponding percentage of resins, rather the percentage of yield of resins diminishes year by year even in the check plots. This gradual decrease in resins in the check plots is due, it is believed, to the cumulative effect of the irrigation. A comparison of the 3-year average of the various plots shows that the percentage of yield of soft resins is generally greater in the check plots than it is in the fertilized plots. This variation is not so marked in the percentage of yield of hard resins, nor in the percentage of yield of total resins. However, the general tendency throughout is for the check plots to yield a greater percentage of resins than do the fertilized plots. As was found true in the J. R. field, no particular fertilizer or combination of fertilizers produced a percentage of yield that stands out distinctly above the general run. Plot 15 is the only one that gives any indication of continuity.

For the purpose of more careful comparison, the percentage of yield of total resins from the J. R. field and the No. 1 field is tabulated in Table IV.

From Table IV the decrease in percentage of total resins in the No. 1 field plots is very apparent, compared as they are with the corresponding plots in the J. R. field. In 1914, 20 per cent of the plots in No. 1 field yielded a smaller percentage of resins than did similar plots in the J. R. field, and in 1915 and 1916 this number had increased to 60 per cent. The 3-year average also shows that the No. 1 field has 60 per cent of the plots with a lower yield of resins than corresponding plots in the J. R. field.

The yearly averages from all the plots in the J. R. field are very uniform; those in the No. 1 field diminish from 17.29 per cent yield of resins in 1914 to 14.55 per cent in 1916. The check plots of the No. 1 field diminish in like manner, whereas similar plots in the J. R. field show no such uniformity.

TABLE IV—COMPARISON OF THE YIELD OF TOTAL RESINS IN HOPS FROM THE FERTILIZED PLOTS IN THE J. R. AND THE NO. 1 FIELD

Plot No.	1914		1915		1916		Three-Year Average	
	J. R. Field Per cent	No. 1 Field Per cent	J. R. Field Per cent	No. 1 Field Per cent	J. R. Field Per cent	No. 1 Field Per cent	J. R. Field Per cent	No. 1 Field Per cent
1.....	13.72	19.58	11.47	10.68	19.13	13.29	14.77	14.51
2.....	16.29	19.33	16.42	10.75	16.33	12.91	16.34	14.33
3.....	14.79	17.89	15.36	15.29	19.33	14.97	16.49	16.04
4.....	19.27	20.24	12.22	17.99	18.99	13.92	16.82	17.37
5.....	18.43	14.05	15.60	15.05	16.52	14.33	16.85	14.47
6.....	16.72	15.36	13.35	13.94	12.84	14.36	14.30	14.22
7.....	15.29	19.13	13.33	12.81	18.45	13.33	15.69	15.09
8.....	13.95	16.28	7.38	14.81	13.02	13.43	11.45	14.83
9.....	17.72	18.30	17.30	18.99	15.29	14.44	16.77	17.24
10.....	15.69	16.16	..	14.15	14.29	16.14	14.99	15.48
11.....	16.78	15.99	16.58	15.10	19.05	17.23	17.47	16.10
12.....	16.01	16.78	20.02	15.82	15.95	15.29	17.32	15.96
13.....	15.04	18.27	13.99	17.86	12.33	15.01	13.78	17.04
14.....	15.24	17.42	20.91	17.80	13.43	14.98	16.52	16.73
15.....	14.15	14.91	19.00	14.75	14.26	14.76	15.80	14.80
Yearly Average	15.93	17.29	15.21	15.04	15.94	14.55	...	...

COMPARISON OF THE YEARLY AVERAGE YIELD OF TOTAL RESINS FROM THE CHECK PLOTS

Field	1914 Per cent	1915 Per cent	1916 Per cent
J. R.	16.09	17.38	15.36
No. 1	17.15	16.37	14.81

To complete the data on yield of resins from the fertilized plots, the available soft resins, which are of most economic importance, in pounds per acre have been calculated, from data on yield of hops per acre not incorporated in this paper, and are presented in Table V.

TABLE V—COMPARISON OF THE CALCULATED AVAILABLE SOFT RESINS IN POUNDS PER ACRE FROM THE FERTILIZED PLOTS IN THE TWO EXPERIMENTAL FIELDS

Plot No.	1914		1915		1916		Three-Year Average	
	J. R. Field Lbs.	No. 1 Field Lbs.	J. R. Field Lbs.	No. 1 Field Lbs.	J. R. Field Lbs.	No. 1 Field Lbs.	J. R. Field Lbs.	No. 1 Field Lbs.
1.......	203	434	178	240	440	425	273	366
2.......	267	371	418	235	448	525	377	377
3.......	250	425	294	217	436	390	326	344
4.......	345	474	211	513	492	523	349	503
5.......	362	246	195	459	419	576	325	460
6.......	275	330	175	253	219	410	223	331
7.......	275	397	326	264	598	452	399	371
8.......	281	359	178	395	466	581	308	445
9.......	324	351	334	528	282	419	313	432
10.......	295	363	...	337	356	602	325	434
11.......	305	415	282	339	404	740	330	498
12.......	240	394	268	342	232	516	246	417
13.......	279	399	221	555	224	473	241	475
14.......	283	476	464	457	187	508	311	480
15.......	208	344	384	296	349	488	313	376
Yearly Average	279	385	280	362	370	508	...	...

COMPARISON OF THE YEARLY AVERAGE YIELD OF THE CHECK PLOTS

Field	1914 Per cent	1915 Per cent	1916 Per cent
J. R.	274	307	271
No. 1	395	355	448

The effect of fertilizers, in general, on the yield of available soft resins per acre of land is fairly evident. In 1914 the J. R. field had an increase of 70 per cent of the fertilized plots over the yearly average of the check plots; in 1915 this percentage of increase fell to 50 and in 1916 it rose to 80. The increase in resins in the fertilized plots over the average of the 3-year averages of the check plots likewise amounts to 80 per cent of the total number of fertilized plots. In 1914 the No. 1 field had an increase in soft resins in 50 per cent of the fertilized plots over the yearly average of the check plots; in 1915 this percentage of increase fell to 40, and in 1916 it rose to 90. The increase in resins in the fertilized plots, over the average of the 3-year averages of the check plots, fell to 60 per cent of the total number of check plots.

Comparing the yields of soft resins from the two fields, year by year, we find that in 1914, 93 per cent of the plots of the No. 1 field yield more resins than the corresponding plots in the J. R. field; in 1915, 64 per cent; and in 1916, 80 per cent. Taken as a whole, the No. 1 field plots average higher each year than the J. R. field plots. This higher yield can be attributed to irrigation which no doubt makes the plant food in the fertilizers more available.

The tabulated results do not indicate that any particular fertilizer or combination of fertilizers is particularly adapted to increasing the yield of available soft resins in pounds per acre over the other fertilizers or combinations employed. In 1916, Plots 10 and 11 in the No. 1 field, which contain lime, produced a high yield of soft resins. In 1915 and in 1914 no large increase was noted for these plots. Here again the question of outside factors enters the problem and it is difficult to say if the influence of the lime is responsible for the large yield of resins. It appears that the only conclusion that can be drawn with any certainty is that irrigation on any fertilized plot tends to produce more hops and incidentally more available soft resins, even though the percentage of yield is decreased.

ASH IN HOPS FROM THE FERTILIZED PLOTS

It was expected that the ash of hops from the various fertilized and check plots would show considerable variation. A certain gradual increase in the amount of ash present was also expected, since the hop roots are perennial and the plant food was available in good quantity. The results of the analyses indicate that the suppositions were not true. In fact, the same erratic variations are found in the percentage of ash as were found in the percentage of resins, with this difference that there is slightly less range from season to season.

The percentages of ash in the hops from the J. R. field are given in Table VI.

The soluble ash, which contains the chlorides, sulfates, phosphates, and carbonates of potassium and sodium, and slight amounts of the chlorides and sulfates of calcium and magnesium, shows considerable range of variation, not only plot by plot each year, but also year by year. The effect of the fertilizers on the ash in hops from the plots of the J. R. field shows no greatly significant differences. The variation in percentage does not remain constant from season to season. The check plots yield like variable results. Plots 3 and 9, which are checks, yield fairly uniform results throughout the time of the experiment.

Plot 2, fertilized with nitrate of soda, indicates a gradual yearly decrease in percentage of soluble ash, whereas Plot 4, fertilized with acid phosphate only, shows a gradual yearly increase in soluble ash of the hops. Plot 5, fertilized with sulfate of potash only, shows a marked yearly decrease in soluble ash of the hops. When nitrate of soda is added to the formula,

TABLE VI—ASH IN THE HOPS FROM THE J. R. FIELD, FROM 1914 TO 1916, INCLUSIVE

	SOLUBLE ASH				INSOLUBLE ASH				TOTAL ASH			
PLOT No.	1914 Per cent	1915 Per cent	1916 Per cent	Three-Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three-Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three-Year Average Per cent
1	1.20	2.34	1.73	1.756	10.15	7.28	10.05	9.16	11.35	9.62	11.78	10.92
2	1.90	1.59	1.28	1.590	9.40	7.98	11.32	9.57	11.30	9.57	12.60	11.16
3	1.90	1.68	1.48	1.686	10.65	8.33	10.76	9.91	12.55	10.01	12.24	11.60
4	1.65	1.98	2.10	1.910	10.45	10.73	9.20	10.13	12.10	12.71	11.30	12.04
5	3.20	2.10	1.69	2.330	9.45	10.58	10.58	10.12	12.65	12.43	12.27	12.45
6	1.70	3.50	1.51	2.255	12.70	9.28	11.29	11.09	14.40	12.78	12.80	13.33
7	2.65	2.23	2.83	2.570	9.65	9.90	10.24	9.93	12.30	12.13	13.07	12.50
8	1.75	2.61	1.87	2.076	9.95	8.93	10.15	9.68	11.70	11.54	12.02	11.75
9	1.12	1.38	1.19	1.230	10.93	9.23	10.73	10.30	12.05	10.61	11.92	11.53
10	3.00	3.65	2.05	2.900	9.85	9.79	11.67	10.44	12.85	13.44	13.72	13.34
11	3.30	2.43	1.06	2.263	12.33	10.03	10.01	10.79	15.63	12.46	11.07	13.05
12	1.90	3.26	1.61	2.256	12.05	8.92	9.97	10.31	13.95	12.18	11.58	12.57
13	2.00	3.64	2.27	2.636	11.45	8.91	10.70	10.35	13.45	12.55	12.97	12.99
14	3.13	1.67	2.15	2.650	9.35	8.98	10.84	9.72	12.48	10.65	12.99	12.04
15	2.70	2.83	1.83	2.453	10.05	8.71	11.01	9.92	12.75	11.54	12.84	12.38
YEARLY AVERAGE	2.20	2.45	1.77	...	10.56	9.13	10.56	...	12.76	11.58	12.33	...

AVERAGE PERCENTAGE OF ASH IN CHECK PLOTS

Year	Soluble Ash	Insoluble Ash	Total Ash
1914	1.950	11.136	13.086
1915	2.298	8.948	11.246
1916	1.588	10.718	12.306

TABLE VII—ASH IN THE HOPS FROM THE NO. 1 FIELD FROM 1914 TO 1916, INCLUSIVE

	SOLUBLE ASH				INSOLUBLE ASH				TOTAL ASH			
PLOT No.	1914 Per cent	1915 Per cent	1916 Per cent	Three-Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three-Year Average Per cent	1914 Per cent	1915 Per cent	1916 Per cent	Three-Year Average Per cent
1	3.10	2.77	3.26	3.04	7.55	9.96	8.87	8.79	10.65	12.73	12.13	11.83
2	3.90	2.85	2.83	3.19	9.15	8.32	7.68	8.38	13.05	11.17	10.51	11.57
3	2.85	1.37	3.31	2.51	8.45	7.07	6.88	7.46	11.30	8.44	10.19	9.97
4	3.35	1.79	2.94	2.69	7.55	7.49	7.58	7.54	10.90	9.28	10.52	10.23
5	3.30	2.51	2.21	2.67	8.05	5.90	7.81	7.25	11.35	8.41	10.02	9.92
6	3.85	1.71	3.26	2.94	12.25	9.08	11.33	10.88	16.10	10.79	14.59	13.82
7	2.75	2.66	2.74	2.71	9.20	7.34	9.88	8.80	11.90	10.00	12.62	11.51
8	3.05	3.07	3.42	3.18	9.45	8.52	8.02	8.66	12.50	11.59	11.44	11.84
9	2.90	1.36	2.83	2.36	10.00	9.04	7.73	8.92	12.90	10.40	10.56	11.28
10	1.20	3.25	3.84	2.66	8.20	9.33	9.23	8.92	9.40	12.58	12.77	11.58
11	2.30	4.27	3.21	3.26	9.75	6.14	9.15	8.34	12.05	10.41	12.36	11.60
12	2.25	2.12	3.71	2.69	10.00	9.58	8.30	9.29	12.25	11.70	12.01	11.98
13	2.42	2.01	2.22	2.21	9.35	9.73	8.63	9.23	11.77	11.74	10.85	11.44
14	3.75	1.25	2.76	2.58	8.75	9.48	8.22	8.81	12.50	10.73	10.98	11.39
15	1.50	2.31	2.23	2.01	9.82	8.21	8.28	8.77	11.32	10.52	10.51	10.78
YEARLY AVERAGE	2.69	2.35	2.96	..	9.16	8.34	7.84	...	11.85	10.69	10.80	...

AVERAGE PERCENTAGE OF ASH IN CHECK PLOTS

Year	Soluble Ash	Insoluble Ash	Total Ash
1914	3.12	7.89	13.01
1915	1.56	8.85	10.41
1916	3.17	8.49	11.66

making the combination acid phosphate, nitrate of soda, and sulfate of potash, as in Plot 7, the soluble ash increases and remains fairly constant throughout the time of the experiment. Lime in combination with sulfate of potash and acid phosphate, Plot 10, yields a hop with a high percentage of soluble ash, which varies from year to year. Lime applied alone, as in Plot 11, apparently causes the soluble ash content of the hop markedly to diminish throughout the experimental season. Rotted barnyard manure, as applied on Plot 13, causes no significant differences in the soluble ash, other than those which can be laid to seasonal variation. The percentage of insoluble ash was found to vary from season to season without apparent regularity due to any influence of the fertilizer. The amount of total ash present also varies from year to year throughout the time of the experiment. The yearly averages indicate that approximately the same results are obtained in the aggregate throughout the time of the experiment, that is, no definite increase or decrease in the percentage of soluble, insoluble, or total ash. The ash of the hops grown on the check plots apparently follows the general run and no doubt is influenced to a considerable degree by seasonal variations.

In the No. 1 field, the results of the ash determinations indicate that variations occur which apparently follow no definite lines and that irrigation does not influence these variations into definite order. The results of the ash determinations on hops from the No. 1 field are given in Table VII.

The soluble ash content of hops from the various plots is without doubt increased by the use of irrigation. This increase is not, however, uniform or regular. On comparing this field plot by plot with the J. R. field, quite different effects of the fertilizers are noted. Plot 2, fertilized with nitrate of soda, shows a gradual diminution in the percentage of soluble ash from year to year. This is also true of Plot 2 of the J. R. field. Plot 4, fertilized with acid phosphate, shows a most erratic yield of soluble ash from season to season. Plot 5, fertilized with sulfate of potash, shows a gradual falling off in the percentage of soluble ash each season. Likewise in this irrigated field, when nitrate of soda, acid phosphate, and sulfate of potash are added in combination, as in Plot 7, a constant percentage of soluble ash is obtained throughout the time of the experiment. Lime in combination with sulfate of potash and acid phosphate, Plot 10, yields a hop with marked increase in soluble ash, after the first season of application. Lime applied alone, Plot 11, causes a growth of hops that yields a high percentage of soluble ash but the yearly variation is marked. Rotted barnyard manure plus the irrigation affects the yield

TABLE VIII—COMPARISON OF THE YIELD OF SOLUBLE ASH IN THE HOPS FROM THE TWO EXPERIMENTAL FIELDS

	1914		1915		1916		Three-Year Average	
PLOT No.	J. R. Field Per cent	No. 1 Field Per cent	J. R. Field Per cent	No. 1 Field Per cent	J. R. Field Per cent	No. 1 Field Per cent	J. R. Field Per cent	No. 1 Field Per cent
1	1.20	3.10	2.34	2.77	1.73	3.26	1.75	3.04
2	1.90	3.90	1.59	2.85	1.28	2.83	1.59	3.19
3	1.90	2.85	1.68	1.37	1.48	3.31	1.68	2.51
4	1.65	3.35	1.98	1.79	2.10	2.94	1.91	2.69
5	3.20	3.30	2.10	2.51	1.69	2.21	2.33	2.67
6	1.70	3.85	3.50	1.71	1.51	3.26	2.25	2.94
7	2.65	2.75	2.23	2.66	2.83	2.74	2.57	2.71
8	1.75	3.05	2.61	3.07	1.87	3.42	2.07	3.18
9	1.12	2.90	1.38	1.36	1.19	2.83	1.23	2.36
10	3.00	1.20	3.65	3.25	2.05	3.54	2.90	2.66
11	3.30	2.30	2.43	4.27	1.06	3.21	2.26	3.26
12	1.90	2.25	3.26	2.12	1.61	3.71	2.25	2.69
13	2.00	2.42	3.64	2.01	2.27	2.22	2.63	2.21
14	3.13	3.75	1.67	1.25	2.15	2.76	2.65	2.58
15	2.70	1.50	2.83	2.31	1.83	2.23	2.45	2.01
YEARLY AVERAGE	2.20	2.69	2.45	2.35	1.77	2.96	..	..

COMPARISON OF THE YEARLY AVERAGE OF SOLUBLE ASH IN THE HOPS FROM THE CHECK PLOTS

FIELD	1914 Per cent	1915 Per cent	1916 Per cent
J. R.	1.95	2.29	1.58
No. 1	3.12	1.56	3.17

TABLE IX—COMPARISON OF THE YIELD OF INSOLUBLE ASH IN THE HOPS FROM THE TWO EXPERIMENTAL FIELDS

	1914		1915		1916		Three-Year Average	
PLOT No.	J. R. Field Per cent	No. 1 Field Per cent	J. R. Field Per cent	No. 1 Field Per cent	J. R. Field Per cent	No. 1 Field Per cent	J. R. Field Per cent	No. 1 Field Per cent
1	10.15	7.55	7.28	9.96	10.05	8.87	9.16	8.79
2	9.40	9.15	7.98	8.32	11.32	7.68	9.56	8.38
3	10.65	8.45	8.33	7.07	10.76	6.88	9.91	7.46
4	10.45	7.55	10.73	7.49	9.20	7.58	10.12	7.54
5	9.45	8.05	10.33	5.90	10.58	7.81	10.12	7.25
6	12.70	12.25	9.28	9.08	11.29	11.33	11.09	10.88
7	9.65	9.20	9.90	7.34	10.24	9.88	9.93	8.80
8	9.95	9.45	8.93	8.52	10.15	8.02	9.67	8.66
9	10.93	10.00	9.23	9.04	10.73	7.73	10.29	8.92
10	9.85	8.20	9.79	9.33	11.67	9.23	10.43	8.92
11	12.33	9.75	10.03	6.14	10.01	9.15	10.79	8.34
12	12.05	10.00	8.92	9.58	9.97	8.30	10.31	9.29
13	11.45	9.35	8.91	9.73	10.70	8.63	10.35	9.23
14	9.35	8.75	8.98	9.48	10.84	8.22	9.72	8.81
15	10.05	9.82	8.71	8.21	11.01	8.28	9.92	8.77
YEARLY AVERAGE	10.56	9.16	9.13	8.34	10.56	7.84	...	...

COMPARISON OF THE YEARLY AVERAGE OF INSOLUBLE ASH IN THE HOPS FROM THE CHECK PLOTS

FIELD	1914 Per cent	1915 Per cent	1916 Per cent
J. R.	11.13	8.94	10.71
No. 1	7.89	8.85	8.49

of soluble ash fairly uniformly year by year. The yearly average of all the fertilized plots and check plots indicate that taken generally the percentage of soluble ash is not widely influenced by the use of fertilizers and irrigation. Specific plots do show wide variation due to the effect of the two agents, fertilizer and irrigation. The average percentage of ash in the check plots varies widely.

The percentage of insoluble ash in hops from the No. 1 field is variable from season to season, but at the same time there is a gradual tendency for the amount of insoluble ash to decrease. This decrease is especially noticeable in the yearly average which shows marked diminution each year. There is also a tendency for the total ash content of the hops from the plots of the No. 1 field to grow less each season.

For purposes of comparing the ash content of hops from the two experimental fields, the soluble, insoluble, and total ash percentages have been tabulated in Tables VIII, IX, and X.

In general, the amount of soluble ash in hops is largest in the No. 1 field. This increase over the J. R. field results is due to irrigation, for both fields received a like amount of fertilizer. The yearly average percentage of soluble ash in hops from the check plots of the No. 1 field was approximately twice that of the J. R. field. In 1915 the J. R. field plots show more soluble ash than the No. 1 field.

The yearly average percentage of yield of soluble ash of all the plots is largest in the No. 1 field in both 1914 and 1916, but slightly less in 1915. It is difficult to attribute the results obtained in 1915 to any one cause or combination of causes, but rather it appears that this varying year's returns must be attributed to the uncertainty that applies to all fertilizer long-time experiments.

The amount of insoluble ash present in hops from the various plots of both experimental areas, varies to a considerable degree, not only plot by plot in each year but also year by year. No definite important differences can be traced throughout the experiment for any particular plot. There is, however, a marked falling off in percentage of insoluble ash throughout the time of the experiment in the yearly average of the No. 1 field. Also there is a marked difference in the amount of soluble ash present in hops from the irrigated and non-irrigated fields. The decrease in amount of insoluble ash present in the No. 1 field hops from year to year is attributable to the fact that the plant contains more soluble ash constituents due to the effect of irrigation plus plenty of available plant food.

TABLE X—COMPARISON OF THE YIELD OF TOTAL ASH IN HOPS FROM THE TWO EXPERIMENTAL FIELDS

	1914		1915		1916		Three-Year Average	
PLOT No.	J. R. Field Per cent	No. 1 Field Per cent	J. R. Field Per cent	No. 1 Field Per cent	J. R. Field Per cent	No. 1 Field Per cent	J. R. Field Per cent	No. 1 Field Per cent
1	11.35	10.65	9.62	12.73	11.78	12.13	10.91	11.83
2	11.30	13.05	9.57	11.17	12.60	10.51	11.15	11.57
3	12.55	11.30	10.01	8.44	12.24	10.19	11.60	9.97
4	12.10	10.90	12.71	9.28	11.30	10.52	12.03	10.23
5	12.65	11.35	12.43	8.41	12.27	10.02	12.45	9.92
6	14.40	16.10	12.78	10.79	12.80	14.59	13.32	13.82
7	12.30	11.90	12.13	10.00	13.07	12.62	12.50	11.51
8	11.70	12.50	11.54	11.59	12.02	11.44	11.75	11.84
9	12.05	12.90	10.61	10.40	11.92	10.56	11.52	11.28
10	12.85	9.40	13.44	12.58	13.72	12.77	13.33	11.58
11	15.63	12.05	12.46	10.41	11.07	12.36	13.05	11.60
12	13.95	12.25	12.18	11.70	11.58	12.01	12.57	11.98
13	13.45	11.77	12.55	11.74	12.97	10.85	12.99	11.44
14	12.48	12.50	10.65	10.73	12.99	10.98	12.04	11.39
15	12.75	11.32	11.54	10.52	12.84	10.51	12.37	10.78
YEARLY AVERAGE	12.76	11.85	11.58	10.69	12.33	10.80	...	...

COMPARISON OF THE YEARLY AVERAGE OF TOTAL ASH IN THE HOPS FROM THE CHECK PLOTS

FIELD	1914 Per cent	1915 Per cent	1916 Per cent
J. R.	13.08	11.24	12.30
No. 1	13.01	10.41	11.66

Comparison of the total percentage of ash in hops from the two experimental fields reveals the fact that no one fertilizer or combination of fertilizers tends to produce more ash than do other fertilizers or combinations, neither does fertilization increase the ash content over that of check plots. The variations that exist plot by plot and year by year are normal and due entirely to factors outside of control. The one prominent difference is that on the irrigated field the total percentage of ash, as revealed by the yearly average of all the plots, is less than on the non-irrigated field. This difference also holds good in the yearly average percentage of total ash in hops from the check plots.

SUMMARY

In 1913, experiments on the effect of fertilizers on the composition of hops were begun at Wheatland, California. Two fields, each one acre in area, were laid out into fifteen plots each. The J. R. field was not irrigated, whereas the No. 1 field was irrigated. Corresponding plots in each field received like amounts of fertilizer each year during 1914, 1915, and 1916.

Each year a sample of hops from each plot was analyzed for soft resins, hard resins, total resins, soluble ash, insoluble ash, and total ash.

The percentage of yield of resins in the J. R. field varied with the various plots but the variations were not constant from year to year, the yearly average of all the plots being approximately the same throughout the experiment.

The percentage of yield of resins in the No. 1 field varied, as in the J. R. field, but the yearly average of all the plots gradually decreased.

The available soft resins in pounds per acre varied in each plot in each field each year. No continuity was noted as the effect of any fertilizer applied. There is, however, an increase in the amount of soft resins available each year. This increase is greatest in the No. 1 field.

The increase in amount of resins available is not due to an increase in the percentage of resins due to fertilizers, but is due to an increased yield of cones which are less rich in resins as the vegetative yield increases. In other words, the fertilizer causes a great increase in vegetative yield which, due to forced succulent growth, causes a smaller percentage of resins to be formed.

The percentage of soluble ash in the hops from the J. R. field varied with the season. Some apparent regularities in certain plots are traceable throughout the time of the experiment. It is doubtful if these regular effects are due wholly to the effect of the fertilizer; and the supposition is advanced that the effect of other factors plays an important rôle in producing the results as found.

The percentage of insoluble ash in the hops from the J. R. field likewise varied with the season. The percentage of total ash was fairly constant in 1914 and in 1916, but decreased somewhat in 1915.

The percentage of soluble ash in the hops from the No. 1 field also varied with the season, but plot for plot it ran higher than in the corresponding plots in the J. R. field, except in the year 1915 when considerable variation occurred.

The percentage of insoluble ash in the hops from the No. 1 field likewise varied with the season, being always lower plot for plot than the corresponding plots in the J. R. field, except in the year 1915 when variation occurred, and with this exception, that the yearly average shows a gradual decrease in the amount of insoluble ash present.

The total ash of the two fields varied with the various plots but shows no apparent significant differences throughout the time of the experiment. The yearly average of the ash from all the plots is less each year in the No. 1 field than it is in the J. R. field, and this yearly average likewise grows somewhat less from year to year.

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THE SOLVENT ACTION OF DILUTE CITRIC AND NITRIC ACIDS ON ROCK PHOSPHATE

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This Station has recently undertaken a series of experiments, one of the objects of which is to ascertain under what conditions the process of sulfur oxidation, termed sulfofication, will bring about an increase in the availability of phosphorus in rock phosphate.

In connection with the experiments in progress, it was of course of prime importance to secure a method by which a reliable index of the changes in availability of the phosphorus compounds in rock phosphate and soil mixtures attributable to sulfofication could be obtained.

Although the monocalcium and dicalcium phosphates are the forms of phosphorus commonly regarded as available, the sulfofication process, being to a great extent the result of biological agencies, will very probably convert some of the phosphorus into organic forms which may be more available than the tricalcium phosphate in the phosphate rock itself.

Neutral ammonium citrate has for a number of years, although without really valid and conclusive reasons, been regarded as the reagent whereby these two groups of phosphorus compounds, the available and non-available, could be distinguished one from the other, because it has been generally considered that neutral ammonium citrate possesses the faculty of dissolving dicalcium as well as monocalcium phosphate, leaving tricalcium phosphate intact. This is not strictly true, however, as neutral ammonium citrate will also dissolve varying amounts of phosphorus from tricalcium phosphate, the amount taken into solution depending upon the conditions under which the extraction is made.

In so far as the adaptability of neutral ammonium citrate is concerned, one cannot refrain from being skeptical as to its value for the determination of the availability of phosphorus, especially when this procedure is applied to composts or mixtures including rock phosphate and soil.

It was found, for instance, in the investigations pertaining to the effect of sulfur oxidation on the availability of phosphorus, that the available phosphorus of the untreated Wooster soil was 30 parts per million of soil; this comparatively high figure is surely contradicted by the fact that this particular soil responds very readily to applications of fertilizers carrying phosphorus. In fact, crop yields in fertility experiments of this soil show that phosphorus is the limiting element.

When neutral ammonium citrate is used to measure changes in mixtures of soil and rock phosphate, the amount of organic matter extracted from the soil, judged by the color of the solution, approaches that obtained when the soil is extracted with the usual strength of ammonium hydroxide used for humus determinations.

While it must follow from this that neutral ammonium citrate cannot serve as a means for determining the absolute amount of available phosphorus, there still remains the possibility that it may be used to obtain an indication of changes which have occurred as a result of treatment.

Before the precipitation of the phosphorus with ammonium molybdate solution, there must be a complete oxidation of the organic material extracted from the soil, in order to convert any organic phosphorus compounds present into the form of orthophosphate, and at the same time to destroy the citrate itself, the presence of which will prevent the complete precipitation of the phosphorus.

The oxidation of the organic matter with aqua regia or with fuming nitric acid is unsatisfactory on account of the large amount of reagents and time required as well as the close attention necessary.

Destruction of the organic matter by ignition with magnesium nitrate is undoubtedly the most convenient method, the only possible objection being that the high temperature necessary may cause a partial change of the phosphorus compounds into forms which are not soluble in either hydrochloric or nitric acid.

The questionable value of the neutral ammonium citrate procedure for determining the availability of phosphorus produced in various mixtures which include rock phosphate and soil, together with the difficulties involved in destruction of the organic matter extracted from the soil, and that contributed by the neutral ammonium citrate, led to tests being made to determine the possible value of dilute citric and nitric acid solutions as substitutes for neutral ammonium citrate solutions.

SOLUBILITY IN CITRIC ACID

Citric acid of various strengths has been recommended as a suitable solvent for the determination of available phosphorus, and has been used with reported satisfaction in soil investigations.

In experimental work in which a number of acids were employed as solvents for the phosphorus of the soil, Russell and Prescott[1] found that the amount of phosphorus dissolved varies greatly with the nature of the acid employed. They also found that some of the acids were themselves absorbed by the soil. As a rule they found that an acid which is absorbed by the soil to a considerable extent also possesses a high extraction power for phosphorus.

The acids investigated were absorbed in the following order:

$$\begin{array}{l}\left.\begin{array}{l}\text{Oxalic}\\ \text{Citric}\end{array}\right\}\text{most}\\ \text{Phosphoric}\\ \text{Sulfuric}\\ \left.\begin{array}{l}\text{Hydrochloric}\\ \text{Nitric}\end{array}\right\}\text{least}\end{array}$$

It should not be inferred from this that citric acid when present will entirely satisfy the soil's absorptive properties; the fact is that when both are present, citric acid takes the place of some of the phosphoric acid in the absorption complex. It must be remembered that the solubility of the phosphorus in the soil as determined by a solvent is the resultant of the difference between the phosphorus dissolved and that absorbed from the solution by the soil. From a soil with a great absorptive power there is always a smaller percentage of the phosphorus capable of being taken into solution by the solvent extracted than from a soil with a small absorption power, although the absolute amounts of such soluble phosphorus compounds may stand in the reverse order.

Citric acid, which shows a high extractive power due to the fact that this acid is itself absorbed when brought into contact with the soil, would therefore seem to be a very desirable acid for extracting the phosphorus of the soil for the purpose of discrimination between the available and the unavailable phosphorus compounds.

To determine the solvent action of dilute solutions of citric acid varying in concentration within comparatively narrow limits, from 0.1 per cent to 0.05 per cent, extractions were made under the following conditions:

3 g. portions of rock phosphate were extracted with 100 cc. of citric acid of the prescribed strength by shaking in shaking machine at ordinary room temperature for 30 min. The solutions were diluted to a volume of 500 cc. After filtering, 200 cc. portions were taken for the phosphorus determinations.

From the amounts of phosphorus extracted, as shown in Table I, it is evident that variations in the strength of citric acid, even when a very weak solution is employed, decidedly influence the solubility of the phosphorus of rock phosphate.

TABLE I—SOLUBILITY OF ROCK PHOSPHATE IN CITRIC ACID SOLUTIONS OF VARIOUS CONCENTRATIONS

Strength of Acid Per cent	Phosphorus Extracted Per cent
0.5	0.4287
0.4	0.3700
0.3	0.2569
0.2	0.1918
0.1	0.1113

The availability of the phosphorus in the particular rock phosphate used in this experimental work was 0.2 per cent when 3 g. of rock phosphate were treated with 100 cc. neutral citrate solution for 30 min. at 65° C.; the citrate solution was then diluted to 500 cc., filtered, and 200 cc. taken for determination of phosphorus.

From the results obtained with the different strengths of citric acid it appears that an extraction with 0.2 per cent citric acid under these conditions has given a value for the availability of phosphorus in rock phosphate which is about equal to that obtained by using neutral ammonium citrate.

The additional data presented in Table II show that varying the amount of rock phosphate treated with a given volume of citric acid has a decided bearing on the solvent power of this acid for the phosphorus in rock phosphate.

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[1] "The Reaction between Dilute Acids and the Phosphorus Compounds of the Soil," *J. Agr. Science*, September 1916, pp. 65–110.

TABLE II—INFLUENCE OF QUANTITY OF ROCK PHOSPHATE EXTRACTED

Weight of Rock Phosphate Treated Grams	Total Phosphorus Extracted Per cent
0.1	4.289
0.5	1.334
1.0	0.747
3.0	0.1918

When 0.1 g. of rock phosphate instead of 3 g. was treated with 100 cc. citric acid, it was found that 4.289 per cent of the phosphorus was taken into solution, and a still higher figure would doubtless have been obtained if a smaller amount of rock phosphate had been treated with the same strength of acid, or a larger volume of acid of the same strength had been used.

The weights of rock phosphate indicated were extracted with 100 cc. of 0.2 per cent citric acid in 500 cc. flasks, shaking every 5 min. during a period of 30 min., after which the solutions were diluted to 500 cc. and filtered.

When 0.1 g. of rock phosphate was treated with 100 cc. of 0.2 per cent citric acid, with continuous agitation in a shaking machine for a period of 30 min., it was found that 5.390 per cent of phosphorus was dissolved as compared with 4.289 per cent obtained when the shaking was not continuous during the extraction period.

When the same weight, 0.1 g., of phosphate rock was mechanically shaken for 30 min. with 500 cc. of 0.2 per cent citric acid, it was found that not less than 6.410 per cent phosphorus was extracted.

EFFECT OF BASICITY

As pointed out by Cousins and Hammond[1] citric acid cannot be used as a discriminating agent for available phosphorus if applied to calcareous soils unless the basicity due to carbonates, etc., is compensated for by the use of a corresponding extra amount of citric acid.

For the purpose of determining the amount of phosphorus extracted by citric acid from rock phosphate alone and from a mixture of rock phosphate and soil with and without additions of calcium carbonate, the experimental data in Table III were obtained.

TABLE III—EFFECT OF BASICITY

No.	Material Treated	Phosphorus Extracted Per cent
1	0.1 g. Rock Phosphate	6.410
2	0.2 g. Rock Phosphate	5.527
3	0.2 g. Rock Phosphate + 0.05 g. Calcium Carbonate	5.000
4	0.2 g. Rock Phosphate + 0.1 g. Calcium Carbonate	3.300
5	0.2 g. Rock Phosphate + 0.20 g. Soil	3.587
6	0.2 g. Rock Phosphate + 0.20 g. Soil + 0.05 g. Calcium Carbonate	2.497
7	0.2 g. Rock Phosphate + 0.20 g. Soil + 0.1 g. Calcium Carbonate	1.950
8	0.2 g. Rock Phosphate + 0.20 g. Soil + 0.2 g. Calcium Carbonate	1.222
9	0.2 g. Rock Phosphate + 0.20 g. Soil + 0.5 g. Calcium Carbonate	0.712

The extractions of phosphorus were made in the same way and under uniform conditions, so far as the temperature, the strength of citric acid, time and manner of extraction and filtration were concerned. The strength of the citric acid was adjusted to equal 0.2 per cent at the end of the extraction, care being taken to neutralize the basicity due to the slight basic properties of the rock phosphate, the calcium carbonate added, and the soil itself which was naturally calcareous. This was done by addition of the necessary extra amount of citric acid to the 0.2 per cent citric acid employed. That the strength of the solution was as desired was ascertained by titration of the filtered extract with standard alkali and phenolphthalein.

When 0.2 g. rock phosphate was treated with 500 cc. citric acid, 5.527 per cent phosphorus were extracted. The addition of 0.05 g. and 0.1 g. calcium carbonate to the same weight of rock phosphate reduced this figure to 5.000 and 3.300 per cent, respectively. As might be expected, similar results in regard to phosphorus extracted were obtained when soil was mixed with rock phosphate and different amounts of calcium carbonate added.

The results obtained pertaining to the influence of basicity do not lend support to the contention of Cousins and Hammond that citric acid can be employed as discriminating agent for available phosphorus in calcareous soils, even though provision is made to add enough extra citric acid to neutralize the soluble bases present in the soil and have the final acidity of the solution at the required strength.

NITRIC ACID

Another solvent which has been considered to afford useful information with respect to the availability of the supply of phosphorus in the soil is fifth-normal nitric acid. As this strength of nitric acid dissolves practically all the phosphorus in rock phosphate, it was decided to determine whether a weaker strength of nitric acid would be more satisfactory. By shaking for 30 min. 2 g. of rock phosphate with 500 cc. nitric acid of various strengths the percentages of phosphorus shown in Table IV were extracted.

TABLE IV—SOLUBILITY OF PHOSPHORUS IN DIFFERENT STRENGTHS OF NITRIC ACID

Strength of Acid Per cent	Phosphorus Dissolved Per cent of Sample
0.06	11.918
0.045	11.488
0.030	10.811
0.015	8.131

The sample of rock phosphate used in this work contained 12.37 per cent total phosphorus. It is evident, from the amount of phosphorus dissolved by weak nitric acid solutions, that this acid is no more satisfactory than citric acid for differentiating that part of the phosphorus which is more easily dissolved and therefore might be regarded as available, especially when one bears in mind that the figure for the availability of the phosphorus of the same sample of rock phosphate as determined by neutral ammonium citrate under accepted standard conditions is only 0.2 per cent.

Contrary to the results obtained with citric acid, the depressing influence of basicity of the sample on the extraction power of nitric acid for phosphorus can be wholly overcome by adding exactly the amount of nitric acid corresponding to the bases present, in this case calcium carbonate. This is shown by the results in the following table. The extraction was made for 30 min. with 100 cc. nitric acid corresponding to 0.2 per cent citric acid plus sufficient extra nitric acid to neutralize the calcium carbonate.

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[1] "The Determination of Available Phosphoric Acid and Potash in Calcareous Soils," *The Analyst*, **1903**, p. 238.

Table V—Basicity and Extraction Power of Weak Nitric Acid

Material Extracted	Phosphorus Extracted Per cent
0.1 g. Rock Phosphate	8.555
0.1 g. Rock Phosphate + 0.1 g. Calcium Carbonate	8.413
0.1 g. Rock Phosphate + 0.2 g. Calcium Carbonate	8.362

The percentages of phosphorus extracted would have been higher had a larger volume of the nitric acid been employed for the extraction. Table VI shows that with various larger volumes of solvent, practically identical percentages of the phosphorus were dissolved, in all cases approaching the total phosphorus content of the rock phosphate, 12.37 per cent. The strength of the acid used was 0.01 per cent. The time for extraction was 30 min. as before and the amount of rock phosphate treated, 0.2 g.

Table VI

Volume of Acid Used Cc.	Phosphorus Extracted Per cent
500	11.094
1000	12.150
1500	12.124
2000	12.131

SUMMARY

Summing up our results as to the solubility of the phosphorus of rock phosphate in very dilute citric and nitric acids with a view to obtaining an indication as to the available phosphorus in this particular material, we find that both possess too high a solvent power.

An additional objection to the use of citric acid is that basicity has a decidedly depressing influence on the solvent power and this cannot be altogether overcome by the addition of an extra amount of citric acid equivalent to the basicity present.

While neutral ammonium citrate cannot serve as a means for measuring the absolute amount of available phosphorus, it probably gives as reliable an indication of the available phosphorus of rock phosphate and eventual changes in availability due to sulfofication and other processes as any solvent can be expected to furnish. It is necessary, however, that two determinations be made, one at the beginning and one at the end of the experiment, and absolutely uniform conditions maintained in both instances.

This latter point must be observed because many factors, including the amounts of the material taken and the volume of solvent, will appreciably affect the availability of phosphorus as measured by neutral ammonium citrate.

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LABORATORY AND PLANT

THE RECOVERY OF WASTE PARAFFINED PAPER BY EXTRACTION WITH VOLATILE SOLVENTS

By Otto Kress and L. F. Hawley

Received August 19, 1918

Some time ago the Forest Products Laboratory was requested to determine whether there was a suitable method for recovering the paraffin and paper stock from waste paraffined paper. This waste paraffined paper has only a very limited value and in the majority of cases it is burned under the boilers. Other forms of paper waste such as oiled paper, asphalt-impregnated papers used for wrapping and case lining, board made damp-tight by means of asphalt or tar for the manufacture of cartons and containers of washing powder, coffee, etc., have very little application either, and are usually burned. Occasionally a small amount of the waste containing asphalt, not to exceed 2 per cent, is worked up in the beater with fresh paper stock, but the difficulties experienced with the pitch on the wire and presses of the paper machine, and the consequent loss of production due to breaks and the necessity of frequent clean-ups, makes the desirability of the practice very questionable.

No accurate statistics are available on the production of paraffined paper, but from a number of sources it is estimated that the production is close to 2,400,000 lbs. per week. Assuming a 4 per cent waste, there would be available 48 tons per week. In the above estimate no account has been taken of the waste incident to the manufacture of paraffined drinking cups, food containers, wrappers for special foods such as breakfast foods, etc.

From a review of the literature and from the experience of the manufacturer who brought the problem to us, it was believed that an attempt to remove the paraffin by melting it with hot water would not be successful. Several runs were made in which the paraffined paper was shredded and then opened up in a beater, the contents of which could be heated by the direct introduction of live steam. By this treatment it was possible to remove part of the molten wax by skimming and part by means of a washer, but the disintegrated pulp apparently held on tenaciously to a portion of the wax.

The resulting pulp was run off in the form of paper on our experimental paper machine, and an analysis for the percentage of wax in the finished paper is given for Run 7 in Table I. While the pulp prepared by this hot water treatment could be run over our experimental machine into finished paper, we believe, in view of the high wax content of the pulp, that it could not run for any length of time on a commercial machine. It was found from our experiment that the treatment of paraffined stock with hot water, heated by means of live steam, caused a decrease in the paraffin content to 0.90 per cent. In this experiment, however, the steaming operation was continued for 2 days, the condensed water carrying with it the extracted paraffin, overflowing constantly from the tub in which the stock was heated. A treatment of this nature, requiring so much time and steam expenditure, would not be commercially feasible.

Our coöperator supplied us with several hundred pounds of waste paraffin paper, some of which had been printed previous to paraffining. Seven runs were made in our experimental extraction apparatus, using gasoline as the solvent, with the object of recovering the paraffin and waste paper stock and determining the general conditions of extraction.

The apparatus used for the extraction experiments consisted of a vertical cylindrical extractor 3 ft. high and 1$^1/_2$ ft. in diameter, provided with a closed steam coil and a steam jet. This extractor was connected with a condenser in such a manner that the vapors of solvent, when boiled off, could be led to the condenser, condensed, and returned again to the extractor, all in a closed system. In the experiments a weighed amount of the paraffined paper was placed in the extractor and a measured amount of the solvent (a middle fraction of gasoline, b. p. 90–140° C.) was added; then the cover was put on and by means of the closed steam coils the solvent was boiled slowly through the condenser, returning continuously to the extractor. The steam was then turned off and the solution drained from the bottom of the extractor. An amount of fresh solvent equal to that drained off was applied and the process repeated. The solvent remaining after the second extraction and draining was recovered by blowing live steam through the extractor to a condenser and collecting the mixed condensate of water and solvent.

Different proportions of solvent and paper and charges of different weights of paper per extractor were used in order to determine the best conditions for extraction. The conditions used and the results obtained are shown in Table I. In Runs 1 to 4 more solvent was used than was found to be necessary, that is, the small amount of paraffin left on the paper was apparently a minimum uninfluenced by the amount of solvent used. Runs 5 and 6 were made to determine how little solvent could be used and satisfactory extractions still be obtained. The maximum amount of paper which could be charged into the tractor was also determined in these runs. In Run 5 the paper scraps, as received in irregular, fairly large sized pieces, were packed directly into the extractor, with occasional tearing of the larger sheets or breaking up of the matted lumps. The material used in Run 6 was run through a Williams shredder; and as may be seen from the table, a larger amount of the shredded paper can be charged in a given space than of the larger sized scrap.

As would be expected, a larger amount of paraffin was left on the paper after extraction in Runs 5 and 6, where much smaller proportions of solvent were used than in the previous runs. It must be remembered that the method used in these experimental extractions would not be used in a commercial process, since in a commercial process where a large number of charges are to be extracted in just the same way, it is preferable to use the countercurrent system of extraction, in which one lot of solvent may be used in regular order on several different charges of paper. By such a method it would be possible to obtain a more complete extraction with the use of even less solvent.[1] Under the conditions used in Run 6, the solvent ratio is $^5/_3$, since, of the 8 gal. added to the paper, 5 gal. are drained off and 3 gal. are retained after draining. By using solvent at the rate of 8 gal. per 20 lbs. of paper in a series of 4 extractions, according to the countercurrent principle, it should be readily possible to obtain a 97.0 to 97.5 per cent extraction (theoretical, 98.02). If it were found that extraction in this way left too much paraffin in the extracted paper, an increase in the amount of solvent used would give more complete extraction. For instance, 12 gal. of solvent to 20 lbs. of paper would give a solvent ratio of 4 which in 4 treatments in series would give a theoretical extraction of 99.61 per cent.

These experiments have determined the conditions under which various degrees of extraction can be obtained, but which of these conditions would be most desirable in commercial practice can be determined only from a study of the costs of different parts of the process. For instance, let us compare the conditions outlined above, of 20 lbs. of shredded paper per 3 cu. ft. of extractor space and 8 gal. of solvent per 20 lbs. of paper, with another set of conditions such as those of Run 5, *viz.*, 15 lbs. unshredded paper per 3 cu. ft. of space and 10 gal. of solvent per 15 lbs. of paper. In the latter case the unshredded and loosely packed paper retains less solvent; the solvent ratio is therefore greater and the extraction percentage which can be obtained in the same number of treatments is higher. The disadvantages of these conditions are a decreased capacity of apparatus and an increased cost of handling the larger amount of solvent (including probably larger solvent loss). These advantages and disadvantages must be compared in terms of costs before the most desirable conditions can be decided upon.

TABLE I

		SOLVENT			PERCENTAGE PARAFFIN			
						In Extracted Paper		
RUN NO. (1)	Paper Used. Lbs. (2)	Gal. Used at One Time (3)	Gal. Retained after Draining (4)	Solvent Ratio a $a = \frac{\text{Col. 3-Col. 4}}{\text{Col. 4}}$ (5)	In Original Paper (6)	On Basis Extracted Paper (7)	On Basis Original Paper (8)	Theoretical $\frac{1}{(\text{Col. }5+1)^2}\times\text{Col. }6$ (9)
1..........	7	20	0.65	30	25.5	0.21	0.15	0.03
2..........	11	16	1.1	15	26.8	0.24	0.16	0.11
3..........	11	16	1.0		23.5	..	..	0.09
4..........	11	16	1.2		19.5	0.46	0.35	0.08
5..........	15	10	2.1	4	19.5	2.03	1.67	0.86
6..........	20	8	3.0	$^5/_3$	19.1	3.40	2.67	2.67
7..........	..	..	..	..	..	7.90	..	..

Our coöperators supplied us with some samples of their mill run of paper before impregnation in order that its strength might be compared with that of the paper made from the extracted pulp. Sample 1 was made at the mill on the following furnish:

50 per cent bleached sulfite pulp
25 per cent bleached soda pulp
25 per cent unbleached sulfite pulp

Sample 2:

20 per cent bleached soda pulp
80 per cent bleached sulfite pulp

All the extracted pulps were made into paper on our experimental paper machine and it may be of interest to compare (Table II) a paper made on Run 7

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[1] For complete consideration of this and other points of the extraction process, the reader is referred to the article, "Discontinuous Extraction Processes," by L. F. Hawley, THIS JOURNAL, 9 (1917), 886.

with the original unimpregnated paper. The paper made from the extracted pulp from Run 7 had the poorest pulp in so far as thoroughness of paraffin extraction was concerned. The strength data clearly indicates that the extraction process had no decided influence on the strength of the pulp.

Some experiments were also made at an earlier date at the request of a manufacturer of damp-tight cartons and packages to determine whether the waste paper scraps from his plant might be treated to recover the paper stock. The damp-tight carton stock consisted of two boards cemented together with asphalt or tar to render the board impervious to moisture. The scrap as received contained 6.6 per cent moisture and 8.6 per cent of ether-soluble material. After treatment in the laboratory extractor the paper residue was made into board on our experimental machine and showed no spots of unextracted material. The extracted paper scrap showed an ether-soluble extract of 0.76 per cent.

TABLE II—STRENGTH TESTS ON COMMERCIAL SAMPLES 1 AND 2, AND CALENDERED SHEET FROM RUN 7. TESTS MADE AT 65 PER CENT HUMIDITY AND 76° F.

	Weight per Ream 24 × 36/500 Lbs.	Mullen Test Points	Strength Ratio per lb. Points	Strength Factor per 0.001 Thickness Points	Breaking Length Average Meters	Folds Average No.	Stretch Average Per cent
Sample 1....	25.5	7.4	0.290	3.7	3010	4	1.27
Sample 2....	26.5	5.3	0.20	2.62	1910	3	1.27
Run 7......	32.0	9.2	0.287	3.03	2330	4	1.43

Some of the paraffined waste paper had been printed with advertisements in a blue ink previous to impregnation. It was found that the solvent extraction of the wax did not affect the blue ink, nor did bleaching with ordinary bleaching powder after the extraction and pulping of the paper. This ink could be removed by means of an alkaline treatment of hydrosulfite and subsequent washing, but reoxidation to the original blue color occurred in the air unless the reduced and consequently soluble dyestuff was removed by washing. No examination was made to determine the particular pigment employed, but from the general reaction there is no question that it was of the nature of a vat dye similar to the indanthrenes. For the printing of bread wrappers, where no great permanency of the printed matter is required, cheaper printing inks which could be readily bleached with chlorine might be used with a consequent saving in cost and ease of bleaching of the resulting pulp.

From the above, it can readily be seen that the extraction of waste paraffined paper by means of gasoline and the consequent saving of the pulp and wax can be accomplished without undue difficulties. The resulting paper stock carries no more material soluble on extraction with petroleum ether than will be found in the form of pitch and resin in good grades of commercial sulfite pulp. Further, the paper stock is not injured, and, with possibly a slight bleaching treatment, may be used again for the manufacture of waxing paper.

The main difficulty attending such a recovery project lies in the fact that the amount of waste available in the United States is just about sufficient for the operation of a medium-sized extraction plant. With the constant increase, however, in the use of paraffined paper for the manufacture of bread wrappers, food containers, etc., the extraction of the paper waste and the recovery of the paraffin, if handled at a centralized plant, may well become a profitable conservation.

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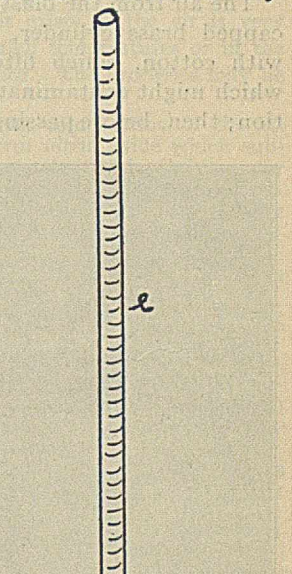
AN IMPROVED AUTOMATIC BURETTE

By GEORGE J. HOUGH

Received December 30, 1918

The burette herewith illustrated was devised by the writer several years ago, and has been found very handy and convenient. Its principal merits are, first, that it requires no bracket or support to hold it on the solution reservoir, and second, that it can be quickly cleaned and used for some other solution; this I have found to be a great advantage as only one burette is required for a large number of standard solutions, especially solutions that are not in constant use, thus obviating a number of permanently attached burettes.



As is seen in the illustration, the base of the burette consists of a glass tube, *a*, for elevating the solution, surrounded by an outer jacket consisting of a much wider tube; and when inserted in a rubber stopper to fit the solution reservoir, this form of base gives the apparatus sufficient stability so that it requires no bracket to hold it upright. The tube *c* is for the attachment of a rubber pressure bulb, and tube *d* is closed with the finger when pumping air into the reservoir. The hole in the outer jacket of the base is to equalize the pressure in the reservoir. The other details of the apparatus require no explanation.

The dimensions of the apparatus are as follows: the burette *e*, including lower stopcock, is 24 in. long; the outlet tube is 4 in. long; jacket *a* is 10.5 in. long, with a diameter of 0.5 in.; tube *c* is 2.25 in. long, and tube *d* is 1 in.; the distance from the top of jacket to the hole *h* is 1.75 in. This hole must be above the level of the liquid in the reservoir.

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LABORATORY APPARATUS FOR RAPID EVAPORATION

By E. C. Merrill and Clare Olin Ewing

Received December 30, 1918

When it is considered that evaporation is a daily proceeding in general laboratory practice, the importance of reducing the time factor in this operation will be at once appreciated. Nevertheless, there seem to be comparatively few analytical chemical laboratories where provision is made for a rapid and effective system of evaporation. The authors have found the following extremely simple apparatus very useful and efficient for this purpose:

The air from the blast is first passed through a screw-capped brass cylinder, *A*, 3 cm. × 15 cm., packed with cotton, which filters out any scale or particles which might contaminate the residue during the operation; then, before passing to the blowers, it is conducted through a 2-meter coil of 0.6 cm. copper tubing which rests on the steam pipes in an ordinary steam bath and has its terminal, *B*, sufficiently elevated above the top level of the bath to enable rubber connections to be made. The individual blowers, which are supported over the respective holes in the steam bath, are provided with glass stopcocks, so that as many as are desired can be used simultaneously. The heavy bent wires *C* that support the blowers slide within hollow standards by means of which the height of the blowers above the bath can be adjusted as desired. Fig. 1 shows the arrangement of the apparatus.

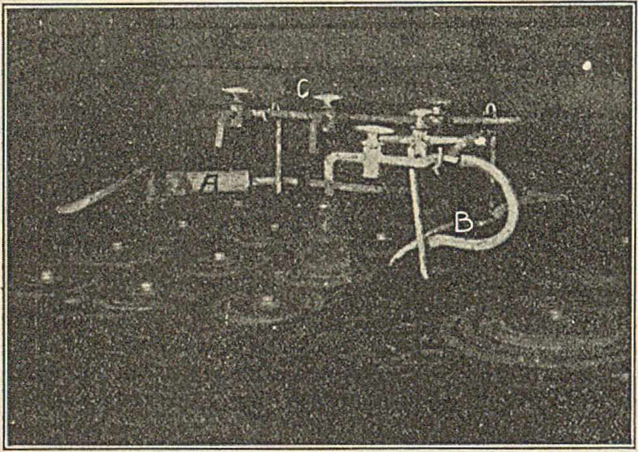

Fig. 1

When the steam is turned on, the air passing out at the orifices of the blowers is heated to approximately 60° C. but can be varied according to the volume of air passing. No doubt a higher temperature could be obtained by using a longer coil. The following tabulation shows how much evaporation may be expedited by the use of this apparatus when other conditions are constant:

Table I—Rate of Evaporation of Several Solvents on Steam Bath, with and without Blast[1]

Solvent	Volume Cc.	Surface Sq. cm.	Time in Minutes: No Blast	Time in Minutes: Ordinary Blast	Time in Minutes: Hot Air Blast
Ether	50	20	7	5	3
Chloroform	50	20	23	11	7
Benzene	50	20	55	14	10
Alcohol, 95 per cent	50	20	100	24	16
Water	50	20	175	100	64

[1] All determinations made in 100 cc. pyrex beakers.

The apparatus has been found especially useful for the rapid top-evaporation of solutions which otherwise are prone to decrepitate, such; for example, as strychnine in chloroform, and also for the rapid drying of wool fibers used in qualitative color analysis. Another advantage of the apparatus is that by insulating the beaker from the bath a rapid evaporation at a low temperature can be made of solution of materials which are apt to volatilize, polymerize, or decompose at higher temperatures. It is useful, for example, in the evaporation of aqueous solutions of glycerin, petroleum-ether solutions of volatile alkaloids such as conine, ethereal solutions of volatile oils, chloroform solutions of salicylic acid, etc.

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A FUSION BOMB FOR SULFUR DETERMINATION IN COAL

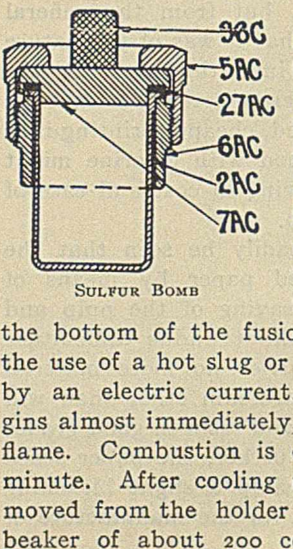
By S. W. Parr

Received January 27, 1919

The determination of sulfur in coal by use of sodium peroxide as an oxidizing medium has met with favor wherever it has been tried. The results have been shown to be in close agreement with those obtained by the Eschka method, hence a reference only to tables already published is sufficient.[1]

In this process the need of a suitable device for carrying out the combustion has been evident for some time. It is the purpose of this note to call attention to a simple piece of apparatus which has been found to operate satisfactorily in this connection.

A fusion cup, 2AC of the figure, has a cover, 7 AC, which is held in place by a screw cap, 5AC. The fusion cup is removable and by having duplicate cups a number of samples may be made ready at the same time.



Sulfur Bomb

The charge consists of 0.5 g. of coal with 9 or 10 g. of sodium peroxide which, after being sealed within the holder, is thoroughly mixed by shaking. Ignition is effected by holding the bottom of the cup for a moment in the flame of a Meker burner or, still better, by having a jet of flame from a blast lamp strike the bottom of the fusion cup. This method avoids the use of a hot slug or fuse wire to be made red hot by an electric current. After ignition, which begins almost immediately, the cup is removed from the flame. Combustion is complete in less than half a minute. After cooling under the tap the cup is removed from the holder and placed on its side in a beaker of about 200 cc. capacity. Solution of the fusion is complete in a few minutes, when the cap may be removed, rinsed, and dried. It is then ready for another charge. The composition of the cup is such

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[1] Preliminary Report of Joint Committee on Standard Methods of Coal Analysis, This Journal, 5 (1913), 525; also *Ibid.*, 1 (1909), 689.

as to withstand the action of the fused alkali in excellent shape; no roughening or corrosion of the interior can be detected even after some hundreds of fusions have been performed.

The same apparatus has been used with much satisfaction in the determination of the sulfur in pyritic material, in rubber and other organic combinations. It has a still wider application in the determination of carbonaceous matter in soils, and as a substitute for the Carius method of determining halogens in organic compounds.

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ADDRESSES AND CONTRIBUTED ARTICLES

THE PRESENT STATUS OF NITROGEN FIXATION[1,2]

By Alfred H. White, Lt. Colonel, Ordnance Dept., U. S. A.

INTRODUCTION

Fixed nitrogen in some form is an essential constituent of the food of all the higher animal and vegetable organisms. Fixed nitrogen in the form of potassium and sodium nitrates has been of prime importance in warfare since gunpowder came into general use. The ammonia resulting from the destructive distillation of coal has been recovered and used in the chemical industry for more than a century. *Free* nitrogen forms nearly eighty per cent of the air we breathe, but in the free form it can be utilized neither by the bodily mechanism nor in explosives or fertilizers. The chemist has known for many years how to convert this inert gas into other compounds in his laboratory, but it is only within the last twenty years that the fixation of nitrogen has been recognized as an industrial as well as a scientific problem, and only within the last five years that its importance has became generally recognized.

Sir William Crookes, in 1898, called attention to the diminishing supply of Chilean nitrate, and the need of replacing it with a synthetic product if the world was not to be confronted with possible starvation as a result of shortage of nitrogen fertilizers. But although this stimulated interest and may almost serve as a date for the commencement of industrial research on nitrogen fixation, it was ultimately war and not peace which caused the rapid development of the processes for fixation of atmospheric nitrogen. One of the proofs of Germany's cold-blooded calculation is found in the subsidized development of the nitrogen fixation industry. The sodium nitrate vitally necessary for explosives was found only in Chile, and its supply would almost certainly be cut off in a war with a first-class naval power. The German government did not declare war until it had the Haber, Ostwald, and cyanamide processes developed to the point where it knew it could become independent of Chilean supplies.

Almost all of the military explosives, whether used as propellants or as bursting charges, contain large percentages of the nitrate group. If this is to be supplied from sodium nitrate, there will be needed nearly two pounds of sodium nitrate for each pound of explosive, as shown somewhat more in detail in the following table:

Explosive	Nitrate Factor
Smokeless powder	1.70
Trinitrotoluol	1.70
Picric acid	2.50
Miscellaneous high explosives	1.50

Ammonium nitrate, while not itself an explosive under ordinary conditions, becomes, when mixed with a portion of its weight of TNT, the very satisfactory high explosive amatol, important as a bursting charge for shells. Ammonium nitrate is the richest of all explosives in nitrogen.

SUMMARY OF FIXATION PROCESSES

It is the first step in nitrogen fixation which is the most difficult. The nitrogen molecule as it exists in the air is very inert and becomes active only at high temperatures or in the presence of some activating substance. The processes may be classified as follows:

I—THE ARC PROCESS for the direct combination of the nitrogen and oxygen of the air to form nitric oxide which subsequently by oxidation with air and combination with water forms nitric acid of approximately 35 per cent concentration. There are required about 10.5 h. p.-years electrical energy per ton of nitrogen fixed as nitric acid per annum.

II—THE CYANAMIDE PROCESS, involving:

(1) The production of calcium carbide through reaction between lime and coke in an electric furnace.

(2) The interaction of calcium carbide and pure nitrogen at a red heat to form calcium cyanamide.

(3) The decomposition of cyanamide by steam underpressure, to form ammonia.

(4) The oxidation of ammonia with air and combination with water to form dilute nitric acid of approximately 50 per cent concentration.

The power required by this process is approximately 2.5 h. p.-years per ton of nitrogen converted to nitric acid per annum.

III—NITRIDE PROCESSES. The best developed of these processes is that for making aluminum nitride from aluminum oxide, coke, and nitrogen heated to a temperature of perhaps 1800° C. in an electric furnace. This process has not been developed far enough to show its ultimate power requirements, but it is approximately in the same class as the cyanamide process. The aluminum nitride, after formation, may be decomposed with steam or dilute caustic solutions yielding ammonia and regenerating the alumina.

IV—THE DIRECT SYNTHETIC AMMONIA PROCESS, usually called the Haber process, wherein pure nitrogen and hydrogen are made to combine in the presence of a catalyst, at temperatures which in commercial work have usually approximated 500° to 600° C. and under a pressure of 100 atmospheres or higher. The ammonia made by this process is then oxidized with air and converted to nitric acid. Electrical energy is not necessary for this process and the total power requirements are only about 0.5 h. p.-year per ton of nitrogen fixed as nitric acid per annum.

V—THE CYANIDE PROCESS, wherein a mixture of sodium carbonate and coke with iron in small quantities is heated in a stream of pure nitrogen to a temperature of approximately 1000° C., resulting in the formation of sodium cyanide. This furnace product may be decomposed with steam, yielding ammonia. Power requirements for this process are of the same order as for the Haber process.

It will be seen that all of the above processes, except the arc process, yield ammonia as their initial product. The arc process requires the greatest expenditure of electrical power, the cyanamide and nitride processes rank next, and the direct synthetic ammonia and the cyanide processes require only small amounts of power. In fact, these two latter processes do not necessarily require any electrical power, it being possible to carry out all the heating reactions without the use of electrical energy, although electrical heating may in some cases be more economical. If nitric acid is desired, the ammonia produced by these processes may be oxidized to nitric oxide by air in the presence of a catalyst, usually platinum, working at 750° to 850° C. The nitric oxide resulting is oxidized by cooling, mixing with more air if necessary, and passing through towers, down which water or dilute nitric

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[1] Published by permission of the Chief of Ordnance.

[2] Address delivered at the Chicago Meeting of the American Institute of Chemical Engineers, January 16, 1919.

acid trickles. The resulting product is about 50 per cent nitric acid. This oxidation process requires very little external energy. It may be considered that the principal problem is to get atmospheric nitrogen into a combined form, and that the problem of converting the initial form of combined nitrogen into the final form is distinctly simpler and better elaborated.

NITROGEN FIXATION IN THE UNITED STATES

It was reserved for two Americans, Bradley and Lovejoy, to first place the fixation of nitrogen on an industrial scale in their plant at Niagara Falls, N. Y., in 1902. This historic attempt, though well conceived, failed largely because of the lack of sufficiently cheap electrical power at Niagara to allow the process to be carried to industrial success. Later developments were made mainly in Europe, largely because of the existence there of water power which could be used to generate cheap electrical power necessary for most of the nitrogen fixation processes.

The subject of nitrogen fixation in the United States had been studied by some of the larger corporations prior to the outbreak of the European War in 1914, but no commercial plant had been installed in this country, and only had been actually installed in Canada, that of the American Cyanamid Company, at Niagara Falls, Ontario. The United States Army authorities were alive to the critical situation in which this country would be placed should it enter the war and its connections with Chile be interrupted; but no money for fixation was appropriated until the passage of the National Defense Act of June 3, 1916, which carried as its Section 124 (Nitrate Supply) an appropriation of $20,000,000 to be placed at the disposal of the President for investigation of "the best, cheapest, and most available means for the production of nitrate and other products for munitions of war and useful in the manufacture of fertilizers, and other useful products, by water power or any other power as is in his judgement the best and cheapest to use." This Act also conferred on the President broad powers in the acquisition of processes and of land, and in the construction of plants and sale of product.

The question of nitrogen fixation with special reference to the use to which this money should be put was studied by several nitrate commissions, the first organized by the National Research Council, and the others by the Secretary of War, but retaining a considerable proportion of the original membership. Their conclusions and the action recommended and taken up to August 1917 have already been published.[1]

When this country declared war on Germany on April 6, 1917, no definite program had been approved and no further commercial developments on the manufacturing scale had taken place, although the American Nitrogen Products Company had established at La Grande, near Seattle, Washington, a small experimental arc process plant, which was producing sodium nitrite. On July 7, 1917, the Secretary of War on behalf of the President approved the recommendations of the Nitrate Supply Committee and directed that approximately $3,900,000 be placed at the disposal of the Chief of Ordnance of the United States Army to carry out the recommendations of the Committee. The Ordnance Department instituted the Nitrate Division on July 25, 1917, with Colonel J. W. Joyes as Chief, to carry out the program of construction and research therein laid down, and to have charge of such other nitrogen fixation projects as should be committed to it.

The files of the Nitrate Division contain confidential reports received from the French and British governments, as well as the records of eighty-four special investigations that have been made in this country. The Nitrate Division corresponded with and in most cases had personal interviews with every person or institution which it could learn was interested in or had worked on nitrogen fixation. It is a great gratification to be able to record that with hardly an exception all of these individuals and firms placed their information at the disposal of the Government without reservation. They cheerfully allowed the Government to make any tests which it wished at their plants, and many of them went on with the work at their own expense at the request of the Government, in spite of the difficulties of conducting the work in war time, and in spite of their feeling that from their own standpoint they would rather have put their energies into other lines of work. Although the files of the Nitrate Division contain all these reports, it would be manifestly improper to disclose their content, or even to list the names of those who were working in this field, without their permission. Perhaps some day a complete report may be written on this subject. For the present, a brief summary must suffice.

UNITED STATES NITRATE PLANT NO. 1

The Nitrate Supply Committee,[1] on May 11, 1917, made, among others, the following recommendations:

> The committee, appreciating the offer of the General Chemical Company, recommends:
>
> 1—That the Government enter into negotiations to acquire the rights to use the synthetic ammonia process of that company.
>
> 2—That contingent upon satisfactory arrangements with the General Chemical Company, out of the $20,000,000 nitrate supply appropriation, such sum as may be needed, now estimated at $3,000,000, be placed at the disposal of the War Department to be used in building a synthetic ammonia plant, employing the said process of the General Chemical Company and of a capacity of 60,000 lbs. of ammonia per 24-hr. day, said plant to be located in a region where land, water, coal, and sulfuric acid are cheaply available, where good transportation facilities exist, and where the proposed new powder plant of the Government can be properly located. In the opinion of this committee all of these conditions just enumerated are best fulfilled by a location in southwest Virginia or contiguous region.
>
> 3—That out of the $20,000,000 nitrate supply appropriation an amount now estimated at $600,000, or as much as may be needed, be placed at the disposal of the War Department to be used in building a plant for the oxidation of ammonia to nitric acid and the concentration of nitric acid, of a capacity equivalent to 24,000 lbs. of 100 per cent nitric acid in a 24-hr. day, said plant to be located in the neighborhood of the aforesaid synthetic ammonia plant and the proposed new powder plant of the Government.
>
> 4—That the War Department proceed at the earliest practical date with the construction of the oxidation plant and contingent upon a satisfactory arrangement with the General Chemical Company, also with the synthetic ammonia plant, and that the Government give such priority orders as will secure rapid construction of the structure and machinery needed for these plants.

This recommendation, having been approved by the Secretary of War on behalf of the President, constituted the first instructions to the Nitrate Division of the Ordnance Department. The plant built as a result of these instructions is known as Unites States Nitrate Plant No. 1, and is located at Sheffield, Alabama. This group is composed of four principal parts: the synthetic ammonia plant, the ammonia oxidation plant, the ammonium nitrate plant, and the nitric acid concentrating plant. The synthetic ammonia plant was built in accordance with the designs of the General Chemical Company, and the construction and initial operation were carried out with their active coöperation. It consists of three units, two each of rated capacity of 15,000 lbs. of anhydrous ammonia per day, and one of capacity of 30,000 lbs. per day. The many difficulties in obtaining equipment delayed the completion of this plant, and its first unit did not start into operation until September 15, 1918. As was to have been expected, there were numerous minor troubles in starting this new process, and its operation was still in a somewhat experimental state when the armistice was declared on November 11, 1918. No attempt has as yet been made to start the operation of more than one unit of the plant.

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[1] This Journal, 9 (1917), 829–841.

[1] The full report of this committee, together with some other documents, is to be found in This Journal, 9 (1917), 829–841.

The ammonia oxidation plant was built to oxidize approximately one-half of the ammonia made in the synthetic process, it being the intention to have as the ultimate product of the plant, ammonium nitrate. The catalytic agent in this plant is a platinum gauze, and the converter is one designed by Capt. G. A. Perley, of the Ordnance Department, after designs made initially by Dr. Charles L. Parsons, of the Bureau of Mines, and Mr. Louis C. Jones, of the Solvay Process Company, as the result of coöperative experiments made at the plant of the Solvay Process Company in Syracuse, N. Y. The oxidation towers and acid system were designed and installed by the Chemical Construction Company, Charlotte, N. C. This oxidation and acid plant has had relatively little opportunity to show its efficiency, and has never been operated up to capacity, but so far as it has been operated, it has shown itself to be satisfactory. The ammonium nitrate plant follows a fairly standard design which has been worked out by various munition manufacturers, and although it has not had much continuous operation, it has worked entirely satisfactorily. The nitric acid concentration plant was built in accordance with the recommendations of the Nitrate Supply Committee, to have a capacity of 24,000 lbs. of nitric acid in a 24-hr. day, calculated as a 100 per cent acid, but being actually delivered as 96 per cent. This plant was designed and erected by the Chemical Construction Company, Charlotte, N. C., but has never been tested.

The present status of United States Nitrate Plant No. 1 is therefore that of many other munition plants throughout the country. It was completed, but had not yet really come into operation, when the armistice was signed. It is hoped to keep this plant in partial operation until its measure of success has been determined. The wording of the Nitrate Supply Section of the National Defense Act indicates that at the time the Act was passed it was contemplated that this plant should be operated for the manufacture of fertilizers. The ultimate disposition of the plant is not yet known.

UNITED STATES NITRATE PLANT NO. 2

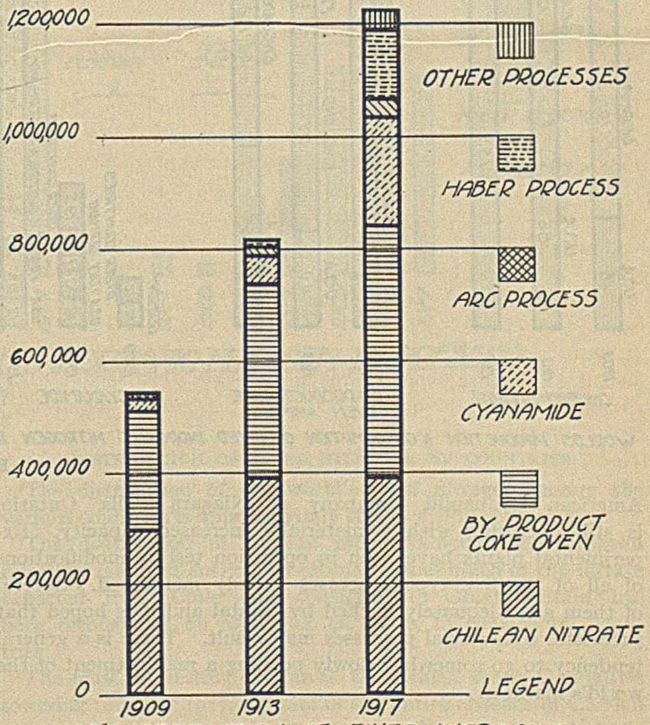
U. S. Nitrate Plant No. 1 was built in accordance with the deliberate judgment of the Nitrate Commission that the direct synthetic process of producing ammonia through combination of nitrogen with hydrogen should be tried in this country, because it did not involve the large amounts of electrical power necessitated by the other processes which had proved themselves successful by actual commercial experience. After this country had been in the war a few months and the loss of ships from submarines became a serious factor, and it was seen that a further source of synthetic nitrate should be supplied, the Nitrate Division unreservedly recommended that the cyanamide process be installed, as involving less electrical power than the arc process, and being the only other process which had been fully developed on a manufacturing scale. The only commercial organization in this country which had expert knowledge of this process and the requisite staff therefor was the American Cyanamid Company. Accordingly, this company was called into conference, and on November 16, 1917, contract was made with them for the erection of a plant to produce 110,000 tons ammonium nitrate per year by the cyanamide process. This plant was to be located at Muscle Shoals, Alabama, and it was proposed to have the plant, to one-half the capacity, ready to begin operations within six months from the date of breaking ground and the remaining half ready twelve months from the same date. The American Cyanamid Company organized the Air Nitrates Corporation as a subsidiary to carry on the actual work and operation of this plant under government supervision. The exceptionally severe winter of 1917–1918 and the difficulties of getting the large steam turbo-generator units required for the plant were important factors which delayed construction so that the plant did not furnish its initial product of ammonium nitrate until November, 25, 1918. The first unit of the plant which was tested behaved satisfactorily except for small minor defects, and there was every expectation that the plant would have rapidly built up to its full rated capacity by the completion of subsequent units. This plant is now being given a careful test on one unit only, which means about one-sixth its rated capacity. It is expected the test will be completed during the month of January and that the plant will be closed about the first of February 1919, pending decision as to its future operation.

UNITED STATES NITRATE PLANTS NOS. 3 AND 4

In the Spring of 1918 when the losses by enemy submarines were becoming increasingly serious and the stocks of sodium nitrate in the country were reduced to alarmingly low levels, it was decided that additional fixation plants should be erected. The question as to the best process was again referred to the Nitrate Commission, who reported unanimously that the cyanamide process was the only one to consider from the standpoint of certainty of operation combined with reasonable cost. A new contract was accordingly made with the Air Nitrates Corporation, and the American Cyanamid Company, for the erection of U. S. Nitrate Plant No. 3 at Toledo, Ohio, and No. 4 at Ancor, Ohio, near Cincinnati. Each of these plants was to have a capacity of 55,000 tons of ammonium nitrate per year. The construction of these plants was well under way when the armistice was declared. Work upon them was at once stopped, and the contracts are now being adjusted and formally cancelled.

CHEMICAL PLANT, SALTVILLE, VA.

The chemical plant at Saltville, Va., was built at the request of the Ordnance Department and with Ordnance money, but through the agency of the Bureau of Mines with Dr. Charles L. Parsons as its representative. This plant was to produce 10 tons of sodium cyanide per day by the Bucher process.[1] The plant was starting initial operation when the armistice was signed. It was given a test run to get information on operating costs, and was then closed down. It is at present under the jurisdiction of the Nitrate Division of the Ordnance Department, but its future is uncertain.



WORLD'S PRODUCTION OF FIXED INORGANIC NITROGEN EXPRESSED IN TONS NITROGEN

Fig. 1

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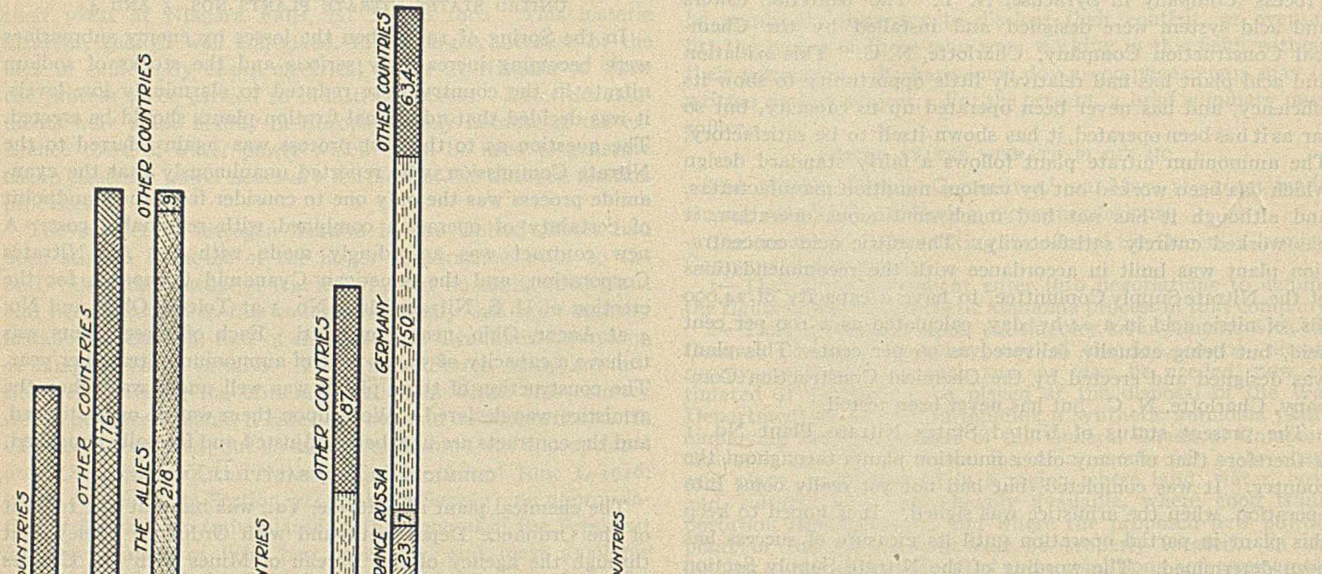
[1] This Journal, 9 (1917), 233–253.

COMMERCIAL DEVELOPMENTS IN THE UNITED STATES

It is felt necessary to speak with considerable reserve about commercial developments, on account of the confidential relation which the writer has sustained to them in his official capacity. The arc process plant of the American Nitrogen Products Company at La Grande, Wash., referred to earlier in this article, has been in successful operation throughout the war and is the single commercial nitrogen fixation plant known to be in operation in the United States proper, although the American Cyanamid Company at Niagara Falls, Ontario, is still operating with a materially increased capacity. Experimental plants have been in operation testing modifications of all of the five type processes already mentioned. Several of them are adequately backed by capital and it is hoped that successful commercial processes may result. There is a general tendency to go somewhat slowly pending a readjustment of the world's markets.

THE WORLD'S SUPPLY OF FIXED NITROGEN

The world can use almost any form of combined nitrogen, either directly or after conversion into a more desired form, so that the clearest way to obtain a view of the world's nitrogen supply is to reduce the figures for the various nitrogenous materials to a common basis of fixed nitrogen. The nitrogen in manure and other organic refuse, while important for agriculture, cannot be estimated with any accuracy. Fig. 1 shows the world's production of fixed inorganic nitrogen expressed in short tons of nitrogen for the years 1909, 1913 and 1917. No great accuracy can be claimed for these figures since some of them are mere estimates. It is believed, however, that the general situation is expressed correctly. Much of the data in Figs. 1, 2 and 3 is due to Mr. Eysten Berg. The first outstanding impression is that of great growth in each period, but on closer analysis the striking fact is that the percentage increase from 1909 to 1913, when the world was at peace, is nearly as great as during the subsequent period when the world was at war. The increase is very closely fifty per cent for each four-year period. The year 1913 shows an increase in production from every source. The year 1917 shows no increase from Chilean nitrate, in spite of the urgent demands of the Allies for greater supply. This was partly due to lack of ships. The greatest increase on the chart for the period 1909–13 is shown by the by-product



WORLD'S PRODUCTION & CONSUMPTION OF FIXED INORGANIC NITROGEN DIVIDED BY COUNTRIES & EXPRESSED IN THOUSANDS OF TONS NITROGEN

FIG. 2

coke ovens. In 1917 the increase was mainly due to the cyanamide and Haber processes, so that in this year the world's supply came almost equally from the three sources, Chilean nitrate, coke ovens, and synthetic, the cyanamide process being the most important in the latter group, with the Haber second.

DISTRIBUTION OF FIXED NITROGEN BY PROCESSES

In Fig. 2 an attempt is made to distribute the world's production of fixed nitrogen by countries and processes. Only approximate accuracy can be claimed for the chart, as was the case with Fig. 1, but certain important factors stand out clearly. In 1909 and 1913 Germany received nearly one-third of all Chile's nitrate. After the war broke out, she received none. If the war had continued, it is probable that the year 1918 would have seen the Chilean output increased nearly 25 per cent over 1917. This probably represents nearly the maximum output, and it is beleived that 500,000 tons of nitrogen as nitrate may be fairly taken as the most that can be expected from Chile.

The figures for ammonia from by-product coke ovens show a steady increase for every country, so that the coke ovens became the largest factor in the world's nitrogen production in 1917. There is every probability that a further increase was registered in 1918. Ovens still under construction, especially in the United States, will afford facilities for further material increase in 1919. In the periods studied, Germany shows the largest absolute as well as the largest relative increase in production from coke ovens.

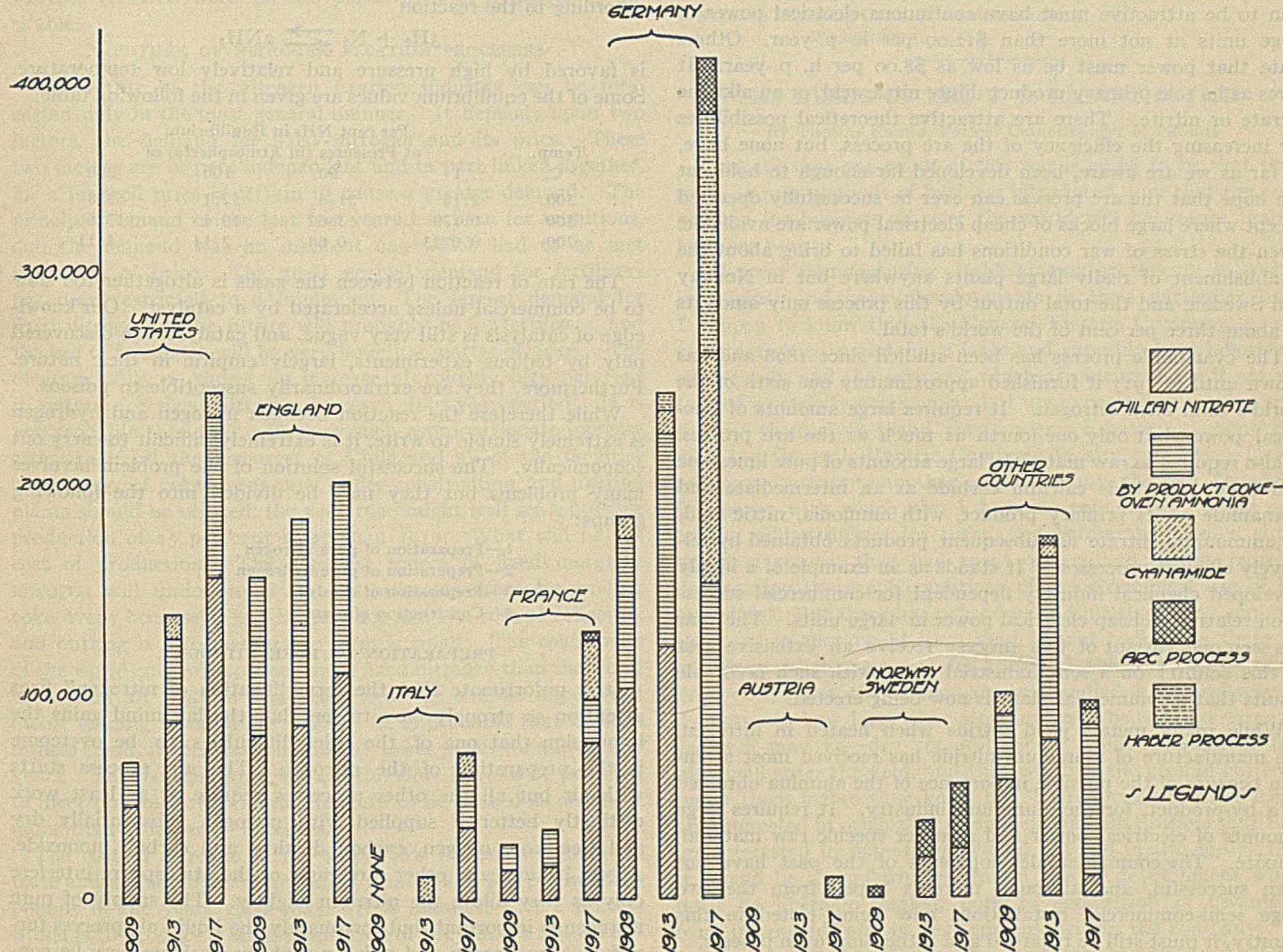


FIG. 3

The cyanamide industry more than tripled in each period, and rose in 1917 to a production of more than half of the equivalent in Chilean nitrate. Facilities provided since 1917 make a further increase of twenty-five per cent possible.

The arc process shows a growth, but in spite of the stimulus of high prices, it has not attained prominence and remains centralized in Norway and Sweden, where water power is cheap.

The phenomenal growth of the Haber process in confined to Germany. The 8000 tons production in 1913 represented success on a manufacturing scale and gave the German government assurance that it could go to war, confident that neither foreign navies nor expensive electrical power could keep her armies from an adequate supply of the material most necessary for explosives.

DISTRIBUTION OF FIXED NITROGEN BY COUNTRIES

The distribution of the world's fixed nitrogen among the various countries is approximately shown in Fig. 3.

The distribution of Chilean nitrate among the European countries is almost entirely an estimate, since much of the nitrate exported from Chile and consigned to Great Britain has been reconsigned, on arrival or en route, to continental countries.

The most interesting column is that which shows Germany's towering total for 1917, in spite of the entire absence of Chilean nitrate. Here again the figures are an estimate. The relatively small production of Norway and Sweden is also interesting and at first disappointing, in view of the large amount of publicity which has been given the installations in that country.

RELATIVE TECHNICAL DEVELOPMENT OF FIXATION PROCESSES

The two processes first commercially established were the arc process and the cyanamide process. Both have had a commercial development of approximately thirteen years in the hands of skilled chemists, chemical engineers, and electrical engineers in countries with high industrial development. There has, moreover, been mutual exchange of information between various groups of plants, both national and international, and the industry has become relatively stabilized along lines which represent the most advantageous process which the combined experts of the various affiliated companies have devised. Improvements will still undoubtedly be made, but the processes are relatively highly developed.

Experts in the arc process state that a commercial proposition to be attractive must have continuous electrical power in large units at not more than $12.00 per h. p.-year. Others state that power must be as low as $8.00 per h. p.-year. It gives as its sole primary product dilute nitric acid, or an alkaline nitrate or nitrite. There are attractive theoretical possibilities for increasing the efficiency of the arc process, but none have, so far as we are aware, been developed far enough to hold out the hope that the arc process can ever be successfully operated except where large blocks of cheap electrical power are available. Even the stress of war conditions has failed to bring about the establishment of really large plants anywhere but in Norway and Sweden, and the total output by this process only amounts to about three per cent of the world's total.

The cyanamide process has been studied since 1898 and has grown until in 1917 it furnished approximately one-sixth of the world's total fixed nitrogen. It requires large amounts of electrical power, but only one-fourth as much as the arc process. It also requires as raw materials large amounts of pure limestone and coke. It yields calcium carbide as an intermediate and cyanamide as its primary product, with ammonia, nitric acid, or ammonium nitrate as subsequent products obtained by relatively efficient processes. It stands as an example of a highly developed chemical industry dependent for commercial success upon relatively cheap electrical power in large units. The war has seen one variant of this process receive an extensive test in this country on a semi-industrial scale, with such favorable results that a commercial plant is now being erected.

While many metals yield nitride when heated in nitrogen, the manufacture of aluminum nitride has received most attention because of the possible importance of the alumina obtained as a by-product, for the aluminum industry. It requires large amounts of electrical power and a rather specific raw material, bauxite. The commercial developments of the past have not been successful, and although more is hoped from the two large semi-commercial installations now being tested in this country, it must still be regarded as a rather unproven process.

The cyanide process does not require electrical power and uses as its raw materials sodium carbonate, coke, iron, and pure nitrogen. Of the raw materials the iron is always recoverable and if the cyanide is converted into ammonia under proper conditions, the sodium carbonate is also recoverable, leaving as the only raw materials actually expended nitrogen and coke in the cyanizing reaction, and steam in the ammonia reaction, together with the coal required to furnish the heat. The initial product is cyanide which may be purified and marketed as such or converted into ammonia with a possibility of sodium formate as a by-product. The development has been largely in the United States and since the war broke out. It has been studied carefully by the United States Government and by several private corporations in plants almost large enough to be called commercial plants. The only really large-scale plant is the United States Chemical Plant at Saltville, Va., previously referred to. The commercial possibilities of this process have not yet been established. The present developments have tended towards an externally heated steel or nichrome retort as the most suitable container for the cyanizing reaction which requires a temperature of 1000° to 1100° C. The retort is necessarily small and the reaction is rather slow. The procses attracted the Government during the war because it was certain nitrogen could be fixed without the use of large amounts of electrical energy, which were then almost unobtainable. At present the process involves high capital, labor, and repair costs. The process must not, however, be condemned in its present immature form.

The direct synthesis of ammonia from nitrogen and hydrogen was first developed both from the theoretical and practical side in Germany, and the name most frequently associated with it is that of Haber. The combination of nitrogen and hydrogen according to the reaction

$$3H_2 + N_2 \rightleftarrows 2NH_3$$

is favored by high pressure and relatively low temperature. Some of the equilibrium values are given in the following table.

Temp. ° C.	Per cent NH_3 in Equilibrium at Pressures (in Atmospheres) of 1	30	100	200
300	2.18	31.8	52.1	62.8
500	0.129	3.62	10.4	17.6
700	0.0223	0.66	2.14	4.11

The rate of reaction between the gases is altogether too slow to be commercial unless accelerated by a catalyst. Our knowledge of catalysis is still very vague, and catalysts are discovered only by tedious experiments, largely empiric in their nature. Furthermore, they are extraordinarily susceptible to poisons.

While therefore the reaction between nitrogen and hydrogen is extremely simple to write, it is extremely difficult to carry out economically. The successful solution of the problem involves many problems but they may be divided into the following groups:

1—Preparation of pure nitrogen
2—Preparation of pure hydrogen
3—Preparation of catalyst
4—Construction of plant

PREPARATION OF PURE NITROGEN

It is unfortunate that the term "fixation of nitrogen" fixes attention so strongly on nitrogen that the lay mind gains the impression that one of the chief difficulties to be overcome is the preparation of the nitrogen. The arc process starts with air but all the other processes require or at least work distinctly better if supplied with nitrogen substantially dry and free from oxygen, carbon dioxide, and carbon monoxide. Argon, helium and other rare gases of the atmosphere interfere only as they dilute the nitrogen slightly. The supply of pure nitrogen is important, but fortunately the liquid air process furnishes it so cheaply and reliably that the problem may be considered as solved. A nitrogen column as delivered to the United States nitrate plants has an hourly capacity of 20,000 cu. ft. of dry nitrogen, with less than 0.1 per cent oxygen for an expenditure of 180 h. p.-hrs. Power is by far the most expensive item, for air is free, only a small amount of caustic is needed for purification of the entering air, and the labor charge is small. The operation is so reliable and the cost so small that efforts to recover waste nitrogen from industrial sources are hardly worth while where a really large installation is being considered.

PREPARATION OF PURE HYDROGEN

Pure hydrogen is needed only for the direct synthetic ammonia process. It forms 17.6 per cent of the theoretical gas mixture by weight, but 75 per cent by volume. Hydrogen is formed as a by-product in the electrolytic manufacture of chlorine, but the expense of collecting it and purifying it is considerable. Hydrogen and oxygen are obtained by electrolysis of caustic solutions, but it is difficult to find a location where both gases can be used to advantage. It is also made by the action of steam on red-hot iron and by the water-gas reaction wherein steam reacting with coke produces approximately equal volumes of carbon monoxide and hydrogen. By further reaction with steam in the presence of a catalyst, as shown by the following equation,

$$CO + H_2O \rightleftarrows CO_2 + H_2,$$

most of the carbon monoxide may be removed with the formation of an equal volume of hydrogen, but a long and elaborate purification process must be followed to bring the gas to a pure and dry state. The refinement of purity necessary will vary with the different catalysts, but the impurities must certainly be measured only in hundredths of a per cent, if not thousandths. Further research work on the purification of hydrogen is desirable.

FUTURE OF NITROGEN FIXATION PROCESSES

The future of the nitrogen fixation industry can be forecasted only in the most general manner. It depends upon two factors, the demand for fixed nitrogen and its price. These two factors are in part independent and in part linked together, for a lowered price is certain to cause a greater demand. The principal demand of the last few years has been for munitions, and the demand was an insistent one which had to be met regardless of price. The great normal demand for fertilizers has been restricted to a minimum. The largest demand for fixed nitrogen in the future will probably be for fertilizers, and the use of fertilizers will be very largely a matter of price. The diagram, Fig. 1, shows an increase of roughly fifty per cent in output for fixed nitrogen for each four-year period. It is not probable that 1921 will show such a proportionate increase although if all the resources of Chile and all of the facilities in the way of coke ovens now under construction, and fixation plants should be utilized, the year 1920 might well see a possible production of 25 per cent more than 1917. What will be the cost of production? The cheapest source of fixed inorganic nitrogen will undoubtedly be the ammonia from by-product coke ovens because it is a by-product and the cost of collecting and putting it into marketable form is small. The coke ovens of the world can now produce more fixed nitrogen than the world used from all sources ten years ago. It will be a powerful factor tending towards low prices. It is probable that Chilean nitrate could, if necessary, be sold at lower prices than in former years. The fixation processes will therefore have to be prepared to meet possible low prices if they are to be ranked as anything more than emergency reliances.

The cost of nitrogen in the staple raw materials sodium nitrate and ammonium sulfate varied from $12 to $16 per hundred pounds in the years 1900–1915. It is manifest that a process which is to produce a large proportion of the world's fixed nitrogen must be able to compete with these staple materials. Smaller factories may produce specialized products such as sodium nitrite and anhydrous ammonia for which there is a demand, large in itself, but small in proportion to the world's total demand.

The necessity and the possibility of independence of Chilean nitrate as a material for munitions has been proved in the past four years. The question as to whether the fixation processes can compete with Chilean nitrate and coke oven ammonia in times of peace, and for the cheapest commercial nitrogenous product—fertilizer—cannot yet be answered.

The cyanamide and arc processes both labor under the handicap of the requirement of large amounts of electrical power. The nitride process has a somewhat similar handicap but possesses a possible advantage in the recovery of alumina as a by-product. The cyanide process labors at present under the disadvantage of small manufacturing units but has the advantage of low-power requirements and the possible recovery of formates as by-products. The direct synthetic ammonia process presents great engineering and chemical difficulties, but has great possibilities of future development. As will be seen from the table earlier in this paper, if an inventor could find a catalyst active at 300° C., he would have the theoretical possibility of increasing the conversion by one passage through the apparatus at 100 atmospheres pressure to fivefold the conversion at 500° C. Or with such a catalyst, he could work at 30 atmospheres pressure and 300° temperature, eliminating thereby many of the serious engineering difficulties and still obtaining a conversion far better than anything now commercially known to us. There is no theoretical reason why such a catalyst might not be made, and its discovery would offer the possibility of cheaper fixed nitrogen than anything heretofore known.

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THE NEEDS OF THE U. S. PATENT OFFICE[1]

By Thomas Ewing, Former Commissioner of Patents

I believe that one result of this war is going to be that there must be new methods of business introduced, and that the competition for business all over the world will be keener than it has ever been.

All great manufacturing establishments are keenly interested in original and novel developments in their particular lines. I happen to know that the General Electric Company, as one of its activities, maintains a large and superbly kept laboratory of research, and the expenses which are incurred for it are not treated as strictly commercial, but are expected, in a large way, to pay themselves many times over. I have no connection with the General Electric Company in any capacity. I once sold some patents to another great company, the Bell Telephone Company, with which also I have no connection. They paid half a million dollars for them, and before they had a single dollar of return, they had spent one million dollars more in determining the exact conditions of the economical use of the inventions. But there has never been a time since they acquired them, when they could have been bought back from them for ten times what they paid for them. I think it is true of all great enterprises, that if they are not handled in a broad way—I do not care how large the company may be, or how large its business may be—dry rot will set in, competitors with new ideas will enter the field, and they will find the ground cut from under them before they know it. Therefore, all great concerns are interested in original development, and that means that they are interested in patents, or should be; and it also means that it should be a regularly recognized line of development which must be liberally treated, both in acquisition of inventions from the outside and in developments within the company.

I know that everybody who has anything to do with the patent system complains about it, and there is reason for complaint, but the complexity of the questions and the vast field which the patent system covers make it impossible that all of the troubles should be either removed or immediately mitigated.

There is one factor in our patent system which everybody should be interested in and should try to help, without any regard whatsoever to one's general opinion about what the patent system should be, or what it is worth; and that factor is the Patent Office.

We could have a system of registration of patents such as we did have down in 1836, and such as a number of countries have to-day, but in 1836 this Government introduced the system of granting patents on examination—examination not only of the form of the papers, but of the invention, as its novelty; and from that period on, the Patent Office has been an important and constantly growing factor in our system.

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[1] Address before the War Emergency Reconstruction Conference held at Atlantic City, December 3 to 6, 1918.

The theory of the Patent Office is that patents will be granted only when they ought to be granted, and that the claims that are allowed will be only such as ought to be allowed; and in view of the fact that there are more than four hundred men engaged constantly in the examination of applications, the courts give great weight to what the Patent Office concludes. They are frequently saying, "Why, there is a finding by the Patent Office; here is something which the experts of the Patent Office have held to be novel over the other patents which are being presented to us;" and the courts will therefore reject arguments for holding a patent invalid, or for limiting it. They rely upon what the Patent Office has decided, and seek to give effect to its conclusions. With such an attitude, which is perfectly proper in view of the theory of the Patent Office, it is the worst sort of business to have a Patent Office that is insufficiently provided with men and facilities for making proper examinations. It becomes dangerous, because weight is given to patents which is not deserved, not that the Patent Office is not industrious, and not that its *esprit de corps* is not high, for the examiners are both industrious and of high character, but because the Office is inadequately supplied with means and with men to make proper searches, and their conclusions are therefore, in many cases, erroneous.

I would like to impress upon you to-day that it is of the utmost importance to all of you, no matter whether you are interested in patenting inventions or are interested in going into new fields which are being developed by other people where you may have to meet hostile patents, it is to your interest, and it is to the interest of every inventor as well, of course, that the Office be efficiently and adequately provided with the means necessary to perform its great labor.

I was in the Patent Office for four years as Commissioner, and previous to that, thirty years ago, as an assistant examiner; and I have practiced before it. I have no personal interest in what may be done for it, or any personal pride of position in it; but it is perfectly apparent to me that the provisions for the Office are inadequate. And it became apparent to me while I was Commissioner that the Office, through the ordinary channels, is not able to influence Congress to give it proper facilities. Only influence from the outside—I mean, of course, influence that is entirely proper and legitimate, of people who are interested in having the thing done right—can bring effective pressure to bear upon Congress. Only in that way will the Office get what it needs.

Let me give you an illustration of the difficulty. The last year I was there I made a recommendation to Congress, asking for an increase in the force which would have cost one hundred thousand dollars a year. I had studied the Office diligently for the three preceding years, and I presented the reasons for the need as strongly as I possibly could. At the end of the deliberations there was not one cent allowed for the things that I asked for. Subsequently we entered the war, and many people who had applications in the Office, which were not being reached for action because we were behind, were writing, asking to have their cases made special. I could not make one man's case special without being guilty of unfair treatment to the others whose cases were awaiting action, and I adopted the method of writing to each one who asked to have his case made special that I was unable to do so, because the facilities and means provided in the Office for acting upon the applications were insufficient, and that my appeal to Congress to increase these means, which I had based particularly upon the probability that we were going into a war, and a dangerous situation might arise, had been entirely fruitless. Some of the letters which I wrote—and I wrote many—came back to the congressmen, and the congressmen went to the appropriation committee, and the committee finally sent for me and said that they would hear me over again; and after a great deal of effort, I succeeded in getting an increase of about forty thousand dollars where I had asked for one hundred thousand.

What the Patent Office needs is not forty thousand dollars, or one hundred thousand dollars, but about one million dollars; and it is utterly impossible for the Office to get any such increase of appropriation unless some large influence is brought to bear to make Congress look into the matter and see what the situation really is.

Six hundred thousand dollars a year more than is now spent ought to be spent in increasing the examining corps and the clerical force, that is, increasing the personnel. Three hundred thousand dollars more ought to be spent in increasing salaries. The salaries are ridiculously low. The primary examiners, of whom there are forty-five, have the authority to pass out patents, sometimes of enormous value. If one of these primary examiners signs a file wrapper, the patent goes out automatically. It is true that the Commissioner must sign it, but as he has to sign about seven or eight hundred a week, it is entirely impossible for him to examine them; and, therefore, these forty-five men have it in their power to pass out patents which may be worth millions of dollars. Men who are doing work of that sort should be properly paid. The primary examiners who have that authority receive twenty-seven hundred dollars a year. A very large percentage of them are men of college education or technical school education. Most of them have gone through a law school; they are highly educated men; they are, I am happy to say, men of character. It is one of the greatest reasons for pride that we may all have that the Patent Office, the repository of secrets of great value, immense value, is practically above suspicion as to improper dealing. In the four years that I was there as Commissioner my door was open to anybody who chose to come in and complain. I never refused to see a man who called upon me the whole time I was there. I saw everyone alone. I have never had a man come to me and say there had been any improper dealings in the Office. I had letters, a few letters, saying that there was, and I investigated every instance carefully. I never found ground for belief that there was anything of the sort, and in the experience which I have had with the Office, running now over thirty years, only two cases have ever arisen, so far as I have been able to find, where any man was seriously suspected; one man was sent to the penitentiary and the other man died just before the question was brought up for decision. No man who had any disposition to use the Office improperly could live in the atmosphere there. He would be driven out by the other members of the corps. Now, men of such character, men who are serving in the Office as primary examiners—on the average the primary examiners have been in the Office for twenty-five years—devoting all their lives to that work, ought to be paid a salary which will enable them to bring up their families with the same educational advantages that they had themselves; that their place demands of them. Yet this is not possible under present conditions.

And what is true of the primary examiners is also true of the first assistant examiners, and the second assistant examiners. The lower grades of assistant examiners are not so important. Young fellows come in and stay a few years, go through the law school, learn the ropes, and go out to practice. The third and fourth assistant examiners probably get enough, but if a man is willing to stay and make that a life work, becoming, as he does, more valuable every year, because of his knowledge of the arts that he is examining, these men ought to be paid a proper salary, not only as a matter of justice, but as a matter of wisdom.

While there are some men of very fine ability in the Office, it is true that the work suffers seriously because of low salaries. And yet, if you go to Congress, as I went year after year, and ask for an increase of salaries for the primary examiners, and for the assistants, you will meet with this statement: "You are simply trying to get more money for a lot of men who are there now." Well, I was not. I was trying to build up a great Office, or help to. It is a great Office now, but I was trying to improve it, but that is the spirit that Congress displayed. They treated it exactly as if it were any clerkship that was under discussion; and the Office cannot get by it, but men like you can; if you will give the matter sufficient thought, and make up your minds that it is right, and bring influence to bear upon Congress, the matter can be rectified.

The equipment is also insufficient. For example, there is a library of technical books and technical literature. You gentlemen all know that the technical literature of the world is very large, and constantly increasing. Congress allows three thousand dollars a year for the Patent Office to keep up with all the technical literature of all the arts. It ought to be fifty thousand dollars, and it ought to be whatever is necessary beyond that; and yet it was absolutely impossible for me to get one dollar beyond the three thousand dollars a year while I was there. There was a separate set of German patents, two hundred thousand in number, which we wished to bind by classes according to German classification, so that searches might be made through them by the public who are interested. Instead of making a list of all the patents that dealt with electrical motors, for example, and then going through twenty-one hundred volumes to get at them, we wanted to have four or five volumes of electrical motor patents, and so with the other arts. It took me three years to get an appropriation of twenty thousand dollars to bind them, and during that whole time they were tied in bundles, because we did not dare open the bundles for fear numbers would be lost.

There is another matter of great importance. These young men and these older men, the examiners, instead of being obliged to get knowledge from books only, ought to be able to go out and see what the manufacturers are doing in their establishments. They ought to learn the arts as they are actually practiced, so that their judgment would be sound. I sent out as many as I could; I would have sent all of them out from time to time to make investigations if I had been permitted to do so. I could have raised a fund of fifty thousand dollars easily by voluntary subscription from concerns that had applications pending, but sending the young men out by the use of funds raised in that way would have put the Office under obligations, and it would have placed the assistants in positions where they might be open to suspicion and criticism because they had a pleasant trip to Chicago, or St. Louis, or elsewhere; and Mr. Lane, I think properly, said he would not permit it. But here was a fund which I used for that purpose. It was five hundred dollars. There are now four hundred and nineteen in the corps; this sum was about $1.25 apiece for these men. I tried my best to get Mr. Lane to agree to ask Congress for thirty thousand dollars for that purpose, and he said it was absolutely useless; he would not do it; he knew it would not be granted. But an appropriation like that, properly presented to their congressmen, by people who know the importance of it, might easily be secured.

I wish to speak also of the position of the Office in the governmental system. The Patent Office is a bureau of the Interior Department. When I went into office I did not know Secretary Lane. He sent for me shortly before I was appointed and I then met him for the first time. I formed an intimate friendship with him, our relations were most cordial, and I regard him as a great man, and yet, in spite of that, I am obliged to say after a four years' experience as Commissioner that the Office gains nothing by being a bureau of the Interior Department, and that it is seriously handicapped by the connection. It ought to be an independent office, answerable to nobody but the President and Congress, just as the Agricultural Bureau was before the present Department of Agriculture was created. The reason is that it is one of eight different bureaus, unrelated, the work in one not similar to the work in another, the needs of one not similar to the needs of another. But, if an attempt is made to increase the salaries in the Patent Office, or to increase the personnel, immediately the question arises, "What about the Land Office? Won't the Commissioner of Pensions want salaries raised?" Thus a comparison is made between the Patent Office and its needs, and the needs or demands of other offices having no relation to it whatsoever. That comparison the Secretary could not fail to make, no matter how well he might understand the conditions in the offices, because he would arouse jealousy. And if he made up his mind that one office needs better salaries than the others, because it is engaged in a higher class of work, and were to pass that recommendation on to Congress, the Congress itself would make the very same comparison and he would not get anywhere.

If the Office were an independent bureau it could fight its own battles without any such disadvantageous comparisons, and I believe that if that change were made and gentlemen such as you would interest yourselves, and get your local bureaus and your legal departments to interest themselves, in any way you may see fit, in the needs of the Office, we might get the necessary assistance from Congress, and we could build the Office up to the point where it would be, in fact as it should be, the most superb patent office in the world—and its judgments would be far more certain and trustworthy. I think such action would save every year, in the relief of business from the uncertainty of wrongly granted patents, millions of dollars over all that it would cost.

It is constantly said, when the subject of increased appropriations for the Patent Office is raised, that the Office pays its own way. In the last five years it has turned back into the Treasury about one million dollars over the entire appropriation for it, and the building which it occupies was largely built out of surplus which had accumulated in the Treasury from Patent Office fees. But there is no reason why public money should be wasted, no matter where it is drawn from, and the income of the Office is not the measure of its needs, nor of the service it renders to the public. If the Office must be kept self-sustaining, it is an easy matter to increase the fees for patents, and I think that the business interests of the country would stand it. I do not think that is important. The important thing is that the needs of the Office should be intelligently studied by Congress, and when ascertained they should be provided for, without any regard to whether the Office costs one million dollars over what it receives in fees or not.

As I have said, the Office is absolutely unable to help itself. Anybody who as Commissioner starts in to get something for the Office is immediately accused of trying to get something for himself. But intelligent bodies, and influential bodies such as this, can influence and should influence Congress. Here is a field for constructive work, where the results will be to the interest and advantage of all of us. I trust that you will make it a matter of serious thought and concerted action. I thank you very much for the opportunity to bring the subject to your attention.

160 Broadway
New York City

THE PHARMACEUTICAL CHEMIST AND THE SCOPE OF HIS WORK[1]

By Frank O. Taylor

Each of us is prone to magnify the importance of that particular branch of chemistry in which he is actively engaged, so perhaps I may be pardoned for what, to many of you, may seem a biased and erroneous opinion, or evidence of a dense ignorance concerning other fields of chemical endeavor, when I say that I believe no field of chemistry is of greater scope or more varied character than that of pharmaceutical chemistry. And

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[1] Address before the Detroit Section of the American Chemical Society, January 16, 1919.

yet, I hope to give you such reasons for the faith that is in me that, if not fully agreeing, you may at least recognize a measure of justice in this claim and have a better understanding of the reasons back of it.

Pharmacy has to do with the compounding and dispensing of medicinal products and is most frequently thought of in the very narrow sense of mere mixing together of various individual substances, or the extraction of drugs with the proper solvents and dispensing in suitable form for use, the whole process involving only a very moderate degree of chemical knowledge.

It is to this extremely limited scope that the term "pharmaceutical chemistry" is all too frequently confined. I wish to direct your attention, however, to pharmaceutical chemistry in its broadest sense as being the chemistry of medicinal substances, pertaining to their origin, preparation, dispensing, and effects, and the remarkable and varied ramifications of these subdivisions. Far from being a limited and somewhat isolated division of chemical science there is, I believe, no other branch of chemistry that needs for the solution of its diverse problems so many otherwise distantly related portions of chemical knowledge.

The metallurgist, who from the iron ore of northern Michigan produces by reactions in blast furnace and Bessemer converter, iron and steel of varied composition; or from the scarlet cinnabar of southern California wins the mercury for use in physical instruments and amalgams; or from the ores of Missouri obtains in giant smelters the zinc for innumerable industrial uses, may often forget that iron is intimately associated with vital processes as in the red blood corpuscles and plays an important rôle as a curative agent; that the mercury salts are used in combating some of the most deadly and insidious diseases, or as highly effective germicides and antiseptics; that the zinc in one form may be intensely escharotic and in another may be the basis of mild and healing ointments of wide use.

The agricultural chemist, who makes two blades of grass or ears of wheat grow where only one grew before, may also develop digitalis or belladonna or hydrastis or cannabis in greater abundance or of higher potency.

The glass chemist may have his skill taxed to produce ampoules of glass free from excess alkali and easily workable in a blow-pipe flame or free from soluble iron salts that rapidly decompose such substances as hydrogen peroxide or adrenalin.

The coal-tar industry contributes from its cruder products the so-called "dead oils" as a basis for disinfectants of considerable potency; pure cresylic acids, to make antiseptics for surgical or general use; and phenol for use as such or in various compounds such as phenyl salicylate (salol) or the phenolsulfonates of zinc and calcium.

The dye chemist furnishes for medicinal use such things as phenolphthalein, so widely employed as a laxative; phenolsulfonaphthalein as a test for activity of the kidneys; scarlet-red for stimulating healthy and rapid growth of skin over surfaces denuded by burns or other accidents; acriflavine, but recently recommended in solution as a surgical dressing for extensive wounds, to be used in a manner similar to the sodium hypochlorite solution, known as Dakin's Solution, being destructive to bacteria in high dilution and apparently harmless to living tissues; malachite green proposed and widely experimented with for the same purposes; or methylene blue, so extensively used in certain types of urethritis.

Physical chemistry lends its aid in the production of such remedial agents as colloidal solutions of silver, mercury, sulfur, etc., obtained either by direct electrolytic action or in the presence of proteins, and adds to our slowly acquired empirical knowledge of emulsions an understanding of the reasons why, and the conditions under which the best results may be obtained.

Radiochemistry finds its pharmaceutical application in the use of ultra-violet rays for sterilizing water or various solutions, or the employment of radium salts and radioactive solutions in the treatment of various diseases, notably cancer.

The petroleum industry gives to the pharmaceutical chemist solid and liquid petrolatum of varying degrees of purity ranging from cruder petrolatum for veterinary ointments to the most highly purified liquid oil intended for human use as an intestinal lubricant, and paraffin as an ingredient of ointments or base of surgical dressings for application to extensive superficial wounds or burns.

The consideration of oils and fats, both vegetable and animal, applied one way or another to medicinal use, opens up another wide range through which our chemical investigations may lead us, including such things as the familiar castor and cod-liver oils; the intensely active cathartic, croton oil; that relic of old-time pharmacy, citrine ointment, made from lard, nitric acid, and mercury by a process similar to the familiar elaidin test for olive oil; the comparatively little known chaulmoogra oil, which has been used with some measure of success in the treatment of leprosy in India and our own southern states, and was some years ago the subject of extensive chemical investigation; oil of chenopodium or American wormseed, used first as an ordinary anthelmintic and more recently as a highly successful agent in destroying the hookworm, the bane of existence to so many thousands of people in warmer climates; and a great array of other fixed and volatile oils. And these things suggest at once a multitude of gums and resins of more or less interest medicinally, but which we will pass by.

In that limitless domain to which we refer in general as "organic chemistry," including therein those things particularly connected with physiological and biological chemistry, there exists a tremendous number of substances of great interest to the pharmaceutical chemist and there lie before him untouched fields for investigation that almost stagger the imagination. In this category appear substances of natural origin and of synthetic production—the alkaloids of aconite, opium, belladonna, stramonium, ergot, nux vomica; the comparatively innocuous glucosides of cascara or the highly toxic ones from strophanthus and digitalis; the digestive ferments such as pepsin, diastase, pancreatin; the endocrine glands and their derivatives, such as the suprarenal whence comes adrenalin, so marvelously potent in its effects on the blood pressure that one-twentieth of a milligram will show pronounced effects on a man; the thyroid, from which but recently an active iodine-bearing substance has been isolated; the pituitary gland of inestimable value in obstetrical practice and in the treatment of surgical shock; and others still less understood. Then we have that formidable and continually increasing array of synthetic substances, some of which, like acetylsalicylic acid (aspirin), or acetphenetidin (phenacetin), are part of the equipment of almost every household medicine cabinet, and others that you and I never heard of and probably never will.

These brief citations give some idea of the infinite variety of work presented to the chemist who deals with medicinal products but do not give any adequate conception of the great number of unsolved and abstruse problems which still lie before us and to which I will refer presently. You can at least see that the chemical knowledge of the man who has to do with pharmaceutical problems in their fullness must be extensive and that he will certainly have no monotonous existence.

Specific examples of some of the interesting questions that arise, which in some instances are very easy of solution and in other cases give us problems that promise to remain unsolved for an indefinite time in the future, will serve to give a more concrete conception of the requirements of the man who has to do with the development and production of medicinal substances in their widest scope.

Remember also that sometimes the solution of the simplest problems may involve the saving of hundreds or even thousands of dollars to the manufacturer who is producing medicinal substances on a very large scale. A question that may be of no particular moment when the quantity involved is only a few ounces becomes of intensest interest when it may mean the difference between entire loss or the satisfactory distribution of hundreds of pounds or thousands of pints of medicinal compounds of properly high quality.

Take so simple a thing as the almost universally used mild tonic, Beef, Iron, and Wine. Why should continual trouble be experienced with the development of pressure in the bottles, the evolution apparently of carbon dioxide, and continual breaking of packages and consequent loss? "Fermentation, of course," will be your first answer, and the fact that carbon dioxide is evolved seems excellent evidence that this supposition is correct, but fermentation is not likely to occur in a product that contains 18 per cent alcohol, and furthermore, this explanation is impossible when the trouble continues after the product has been thoroughly sterilized in an autoclave and proven sterile by bacteriological tests. The solution when found is very simple and is that due to the action of the actinic rays of light the ferric citrate in the slightly acid solution is reduced to a ferrous salt with liberation of carbon dioxide. If a ferrous salt is originally used, there is no such trouble, and if the ferric salt is employed, the product must be carefully protected from bright light, especially direct sunlight.

Take another case: Why should breakage in ampoules containing cacodylates be very much greater than with any other of the solutions usually prepared in this form? There was no pressure developed and no decomposition of the solutions could be detected. The fact that the breakage occurred largely at the extreme end of the capillary tip, where the ampoule is finally sealed in a blowpipe flame, gave a clue, and the solution of the problem was that traces of the cacodylate solution adhering to the glass were decomposed just at the tip where the flame is used for sealing; the arsenic combined with the glass, forming a ring of arsenical glass, which is entirely different in coefficient of expansion from the remainder of the ampoule and very brittle, hence comparatively slight changes in temperature frequently caused the tip to snap off. On putting into effect means for carefully washing out the tip of the ampoule with distilled water before sealing, the trouble disappeared.

Again, in the manufacture of antiseptic tablets containing corrosive sublimate, some suitable diluent is used that will be completely soluble in water and if possible aid in the solution of the mercuric chloride without reacting with it chemically; for this purpose ammonium chloride or citric acid is commonly used. In some few instances both together have been employed. To prevent the material sticking to the dies on a tablet machine, some lubricant is necessary, and as a comparatively soluble substance, antiseptic in itself, boric acid is often employed in a case of this kind. A quantity of tablets began to evolve considerable amounts of hydrochloric acid gas, sufficient to rapidly attack tinned-iron containers shortly after they were made. It was found that the boric acid used as a lubricant, in the presence of citric acid, reacted upon the ammonium chloride with the evolution of hydrochloric acid. The omission of either the boric or citric acid immediately remedied the trouble.

Another problem that seemed on the face of it so simple that it was really no problem at all was the obtaining of material such as sodium chloride, milk sugar, and alkaloidal salts of such purity that they would give a solution in distilled water *completely free* from insoluble floating particles. I would not go so far as to say that it cannot be done; I think that conditions are conceivable under which it might be accomplished; but I have never seen it done, and upon a commercial scale it has, so far as I know, never been accomplished. You must remember, of course, that the floating particles thus referred to are minute, though easily visible to the naked eye. Some years ago it was desired to prepare C. P. sodium chloride in crystalline form suitable for redissolving in distilled water for intravenous injection. No sodium chloride of sufficient purity was obtainable on the market, and in attempting to make a quantity, it was found that during evaporation of a carefully purified solution, the sodium chloride would attack tinned copper, aluminum, and several grades of special enameled iron to such an extent that the crystals when redissolved in water would show a weighable amount of insoluble matter. The best thing available was one particular grade of resistant enamel, though had it been available on a commercial scale, a pure silver pan would probably have been just as effective.

When it comes to milk sugar or alkaloidal salts, it would seem that all that is necessary is to carefully filter the solution and evaporate, to obtain a product that will redissolve in distilled water without showing any signs of floating particles. When you come, however, to critically examining such solutions, you will discover that the first thing is to get distilled water which under the most rigid tests will show no tiny particles floating in it. So far I have never seen any of the above mentioned substances or distilled water that would show absolutely no signs of tiny floating particles when viewed by the naked eye against a dark background under an electric light. Remember, though, that one liter or even five liters of such a solution will leave no weighable residue on a filter paper; in fact, unless the filter is hard and smooth it is very likely to make the solution worse.

After problems connected with the manufacture are solved, there come up also numerous questions in regard to containers used. For example, glass that contains any trace of alkali soluble in water (and this is the rule rather than the exception) cannot be used in making ampoules containing very delicate substances, for strychnine alkaloid will be precipitated from its salts and a delicate organic preparation like adrenalin will be quite rapidly destroyed. Containers made from coke tin plate cannot be used to hold materials that might slowly attack iron, whereas charcoal tin plate is satisfactory, the difference being that the former has occasional exceedingly minute holes through the tin, while in the latter the tin coating is uniform and unbroken.

When we come to the consideration of the more difficult problems connected with medicinal substances and their development we reach a vast unknown region that has been but most imperfectly explored. We speak glibly oftentimes of relationship between chemical constitution and physiological action, but our actual and definite knowledge of the relationship is at the best extremely limited. We have acquired what seems like a considerable amount of empirical understanding that certain effects are in some way associated with certain combinations of elements or radicals, but we may draw a hasty conclusion merely to find that there are numerous exceptions to our supposed "law." For example, pyrocatechol (ortho-dihydroxy-benzene) is more poisonous than its monomethyl derivative, guaiacol, which in turn is more potent than the dimethyl derivative, veratrol. Apparently we are on the road to prove that alkylation of a hydroxy group in aromatic compounds decreases the toxicity, but presently we find that from resorcinol, which is meta-dihydroxy-benzene, we obtain a dimethyl derivative that is very much more toxic than the parent substance and our interesting theory suffers a rude shock.

If now we cautiously advance along some of the blazed trails in the jungle of organic compounds, hoping fervently that harsh and unrelenting facts will not pounce upon and tear to pieces some of our nicely domesticated pet theories, we discover some rather astonishing things. Take adrenalin, which, as derived from its natural source, is levorotatory. When prepared synthetically it is racemic and much less active than the naturally occurring form. Further investigation shows that the dextrorotatory form is only about one-twelfth as powerful in increasing the blood pressure as the levorotatory form. The peculiar effect of the atropine group of alkaloids in dilating the pupil of the eye is about fifteen times as great in levohyoscyamine as in its stereoisomer. Atropine and cocaine are not widely different chemically, both being derivatives of the nucleus tropine, but while some points of likeness may be found in their physiological action, there are many and pronounced differences, for instance, cocaine is a powerful local anesthetic, while atropine is devoid of this effect. Again, cocaine is methyl-benzoyl-ecgonine and ecgonine has no local anesthetic properties, while neither benzoyl-ecgonine nor ecgonine-methyl ester have more than a very slight effect of this kind. And so we go, gradually accumulating a great store of isolated facts and laboriously fitting them together. We are very like the child with a jig-saw picture puzzle: we fit together a few facts here and a few more over there and occasionally have to take apart some which do not fit perfectly, hoping that some day we will get enough of this picture together to find out what it really looks like.

Turning for a moment to other questions, how shall we determine the medicinal activity of aconite preparations? The drug contains one important and highly toxic alkaloid, aconitine, but also varying amounts of related alkaloids which are not only much less toxic but in some cases actually antagonistic in their action to the aconitine. The aconitine itself is very easily affected by heat, especially in the presence of moisture, and decomposes into various other bodies which possess quite different physiological action. One can obtain concordant results on repeated chemical assays, and find that they fail entirely to agree with the physiological activity as determined by tests on animals. Both the physiological test and the chemical assay seem to be affected by the presence of secondary alkaloids. The present situation as regards the determination of the activity of aconitine preparations is in a very unsatisfactory state.

For over 100 years we have known that the most important alkaloid of opium is morphine, but only within the past 10 years have we come to a definite understanding of its chemical constitution, and though at present morphine is worth $200 per pound, there is no commercially available process for producing it synthetically.

Then there is that class of substances known as enzymes, typified among medicinal agents by pepsin, pancreatin, and diastase. We have for years used these products, particularly pepsin, as an aid to imperfect digestive activity, but do not yet know their exact constitution. Most extensive investigations have been pursued regarding the nature of pepsin, and it has been possible to produce a material under this name of such strength that one part will digest 50,000 parts of coagulated egg albumin, showing a tremendous power of protein digestion. Even here apparently the limit is not reached, and we have not succeeded in isolating any definite substance whose chemical identity we can establish.

Pancreatin is known to be a mixture of several different enzymes, but we are no better acquainted with the constitution of any of them than we are with that of pepsin. Besides these substances there are numerous other enzymes of more or less importance that occur either in vegetable or animal life, and many of which undoubtedly have important rôles to play in connection with vital processes, and as we come to understand them better we may find some of them of great service in dealing with diseases that are now but imperfectly understood.

In investigating enzymes we are struck with the similarity in many respects between catalytic action of these organic substances and those inorganic colloidal solutions of metals that are quite extensively advocated as remedial agents. For instance, both are rendered inactive by boiling and are affected by the reaction of the medium in which they act. The decomposition of hydrogen peroxide by catalase, which reaction may be used for the quantitative determination of this enzyme in the blood or liver, or the similar decomposition by colloidal solution of platinum, both proceed more rapidly in a slightly alkaline medium. The presence of a trace of hydrocyanic acid acts as a distinct poison, and inhibits the activity both of enzymes and colloidal solutions, though there are some exceptions to this rule. What is the chemical reason back of these resemblances between substances that seem otherwise so dissimilar?

One of the scourges of humanity in Eastern Asia, the Philippines, Borneo, Sumatra, and the Straits Settlement has been a disease known as beri-beri. This through long and laborious investigations was found to be connected with the type of food used, being especially prevalent where polished rice was the main article of diet. It was found that a very remarkable and rapid improvement in the condition of those afflicted with this disease could be produced by extracts from the husks and polishings removed from rice. Continued investigation has led to recognition of certain bodies called "vitamines" present not only in the pericarp of rice but also in other grains, in yeast, and in a number of different plants. The name has been given because it is known that these substances are related to the amines and are so intimately associated with vital processes. They are present in only exceedingly minute amounts and yet their effect is very great. To the presence or absence of the same compounds has been traced the disease quite prevalent in our own southern states, known as "pellagra."

We are just beginning to understand that these vitamines, which all these years we have taken into our systems with our daily food, have in some way a tremendous effect upon our health, but how widely they are distributed or what their chemical constitution is and how they may differ as derived from different sources, and why they are so necessary to our healthful existence, still remains almost a complete mystery. Few, if any, greater fields for chemical investigation of medicinal substances exist at present than that of the vitamines.

Some 400 years ago Paracelsus founded what came to be known as the School of Iatrochemistry, on the assumption that the human body was made up of chemical substances and that illness was caused by chemical changes in the organs and juices of the body, and that to cure these ills chemical compounds must be found that would restore the original healthy condition. This fundamental principle was so obscured by fantastic ideas and was carried to such extremes by overzealous followers that it fell into disrepute and finally disappeared entirely, giving place to a chemistry founded on careful experimentation rather than fanciful theories. Strangely enough we are now returning, but under very different auspices, to something of that older idea. We have come to understand better the limitations of our knowledge and the fact that we must not be too eager to draw conclusions from the isolated facts we know, but as in former days the practice of pharmacy and the art of healing did much to develop chemical knowledge, so to-day must chemistry in its fullest application go far toward improving our means of treatment and control over disease.

Parke, Davis and Company
Detroit, Michigan

THE DEOXIDATION OF STEEL BY FERROMANGANESE[1]

By Alex. L. Feild

In spite of the recent advances in the field of high temperature research, the precise nature of the function which ferromanganese performs in steel manufacture is not yet known with certainty. Owing its discovery to accidental circumstances in the early days of the industry, the addition of a manganese ferro-alloy to molten steel for the purposes of producing a sound product, free from undesirable "blowholes," still remains one of the basic practices in modern steel metallurgy. The question of an adequate supply of manganese ore has been one of the most critical problems of the present war, so that, search where he may, the chemist

[1] Presented before the Division of Industrial Chemists and Chemical Engineers at the 56th Meeting of the American Chemical Society, Cleveland, September 10 to 13, 1918.

can with difficulty find a problem possessed of such fascinating possibilities.

Without bringing forward any new experimental data, it is the purpose of this paper to discuss briefly certain of the more striking features of the work of other investigators, and in the light of this to consider the evidence in the case.

It may be said in advance that the statements regarding the action of manganese alloys on molten steel which are found in the various texts are so confusing when taken singly and so contradictory when examined collectively that a detailed discussion is not possible here.

COMMON THEORY REGARDING DEOXIDATION

It has been commonly stated that the reactions between manganese and the metal bath can be represented by the equation

$$FeO + Mn \rightleftharpoons Fe + MnO \qquad (1)$$

and that because the free energy, or affinity, of the oxidation of manganese at this temperature is considerably greater than that of iron, the reaction goes practically to completion from left to right, being assisted by the very low solubility of manganese oxide in molten steel. Furthermore, it is postulated that the manganese oxide thus formed is not as readily acted upon by the carbon contained in the steel, after recarburization, as is ferrous oxide over that temperature interval during which solidification occurs, thereby avoiding the liberation of carbon monoxide, through the mechanism of any such reaction as one of the following:

$$FeO + C \rightleftharpoons Fe + CO \qquad (2)$$

$$FeO + Fe_3C \rightleftharpoons 4Fe + CO \qquad (3)$$

The corresponding reactions with manganese oxide are, according to this view, also opposed to a considerable degree by the ease with which the manganese oxide formed according to Equation 1 rises to the surface of the bath and enters the slag layer.

This supposedly deoxidizing effect on manganese should not be confused with its well-known effect on the sulfur content of the metal bath. The desulfurizing reaction

$$FeS + Mn \rightleftharpoons MnS + Fe \qquad (4)$$

seems to be firmly established experimentally.

It has not, however, been universally customary to ascribe deoxidizing properties to manganese, and the older writers on the subject were inclined to regard it preëminently as a recarburizer, and, of course, at the same time a desulfurizer. In such cases ferrosilicon was named as the principal agent in ridding the bath of oxide and gaseous impurities. Its action on ferrous oxide was represented by the equation

$$2FeO + Si \rightleftharpoons 2Fe + SiO_2. \qquad (5)$$

It has been customary to explain the absence of practice wherein only a single deoxidizer, such as ferrosilicon, is used by calling attention to the fact that such a steel, while possibly free from "blowholes," undergoes cracking in passing between the rolls. Such a phenomenon is explained by assuming that the particles of silica resulting from Reaction 5 are perfectly solid at the rolling temperatures and not sufficiently plastic for the needs of the process, whereas, in case manganese is added at the same time, the manganese oxide formed in accordance with Equation 1 unites with the silica to form a plastic manganese silicate which does not seriously impair the strength of the metal. Then, too, a smaller amount of slag material actually remains in the steel, since the manganese silicate is very fluid at the temperature of the bath and forms liquid globules which coalesce into larger droplets and rise rapidly to the surface into the slag layer.

Finally it has been suggested that the ferro-alloys increase the solubility, as such, of the gases dissolved in the metal, or else form stable compounds with them, suppressing thereby the evolution of gas while solidification takes place.

OXYGEN CONTENT OF STEEL

Oxygen in steel does not refer to the presence of elemental oxygen but to the oxygen content of those oxides which are reduced by the action of hydrogen at a temperature of 850°–950° C. The method by which it is usually determined is that of Ledebur[1] as modified by Cushman.[2] Since it is agreed that at this temperature only the oxides of iron would be reduced, it ought to be possible to detect by analysis whether Reaction 1 actually occurs. Having this in mind, Shimer and Kichline[3] investigated samples of severely "over-oxidized" steel and of the same metal to which ferromanganese and ferrosilicon had been added. They found that the oxygen content of the deoxidized steel was just as high as that of the undeoxidized steel.

The importance of this fact does not seem hitherto to have been given sufficient attention. Until these results of Shimer and Kichline can be satisfactorily explained on grounds other than that the iron oxide content of the two steels is the same, the entire theory outlined above regarding not only the action of ferromanganese, but of ferrosilicon as well, must be regarded as extremely doubtful. So far as I have been able to ascertain, the vital point regarding the entire deoxidation theory has never received any direct experimental proof, and the only existing evidence is directly contradictory.

GAS CONTENT OF SOLID AND LIQUID STEEL

Baraduc-Muller[4] has found that a steel, in the molten condition, 5 min. after being poured from the Bessemer converter, and after additions of ferromanganese had been made, liberated, on cooling under a vacuum, 22.4 times its own volume of gas of the following average composition:

Gases	Per cent by vol.
CO_2	3.6
O_2	0.9
CO	30.5
H_2	52.1
CH_4	0.2
N_2	12.7

Until the surface setting of the steel occurred during the cooling, the percentage of carbon monoxide exceeded that of hydrogen in the issuing gases, reaching a maximum value of 56.8 per cent. Hydrogen liberation predominated at low temperatures.

Whatever, then, the nature of the deoxidation process, it must certainly be connected with the equilibria between these various gases, the carbon of the bath, and the metals and their respective oxides. It is undoubtedly a very complex process, involving a number of reversible gaseous reactions operating over a wide range of temperature. It would be surprising, indeed, if the simple reactions given above could adequately describe the processes occurring in the metal bath.

Goerens and Paquet[5] have recently analyzed cold samples of basic Bessemer and open-hearth steel for the presence of gases. Their observations were as follows:

BASIC BESSEMER	Carbon monoxide Per cent by wt.
Before deoxidation	0.010
After deoxidation	0.059
After rolling	0.025
OPEN-HEARTH	
After melting down	0.0775
Before deoxidation	0.0665
After deoxidation	0.0770
After rolling	0.0550

The changes in the percentages of the other gases were slight, and no particular importance could be attached thereto.

These results indicate that there may be important differences in the exact procedure of the deoxidation process in the case of steel made by the basic Bessemer and open-hearth method,

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[1] *Stahl und Eisen*, **2** (1882), 193–198.

[2] THIS JOURNAL, **3** (1911), 372–4.

[3] *Trans. Am. Inst. Min. Eng.*, **47** (1913), 436–463.

[4] Iron and Steel Inst., *Carnegie Scholarship Memoir*, **6** (1914), 216–40.

[5] *Ferrum*, **12** (1915), 57–64 and 73–81.

and it is certain that the results of the analyses given above are exactly the reverse of what most metallurgists would have expected.

FERROMANGANESE CONSIDERED AS A CARBIDE

The composition of ordinary commercial 80 per cent ferromanganese corresponds very closely to what would be theoretically the case for manganese carbide, Mn_3C. The extreme difficulty of preparing carbon-free manganese by any of the ordinary methods indicates that the affinity of manganese for carbon is very great, and there is no very good reason to suppose that it does not persist in the liquid state. The experience of Wright[1] in attempting to prepare manganese free from carbon points strongly to the conclusion that such a reaction as

$$Mn_3C + FeO \rightleftarrows Fe + 3Mn + CO \qquad (6)$$

would not be expected to proceed from left to right appreciably during the deoxidation process.

This viewpoint appears even more reasonable when we examine the extensive researches of Boylston[2] who found that ferromanganese when added without ferrosilicon decreases the number of blowholes in a steel ingot to no appreciable extent, whereas ferrosilicon alone produced a very marked effect.

Whatever may be the exact nature of the process, it seems that manganese carbide, *i. e.*, ferromanganese, does not take a prominent part, due probably to the difficulty with which it parts with its carbon content.

QUESTION OF THE IDENTITY OF FERROUS OXIDE

It has been assumed in the foregoing discussion that the compound ferrous oxide exists as such in equilibrium with iron. However, there is conclusive proof[3] given by Sosman that at ordinary temperatures the compound usually referred to as ferrous oxide is in reality a mixture of iron (or iron carbide) with magnetite or with some oxide intermediate in composition between FeO and Fe_3O_4. It goes without saying that in this light our interpretation of the well-known equilibria between iron and its oxides, carbon and its oxides as described by Bauer and Glaessner[1] and Preuner,[2] as well as the equilibrium between iron and its oxides, hydrogen and water vapor as reported by Chaudron[3] must be revised in order to accord with the facts.

CONCLUSIONS

It is obvious then that our present knowledge regarding the true function of ferromanganese, ferrosilicon, and the other deoxidizers is insufficient to explain the observed facts. Furthermore, the current theory has been shown to be contradicted each time by those few experimental facts which investigators have been able to gather.

In such a situation it is difficult to refrain from offering a new theory regarding the process, since it would be hard to devise any reasonable kind of hypothesis which would not fit experience at least as well as our present one.

It can be predicted, however, with considerable certainty, that this most important industrial problem, and by this I would include the general question of substitutes, will be solved not by postulates and theories, but by painstaking measurements of equilibria at high temperatures, and by the accumulation of a more adequate supply of data concerning the specific heats and stability relations of the elements and compounds concerned.

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[1] Iron and Steel Inst., *Carnegie Scholarship Memoir*, 1 (1909), 143–60.

[2] *Ibid.*, 7 (1916), 102–171.

[3] *J. Wash. Acad. Sci.*, 7 (1917), 55–72.

[1] *Z. phys. Chem.*, 43 (1903), 354.

[2] *Ibid.*, 47 (1904), 385–417.

[3] *Compt. Rend.*, 159 (1914), 237–39.

FOREIGN INDUSTRIAL NEWS

By A. McMillan, 24 Westend Park St., Glasgow, Scotland

A NEW TEXTILE FIBER

According to the *Z. angew. Chem.* for June 14, 1918, a manufacturing company in Chemnitz has succeeded in producing a useful substitute for cotton and jute from pine tree needles. These needles are treated chemically and then prepared by machinery. The finished material can be spun on any cotton spinning machine. The spun yarn breaks less easily than paper yarn and is also more elastic. This company also manufactures a very serviceable watertight and pliable substitute for shoe leather.

ANNEALING OF GLASS

The *Proc. Tokyo Physic. Soc.* for September 1918 contains an interesting paper on the annealing of glass. In the first case a newly drawn glass fiber is heated slowly in an electric furnace and its length observed. It was found that it increases as the temperature rises but at a temperature about 400° C. it begins to contract and at 500° C. it becomes elastic. Again, when a short cylinder of the glass between crossed Nicols is heated, the interference rings show little change until a temperature of 400° C. is reached. They then widen and disappear at about 500° C. Lastly, when the glass is slowly heated or cooled, the curve of temperature change shows that over the plastic range of temperature there are absorption and liberation of heat, proving that some change of state of a constituent of the glass takes place at that temperature. The first two effects vary with the nature of the glass and are not exhibited by annealed specimens. The third effect is found in both annealed and unannealed glass.

TETRAPHOSPHATE

The new Italian fertilizer known as tetraphosphate is produced by mixing natural phosphate rock powder with 6 per cent of a powder containing equal parts of carbonates of calcium, sodium, and magnesium with a little sodium sulfate. According to a report in the *Chem. Trade J.*, 63 (1918), 406, the mixture is roasted several hours at 600° to 800° C. in special furnaces. After treatment with cold phosphoric acid the product is reduced to required strength by mixing with dry earth and sand. In tests by the Italian commission, the new fertilizer has been applied to wheat, rice, potatoes, oats, beans, and clover, and the results are said to have equaled or surpassed those from superphosphate. It was found to have special advantages in freedom from acidity, causticity, and deterioration, while it can be made from phosphate rock of much lower than usual percentage.

JUTE SUBSTITUTE

Paper yarn, says *Nature* quoting from the *Z. angew. Chem.* for August 2, 1918, of from 1 to 5 mm. diameter is in use in Germany as a substitute for jute, while paper yarn from parchment paper is woven into belts for driving light machinery. The yarn, when treated with 1 per cent solution of tannin, is rendered soft and flexible to the touch and its strength increased by 49 per cent. The addition of gelatin gives a hard, firm touch to the yarn and an increased strength of 25 per cent. When wet its strength is reduced by only 15 per cent. Neutralized aluminum acetate added to the tannin gives the yarn a strong, elastic touch and increases its strength 44 per cent. The average water content of the yarn is about 38 per cent.

COMBINED RAIL AND ROAD TRUCKS

A scheme of which particulars are issued by Mr. T. Bennett, St. Albans, England, contemplates the use of combined rail and road trucks. He would collect and deliver goods in containers or "loaders" provided with wheels which would permit them to be hauled over ordinary roads. On arriving at a station by road these loaders would be taken to a bank or platform raised to such a height as to be level with the flat tops of wagons or "chassis" running on the railway track. On this bank each of their wheels would be placed on "laterals" furnished with four small wheels or rollers, and then they would be moved upon the chassis and secured in place. On reaching its destination the train would be taken alongside a similar bank, and the loaders would be pulled off the chassis and removed from the laterals to be subsequently delivered by road. Mr. Bennett claims advantages for his plan, including saving of shunting and of handling goods, but whether or not these could be realized in practice, the permissible height of the loads he could carry would be less than at present owing to the limitations used vertically on the landing gauge by overbridges and tunnels, and probably also the gross weight of the trains would be greater in relation to the paying load.

TWO-CYCLE PARAFFIN OIL ENGINE

In accordance with the requirements of the government department by which it was ordered, a 50-h. p., 2-cycle internal combustion engine made at Manchester by the Record Engineering Company was recently subjected to an endurance test of five days. During that time, says the *Times Engineering Supplement*, it ran continuously night and day at full load under paraffin oil, without attention or adjustment of any kind beyond the usual filling up of the fuel tanks and the supply of lubricating oil. None of the plugs was changed, and when the engine which is of the V type, with 4 cylinders and 2 cranks, giving 4 impulses per revolution, was dismantled at the end of the test, it is stated that no appreciable signs of wear were visible and that the cylinders were practically free from deposit. In the design adopted by the company, the two-to-one gears with the camshafts, cams, tappets, and poppets found in the ordinary 4-cycle engine, are eliminated and are replaced by a simple piston valve generally for each pair of cylinders worked by an eccentric on the main shaft. As a valve merely controls the distribution of the gaseous fuel to the pump cylinders it is not subject to a pressure exceeding a few pounds per sq. in. nor to the high temperatures of the working cylinders. The crank case is used only as a reservoir for lubricating oil, and not for handling the fuel mixture, so that the deposition of carbon and soot on the bearings is avoided, as also is the mixture of fuel oil with the lubricating oil. As the cylinder heads are made loose, both piston tops and combustion chambers can be cleaned without dismantling.

PRESENT STATE OF RUSSIAN INDUSTRY

According to the *Z. angew. Chem.* the latest information concerning the industries of Russia is of a pessimistic description. The *Sarja Rossijii* affirms the complete destruction of the starch industry in the government department of Rjasan. The factories which were in part destroyed remain idle, and the peasants have taken possession of the stocks of materials. All industry in the Urals is carried on under great difficulties. In the district of Bogeslewisk the monthly output of iron ore has dropped from 4017 to 3570 tons. In the Hylyswenski district, where 21,000 workmen were employed, not more than 4000 are now working. At Tschusowslosawod, an iron-producing district, all the furnaces are out of blast. In Werchniisetzke likewise all the factories are idle. State help has been given to the industries of the Urals without, however, any visible effect in improving the situation.

ELECTRIC MELTING OF BRASS

In the *J. du Four Electrique* some notes on electric brass furnaces are given, the advantages of which are summarized as follows: Hand labor a minimum, because the capacity can be raised to 3-4 tons and the application of the heat does not involve manual labor; no crucible and maintenance running costs, except the renewal of electrodes which requires determination by long experience; loss in zinc probably little different from that in small covered crucibles as the furnace is a closed one; insignificant oxidation; no dross requiring treatment. It is convenient that if combustibles are replaced by electric power, the furnace will require about the same number of kilowatts per 100 kg. of metal turned out as the kilograms of coke consumed by the ordinary furnace for the same output. Theoretically, the electric furnace is the ideal but its practical development is contingent on a sufficiently low price of energy.

AUSTRALIAN EUCALYPTUS OIL TRADE

Considering the great variety of the Australian eucalyptus trees, it is not astonishing, says the *Oil and Color Trade J.*, that there are many kinds of eucalyptus oils which already find varied applications but which certainly could be more fully utilized. In 1917 Australia exported to the United States $24,145 and to Canada $6,120 worth of such oils, the figures for 1916 being, respectively, $12,170 and $700, and the production and trade in these oils could be largely increased, no doubt. It is said that of the 300 specimens of eucalyptus not more than 15 can be utilized for their oils but that estimate may be too low. So far, the oils of 160 specimens of eucalyptus have been examined for their products. The leaf oil of *Eucalyptus macarthuri*, a tree of very rapid growth, contains 60 per cent of geraniol and geranyl acetate, valuable in the preparation of perfumes. *Eucalyptus citriodora* and *staigeriana* yield substitutes for lemon oil only in small percentages but yet in industrially paying quantities. Eucalyptus trees flourish also in other countries into which they have been introduced, notably in swampy districts, and the oil industry is, therefore, not of interest to Australia alone.

PAPER-MAKING MATERIALS

As the results of the tests made by the Imperial Institute, London, on South African grasses as paper-making materials, a grass called "thatching grass" or "Dek grass" is said to have proved a promising material. It gives a satisfactory yield of long-fibered pulp of good quality suitable, in the unbleached state, for the manufacture of brown paper or, after bleaching, for the manufacture of fairly good cream-colored or white paper. According to report, however, the export of South African grass would scarcely be possible, as it would probably have the same value as Algerian exports, *i. e.*, $12 to $14 in the United Kingdom in normal times. It may be possible, however, to convert the grass into "half-stuff" or paper in South Africa for export.

TREATMENT OF PEAT

In the improved Ekenberg process of treating peat, says the *Chem. Trade J.*, 63 (1918), 406, as being tested at Chateauneuf, France, the raw material is first compressed to reduce the water from 90 to 60 per cent. It is then subjected to the action of superheated steam at 160° C. for 25 min. and is afterwards again compressed or at once dried in special chambers or in the open air. Turbon, as the product is called, still retains 20 to 25 per cent moisture. It yields 61 per cent volatile matter and its calorific value is 10 per cent higher than that for ordinary peat. It is recommended for direct firing where ammonia can be recovered and especially for power gas for internal combustion engines.

FUTURE OF GERMAN IRON INDUSTRY

In the *Berliner Tageblatt* of October 19, 1918, Dr. F. Pinner discusses the relation which Alsace-Lorraine has hitherto borne to German industries and the effects which might result from the loss of these provinces. The point which is most worthy of notice is that the cession of Alsace-Lorraine would mean the cutting off of sources of raw materials with which Germany is not too well supplied. Manufacturing industries can be set up anywhere but the loss of raw material is irreparable. Three words suffice to describe what Alsace-Lorraine means to Germany—iron ore, potash, petroleum. While the loss of Alsace petroleum deprives Germany of 42 per cent of her total petroleum production and while, with the cession of Alsace, Germany loses also her world monopoly of potash, the question of the iron production affects her most of all. It cannot be doubted that the enormous rise in the German iron trade was due to the acquisition of the Lorraine mines in 1871. From a few million tons, the production has risen to 19 million tons and Germany has outstripped all other countries in the iron trade except the United States. In 1913, out of a total ore production of 35.9 million tons for the whole of Germany, Lorraine and Luxemburg contributed 28.5 million tons, and of a total iron content of 10.54 million tons, Lorraine and Luxemburg represented 8.15 million tons, or 77 per cent. When Lorraine is lost, Germany will have to go abroad for iron ore. She may get supplies from Sweden, Spain, Russia, and even from France, but the ore basis of the German iron industry will be so restricted that its maintenance and continuation will, in the opinion of the *British Board of Trade Journal*, become a matter of question.

LIQUID CRYSTALS

Evidence has been accumulating during the last few decades that there is justification for speaking of liquid crystals. The term, says *Engineering*, certainly does not appear to accord with the time-honored distinction of the three states of aggregation—solid, liquid, and gaseous—and, besides, bodies like pitch and wax, which gradually soften and have no definite melting point do not exactly fit into this classification. But crystals, substances which in solidifying assume definite though varying shapes with straight edges and plane surfaces and which are characterized by optical and other physical properties not found in either amorphous or in liquid substances, seem to be solids *par excellence*, and it is difficult to imagine such substances to partake simultaneously of the characteristic properties of solids and of liquids. Yet we know now a large number of crystal-like bodies of more or less constant shapes which unite when they meet, forming twins which may split again or be distorted into spirals and which not only possess some of the specific properties of crystals to an enhanced degree but which actually display certain optical properties for which scientists have so far been looking in vain in solid crystals. These liquid crystals may drift in a trough across which wires are stretched and float right through the wires to close up again and to reassume their original shape and properties, very much as the proverbial ghosts float through walls and are left unharmed by bullets and sword thrusts. These liquid crystals are real though they are best studied under the microscope or polariscope.

POTASH DISCOVERY IN SICILY

An important message has been received from Rome in connection with the supply of potash. It is stated that in the province of Cattaniselta in the Island of Sicily, immense deposits of potash have been discovered and the preliminary investigations are said to establish these as the richest in the world. The exploitation of these deposits, if the first reports receive the confirmation hoped for, would make it quite unnecessary to have recourse to the German supplies.

MINERAL WEALTH OF THE UKRAINE

The important bearing on the food supply of artificial manures containing phosphorus, says a writer in an Austrian contemporary, makes the mineral wealth of the Ukraine of some account at the present time. Phosphorite is found in many districts, in some parts in great abundance, and large quantities can even be obtained from open-cast workings at low cost. Before the war Austria obtained phosphorite in considerable quantity in ground condition. The mineral on analysis is found to contain a high percentage of calcium phosphate and no less than 27.5 per cent of phosphoric acid. In order to produce the best results, the deposits would require to be worked systematically and not by the antiquated methods which were formerly employed.

IRON TRADE IN SWEDEN

According to official statistics for 1917 now available, the financial result of the Swedish iron trade is, on the whole, satisfactory on account of the higher rate of prices although the production in several cases is smaller than during the preceding year. The production of iron ore amounted to an aggregate of 6,217,172 tons against 6,986,298 tons for the preceding year, but the value rose from $17,250,000 in 1916 to $21,000,000 in 1917. The production in pig iron showed an increase, the total for last year being 828,969 tons as against 732,734 tons in 1916. The value of the pig iron rose even more than the production, being nearly doubled. The figures for 1917 were $58,450,000 as against $28,675,000 for 1916. The production of bar iron and steel receded some 29,000 tons; band, nail, and other fine iron, 1400 tons; and solid tube material, some 8,700 tons. The total aggregate value of production of Swedish iron and steel work during 1917 is put at $95,425,000 against $60,975,000 for the preceding year.

SEA-ANIMAL OIL

In 1915 and 1916 a large number of samples of sea leopard oil, seal oil, and penguin oil, prepared at Adélie Land during the Australasian-Antarctic Expedition in 1912–13, were forwarded to the Imperial Institute, London, for examination. The results found were interesting. An eminent authority on the subject considers that there is an assured future for penguin, seal, and whale industries in Antarctic regions, but that any plans for developing them would require to be very carefully considered before action is taken, and several years preliminary work might be required before such industries could be started on proper lines. It would also, in the opinion of this authority, be necessary to introduce some form of protection for these animals.

AGRICULTURAL IMPLEMENTS

Before the war Austria-Hungary supplied Rumania with 40 per cent of her requirements in agricultural implements. This supply has ceased since 1914 and, as Rumania had a large stock of agricultural machines sufficient to last her up to the present time, only various spare parts had to be furnished. The supply is now giving out and Rumania offers an excellent market for agricultural implements, especially for tractors and fodder-cutters which are little known in that country. Again, Russia used 6,000,000 scythes annually, of which one-half were for Siberia. About 4,500,000 were imported and those which came from Austria were most in demand because of light weight and cheapness. At present, there are hardly any scythes in Russia as the native industry is at a standstill and import is closed. Before the war the price for scythes ranged from one to two roubles ($0.76 to $1.50). Here, again, a good market could be found, as large numbers of scythes will soon be required.

LARGEST OIL-TANK STEAMER

A notable addition to the oil-tank fleet of the Eagle Oil Transport Company was successfully launched on December 3, 1918, from a yard at Wallsend-on-Tyne, England. The vessel, San Florentino, is constructed to carry a total weight of 18,000 tons and is the largest oil-tanker afloat. She is 546 ft. in length, 68 ft. 7 in. in width, with a moulded depth of $42^{1}/_{4}$ ft. The hull of the ship is divided into 13 oil-tight compartments and fitted with $4^{1}/_{2}$ miles of oil pipes. The system of piping is so arranged that the pumps can discharge the vessel by grouping together a given number of oil-holds in every conceivable way. Four different grades of oil can be either loaded or discharged simultaneously without getting mixed. The engines consist of a set of compound geared turbines.

SOCIALIZATION OF GERMAN INDUSTRIES

The socialization of certain German industries, notably mining, the steel and iron, and textile industries, for which the extreme wing clamors, says *Engineer*, is not likely to materialize at present. The government does not find the time convenient and fears that German industry cannot stand any further disturbance lest its foundation should be entirely shaken. The Bavarian shares the view of the Berlin government and deems it inopportune to transfer the industries to the state at a time when it is entirely exhausted. In the meantime, industrial circles are alarmed at the prospects of immediate higher taxation.

MAGNETIC PROPERTIES OF IRON ALLOYS

The results of some investigations by Gumlich are quoted in *Elektrotechnik und Maschinenbau* for September 1, 1918, on the magnetic properties and resistance of iron alloys. The materials used in the investigation consisted of pure electrolytic iron and four series of alloys with increasing carbon content (up to 1.8 per cent). The density and specific resistance vary with the percentage of added material. According to the results given, it would seem that the addition of silicon or aluminum do not improve to any extent the magnetic properties of iron, and any benefit derived by their presence is due to secondary causes as oxygen is removed and the effect of the carbon somewhat neutralized. Eddy-current losses are reduced by the addition of silicon and aluminum. Results are also given showing the effect of the added materials on the coercive force and from them it would appear that good permanent magnets may be produced by adding tungsten, chromium, or molybdenum.

LUBRICANTS

Various forms of lubricating oils and greases are described in a list issued by Messrs. Sterns, Limited, of 16 Finsbury Square, London, E. C. 2. Of solidified lubricants it is said that their use secures economy and cleanliness, reduces friction to a minimum, and diminishes the risk of fire, owing to the non-combustibility of the solid matter. Oil leads to dirtiness and waste through dripping from bearings, upsetting, and leakage of containing vessels, and overfilling of lubricators, and is very susceptible to changes of temperature by which solid lubricants are not affected. The employment of the latter is stated to mean, in almost every instance, simpler construction of machinery and economy of lubricating material, 11 to 16 lbs. of solid being equal to 1 cwt. of liquid oil. The list also refers to lubricating oils for machinery, oil and gas engines, steam engine cylinders, motor cars, and marine purposes, to belting bricks for leather, balata and textile belts, to pastes for piston rods, and for cog wheels and driving chains, to soluble cutting oil, and to various other oil preparations.

THE GERMAN DYE INDUSTRY

The *Morning Post*, London, states that German chemical and dye works are being rapidly readapted to the manufacture of peace-time products, and the future is regarded as by no means unpromising. Manufacturers realize that they will not be able to export for some time to come 70 to 75 per cent of their total output, but they are already resuming the production of dyes from coal tar, and the manufacture of pharmaceutical products has been carried on at full pressure during the war. A German contemporary points out that the demand for pharmaceutical products, which is imperative everywhere, can be at once met, while the stocks of dyes must be greatly reduced both in Germany and throughout the world. Manufacturers rely on the excellence of the German products being able to open up doors at present closed to them. They further state that they do not underestimate the efforts which have been made in England and the United States to create a chemical industry of their own, particularly for dye manufacture, and are conscious of the fact that considerable success has attended their efforts, especially in the case of the United States, but consider that serious importance should not be attached to these foreign efforts as German industry has the great advantage of long experience. Germany admits that she may feel the competition in the simpler products but not in the more complicated products which are a specialty of German manufacture. In this latter department, she fears greater competition from the Swiss, who have made great advances and succeeded in gaining entry into a market which was formerly held by German industry.

SOURCES OF ALCOHOL

Particulars are given in *Z. angew. Chem.* for September 13, 1918, regarding a process at present largely used in Germany, for the manufacture of alcohol from sawdust, chips, and shavings. It is estimated that from a half to one million tons of such waste material are produced annually in that country. Four distilleries are at present being run on these raw materials, each having fifty-one autoclaves of 1000 kg. capacity. The cost of production is said to be high when the residue cannot be used as cattle fodder or the waste liquors used for other products. The material is heated in an autoclave with either sulfurous or hydrochloric acid for from 20 to 40 min. at 265° C. at a pressure of 7 atmospheres, then quickly drawn off, neutralized, and run into the fermenting vat, beer yeast being used.

GERMAN SYNTHETIC RUBBER

The full story of the efforts of German chemists and engineers, says *Chem. Trade J.*, 64 (1919), 26, to produce substitute materials during the four years' war scarcity will be an interesting one. Synthetic rubber, one of the most important of these substances, was more or less successfully made by Frantz Hoffmann, as early as 1912, but his experiments were partially abandoned on account of the lower cost of the natural rubber at the time. With the stimulation of the industry by the war demand, the process was improved and such difficulties as ready oxidation in the air and imperfect vulcanization were overcome. At a recent meeting of the Bunsen Society, in Berlin, it was stated that, in spite of the trouble in obtaining new materials, the production of methyl rubber had reached 165 tons per month, and a large factory at Leverkusen has a capacity of 2,000 tons yearly. The hard rubber, claimed to be a 20 per cent better electrical insulator than the natural rubber, was used for the accumulator boxes on submarines. The soft rubber, less easy to develop, is leather-like and inelastic at ordinary temperatures, but is given increased elasticity in manufactured articles by the addition of dimethylaniline and toluidine. It now serves for tires for heavy road motors.

SCIENTIFIC SOCIETIES

THE NAVAL CONSULTING BOARD OF THE UNITED STATES

The Naval Consulting Board of the United States was called into existence through the Secretary of the Navy in September 1915 to establish a link between the Navy of the United States and civilian technologists, inventors, and scientists. It was the first one of the so-called civilian war boards which were created later on, after our country had entered the war, and consists of 22 members.

The American Chemical Society was one of the several technical and scientific organizations which were asked to designate their two representatives.

It soon became obvious, and more so after the United States entered the war, that it was undesirable, except in special cases and to a limited extent, to divulge the program or the detailed activites of this Board. Several of its members became also active members in other war boards created later on. Others were just as active as members of the National Research Council, so that the activities of the Board, in many cases, ramified through and intertwined with those of the many departments of the Council of National Defense. Frequent cases occurred where the collaboration of members of the American Chemical Society and of the other engineering or scientific societies of the United States was requested, to serve as aids or advisers in the many committees or subcommittees. The enthusiasm with which, in each case, such coöperation was furnished, without desire or hope of reward, and frequently at the sacrifice of personal interests or private occupations, was one of the many symptoms of that great wave of patriotism and devotion to a great cause, which swept over our whole country. Several officers of the Army, as well as of the Navy, were adjoined to the Board and furnished most valuable collaboration.

The Naval Consulting Board has not yet been dissolved, and some of its committees are still actively busy with some of its unfinished problems. Some of these subjects are of such a delicate nature that, even to-day, it would be reckless to speak about them, especially in view of the fact that conditions of peace, or future disarmament are far from settled at this moment. But a provisional statement, not involving details, seems desirable, especially in view of the fact that the members of the American Chemical Society are entitled to know something about a Board with which many of them have so heartily coöperated.

The present brief statement seems particularly justified in view of the publication of the Annual Report for 1918 of the Secretary of the Navy. A copy of this report can be obtained from the Government Printing Office, Washington, D. C. It is one of the most interesting documents ever published by the United States Government. The information contained therein should reassure anybody who has ever doubted the organization and efficiency of our Navy, and ought to be a source of pride to every American citizen. The volume comprises 380 pages and covers a great diversity of subjects. In it, occasional references are made to the Naval Consulting Board, of which we beg to quote as follows:

> * * * * The work of the Naval Consulting Board has increased greatly in both importance and volume during the past years. In addition to work especially adapted to naval uses, the members have assisted in almost every field of research, and Mr. Thomas A. Edison, president of the Board, is still devoting his entire time and his laboratory to war work.
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> More than 110,000 ideas, inventions, and devices have been considered by this Board and the department, either separately or conjointly; there have been 4,200 interviews on inventions and upwards of 700 models have been examined. In addition, at the Chicago branch office 2,300 interviews have been granted and 2,500 communications investigated. This gives an idea of the volume of this work and the care that is taken in considering and investigating every invention or suggestion that gives promise of being of any value.
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> A very complete bulletin on the enemy submarine has been prepared, after the most careful study and compilation of all data, and was issued under date of May 1, 1918. This gave all but the most confidential information on the subject and has served as a guide to the country-at-large in making suggestions. A second bulletin on the subject of aeronautics, composed of articles prepared by a number of the best authorities on the subject, was issued on August 1, 1918. This pamphlet included a carefully prepared bibliography that is complete and exhaustive and gives the student in aviation a most valuable fund of information.
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> During the past year the war committee of the technical societies, composed of representatives of the great engineering societies, associated themselves with the Naval Consulting Board, and their chairman, Mr. David W. Brunton, was elected a member of the Board.
>
> With the erection and occupancy of the new Navy building space was provided for the resident member and a staff of examiners directly connected with the office of the Secretary of the Navy, and all the files and correspondence have been concentrated in one location, bringing the examination and consideration of ideas and inventions in closer touch with the Navy Department. The office of the Board is in charge of Mr. Brunton, who is also a member of the advisory committee to the inventions section of the General Staff of the Army, and there is established a close working basis of handling all ideas presented to the attention of the proper authorities with the least effort and by a very direct route. This has not only resulted in increased efficiency, but in a reduction of expenditure of funds and time consumed.
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> Among the subjects studied by the board were: aeronautics, propellers for airplanes, stabilizing and controlling devices, and an instruction machine that has been adopted for use; optical glass, improvements in quality and production; ordnance equipment; anti-submarine defensive devices and offensive instruments; internal combustion engines, refined hydrocarbon fuel for airplane engines giving greater efficiency and longer life to machines, and method sof coal combustion looking to higher economy.
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> When the department called for classes of electrical and mechanical engineers from which to select a number of commissioned officers for active service, the Board was a material assistance in its prompt and efficient handling of the situation, and as a result the Navy was enabled to obtain an excellent selection of able and experienced officers.
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> The officers and members of this Board give their time and talents, many of them to the exclusion of their private business, from a desire to render a patriotic and disinterested service. They are entitled not only to the thanks of the department, but of the large number of other agencies and individuals that have benefited by their counsel and advice. * * * *
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> * * * * The department has been keenly appreciative of the necessity of employing every effort to develop devices with which to combat the enemy's submarine operations. Advices and suggestions were freely requested and carefully considered by the department, the Naval Consulting Board, the National Research Council, the various bureaus and departments, the General Board of the Navy, and other boards in Washington.
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> In order to coördinate the efforts in this matter the department appointed a special board of officers to have complete charge of carrying out experiments on anti-submarine devices. The General Electric Company, the Western Electric Company, and the Submarine Signal Company patriotically offered every assistance in this work, and with a fine spirit of coöperation have rendered valuable service.
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> An experimental station was established at New London, Conn., under the supervision of the special board, and many scientists of unusual attainments were assembled there in connection with the experiments and development of devices for detecting submarines.
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> The naval activities at New London, Conn., embrace also a station for assembling and installing various devices developed and training the personnel for the efficient employment of such devices afloat. The results achieved by these methods have been most gratifying; and the operation of vessels fitted with these devices, both abroad and in home waters, has had a marked effect in restricting submarine operations.

* * * * The most striking engineering accomplishment during the year was the completion of the electrically propelled battleship New Mexico, the results of whose trials confirm the judgment of the department in adopting this type of machinery for the battle cruisers, and mark an engineering advance which will affect battleship construction the world over. Electric propulsion had its inception in the Navy, having first been applied in the collier *Jupiter*, where its superior advantages were so clearly demonstrated that the Bureau of Steam Engineering recommended it for adoption in the New Mexico and subsequent battleships, and still later in the higher-powered battle cruisers. It will be recalled that this decision of the Department led to the bitterest criticism not only from engineers pecuniarily interested in other types of machinery but also from others eminent in their profession who had no pecuniary interest, but who feared that we were embarking upon an experiment that would be fraught with national calamity. Despite the criticism of these eminent engineers, the decision of the Navy Department, supported by the judgment of the best electrical engineers in the country, was followed in the full conviction that no mistake was being made.

The wisdom of this decision has been amply vindicated by the performance of the *New Mexico*, which has been tested in every way, her trials including many more than those specified in the contract. She has failed in none of them; the operation of her machinery has been highly satisfactory in every respect; and today, in this unique vessel the United States Navy has a battleship which has no peer in the world's navies, not only for economic propulsion and less liability to serious derangement, but for her military superiority in greater maneuvering power and increased underwater protection. As so often before, American ingenuity and inventive skill now lead the world in the propelling machinery of battleships. To the vision and the wisdom of Rear Admiral Griffin, Chief of the Bureau of Steam Engineering, and his able assistants, who gave approval to this new method of propulsion, the idea first fully tried in the *Jupiter* upon plans of Mr. W. L. R. Emmett, a naval academy graduate and member of the Naval Consulting Board, the world owes this successful revolution in the propulsion of the biggest fighting ships. This is one of the biggest achievements of this generation in engineering. * * * *

After complete order shall have been restored to the present disturbed conditions of the world, and when non-observance of secrecy seems no longer dangerous, your representatives on this Board may be in a condition to give further information about many interesting details of the subjects which were undertaken.

W. R. Whitney and L. H. Baekeland
Members, Naval Consulting Board of the United States

Washington, D. C.
February 1, 1919

SPRING MEETING AMERICAN CHEMICAL SOCIETY

The Spring Meeting of the American Chemical Society will be held in Buffalo, N. Y., April 8 to 11, 1919. The secretary of the local committee, Mr. E. K. Strachan, writes as follows concerning plans for the meeting:

The local committee desires to make the "Victory Meeting" one of the most famous that the American Chemical Society has ever held.

The headquarters of the meeting will be in Hotel Statler, which is centrally located and furnishes ample space for the general meeting, smoker, and banquet. This hotel can furnish lodging for several hundred members and in addition, we have three or four other excellent hotels within a few blocks.

Scientific meetings will be held at the Technical High School which is but a short distance from the hotel. Mr. Childs, the principal of the school, is working enthusiastically to provide us with the very best accommodations. The school building is of the very finest kind of modern construction and equipment. It is large enough so that the meetings will in no way interfere with the classes. The school is equipped to furnish a cafeteria or buffet luncheon at noon and will do so on the days we hold sectional meetings there. It has every convenience in the way of intercommunication, telephones, projection lanterns, coat rooms, etc.

The public meeting will be held at the Hutchinson High School, which is another building of fine modern construction and equipment. This is located nearer to the residential section and has been chosen because we are making every effort to draw a large local audience. The Engineering Society of Buffalo, an organization of about one thousand members, is being interested in this event as well as in the meeting as a whole.

The smoker will be conducted under the able direction of Mr. Lidbury. Those who know him need no further guarantee that this affair will be a great success.

Our program includes an all-day trip to Niagara Falls. During the morning, the party will visit the various power plants and will be shown the location of the chemical industries. Luncheon will be provided at the Chamber of Commerce, and a comprehensive exhibit of Niagara Falls products will be shown, as well as many moving pictures. Those who prefer to do so may visit the Falls and take the scenic railroad trips down the Gorge and to the various places in the neighborhood. There will also be industrial excursions in Buffalo. Some of the largest chemical and other industries in the country will open their plants to the visitors.

We are in hope of arranging with Dr. Parsons for a general symposium on Tuesday afternoon, which will deal with some prominent, vital subjects, preferably chemical reconstruction problems. During the entire meeting we aim to place the chemist before the public in the most favorable way possible.

We should strike while the iron is hot and while the war is still a live subject. We hope to give the local public and the people of the country-at-large a new knowledge of the chemist and his works.

A delightful program for the visiting ladies is in course of preparation and we feel that all of them who come will enjoy a memorable occasion.

The following committee has charge of the local arrangements:

C. G. Derick, National Aniline and Chemical Company, Buffalo
Chairman, Executive Committee; Chairman, Program Committee
J. F. Schoellkopf, Jr., 1429 Marine Bank Building, Buffalo
Treasurer, Executive Committee; Chairman, Finance Committee
E. K. Strachan, National Aniline and Chemical Company, Buffalo
Secretary, Executive Committee; Chairman, Registration and Information Committee
D. H. Childs, Technical High School, Buffalo
Chairman, Committee on Arrangements for Meetings
W. H. Watkins, National Aniline and Chemical Company, Buffalo
Chairman, Excursions Committee; Chairman, Exhibits Committee
A. M. Williamson, International Acheson Graphite Co., Niagara Falls
Chairman, Niagara Falls Excursions Committee
John A. Miller, 45 Lewis Block, Buffalo
Chairman, Hotels Committee
F. A. Lidbury, Oldbury Electrochemical Company, Niagara Falls
Chairman, Smoker Committee
Walter Wallace, Oldbury Electrochemical Company, Niagara Falls
Chairman, Banquet Committee
F. S. Low, Niagara Alkali Company, Niagara Falls
Chairman, Niagara Falls Exhibits Committee
H. B. Saunders, Chamber of Commerce, Buffalo
Chairman, Publicity Committee
D. C. Howard, 160 Park St., Buffalo
Chairman, Clubs Committee
D. W. Sowers, Sowers Manufacturing Company, Buffalo
Chairman, Invitations Committee
Mrs. J. F. Schoellkopf, Jr.
Chairman, Ladies' Entertainment Committee
G. P. Fuller, National Electrolytic Company, Niagara Falls
L. E. Chamberlain, Hoppenstedt Laboratories, Buffalo
H. S. Lichtenberg, Richardson, Beebe Co., North Aurora
A. C. Parsons, Lackawanna Steel Co., Buffalo
R. E. Fowler, National Electrolytic Co., Niagara Falls
A. P. Sy, University of Buffaol
E. B. Stevens, Wood Products Co., Buffalo
A. H. Hooker, Hooker Electrochemical Co., Niagara Falls
F. J. Tone, 328 Buffalo Ave., Niagara Falls
L. E. Saunders, 123 Buffalo Ave., Niagara Falls

CALENDAR OF MEETINGS

American Drug Manufacturers Association—Eighth Annual Meeting, Waldorf-Astoria, New York City, March 24 to 27, 1919.

American Electrochemical Society—Thirty-fifth General Meeting, Rumford Hall, Chemists' Club, New York City, April 3 to 5, 1919.

American Chemical Society—Spring Meeting, Hotel Statler, Buffalo, N. Y., April 8 to 11, 1919.

National Foreign Trade Council—Sixth National Foreign Trade Convention, Congress Hotel, Chicago, Ill., April 24 to 26, 1919.

NOTES AND CORRESPONDENCE

REPORT OF THE PATENT COMMITTEE TO THE NATIONAL RESEARCH COUNCIL[1]

The Commissioner of Patents in 1917, with the approval of the Secretary of the Interior, requested the National Research Council to appoint a committee to investigate the Patent Office and patent system, with a view to increasing their effectiveness, and to consider what might be done to make the Patent Office more of a national institution and more vitally useful to the industrial life of the country.

Mr. Thomas Ewing, who is a member of your Patent Committee, was the Commissioner of Patents who took that action.

The National Research Council, complying with the request, appointed a Patent Committee, consisting of: Dr. William F. Durand, *Chairman;* Drs. L. H. Baekeland and M. I. Pupin, scientists and inventors; Drs. R. A. Millikan and S. W. Stratton, scientists; Dr. Reid Hunt, physician; and Messrs. Frederick P. Fish, Thomas Ewing, and Edwin J. Prindle, patent lawyers. On the departure of Dr. Durand for Europe, Dr. Baekeland was appointed acting chairman of the Committee.

Your Committee has approached its work in the belief that the American patent system has been one of the most potent factors in the development of the prosperity of our country. Americans, being descendants of the European races, are not naturally more inventive than are Europeans, but under the incentives of the American patent system they have produced many more inventions and been able to pay higher wages and live on a better scale than Europeans.

American inventions have played a vital part in the war. There is hardly any implement or explosive that our Army and Navy has used which is not more or less the result of American invention. The Patent Office is keeping secret and withholding for publication many inventions made since the beginning of the war and which are useful in war. After the war, it will be imperative that American inventors continuously improve American products and the manufacture of them, and make basically new inventions to meet and keep ahead of the strenuous efforts which Germany and other nations will make to attain supremacy by these methods.

Your Committee has, therefore, carefully investigated the Patent Office and the patent system, with a view to increasing their effectiveness, and, based on its investigation and the experience of its members, makes the following recommendations:

The Committee has concluded to propose a program consisting of but four features, because it believes those features are of such fundamental importance that their enactment into law would strengthen the entire system and directly and indirectly establish it upon a new and much more advantageous footing before Congress and the public; and because with a simple program, presenting comparatively little opportunity for difference of opinion as to the desirability of the changes proposed, there would be a unanimity of opinion in support of it which could not be obtained if the program were more extended.

A SINGLE COURT OF PATENT APPEALS

The first proposal which your Committee recommends is the establishment of a single Court of Patent Appeals that will have jurisdiction of appeals in patent cases from all the United States District Courts throughout the country, in place of the nine independent Circuit Courts of Appeals in which appellate jurisdiction is now vested.

Until 1891 the Supreme Court of the United States was the appellate court in patent cases for all the lower courts. At that time the right of appeal to the Supreme Court in patent cases was taken away, and that court now hears patent cases only upon writs of *certiorari*, which are never granted unless certain very unusual conditions exist.

The existence of nine appellate courts of concurrent jurisdiction in patent cases works serious hardships. While, theoretically, the law is the same in all of these courts, there has been an irresistible tendency to drift apart in the application of the law. It has even happened in a substantial number of cases that two of the appellate courts have taken a different view of one and the same patent. It is, of course, very important that the questions which always exist as to the validity and scope of a patent should be settled once and for all at the earliest possible date in the life of the patent, for, as a practical matter, seventeen years (the term of a patent) is a comparatively short time in which to reduce the invention to a thoroughly commercial form to prepare for its manufacture, and to introduce it upon the market, and it is usually necessary to determine the validity and scope of the patent in order to determine the amount of money which it is safe to invest in exploiting the invention. As things are now, whichever party succeeds in the first suit that is tried on the patent, the other party is very likely to feel that in a second trial before another court he might have better luck. He, therefore, is inclined to insist upon a second litigation. Meantime, he advertises that the questions involved were not settled in the first case. This means uncertainty on the part of the owners of the patent as to their rights and uncertainty on the part of the public as to its rights to use the invention or to determine what it must avoid in working in the same field—a really intolerable situation.

Moreover, we shall never have a uniform and definite patent law, consistently applied, until we have a single Court of Patent Appeals independent of local sentiment, realizing a responsibility to fix the principles of the law and enforcing an harmonious application of these principles on the lower courts. It would be of the utmost value to those in the United States who are engaged in industry if the present confused condition could be corrected and a single tribunal devote itself to crystallizing the fundamentals of the patent law and to educating the courts throughout the land to uniformity in applying these principles in special cases.

Attached hereto is a copy of a bill[1] for the establishment of such a court, which has been advocated for many years by the American Bar Association, and is No. 5011, of the House of Representatives, 65th Congress, 1st Session. It provides for a court of seven members, which would sit in Washington, with a Chief Justice appointed for life by the President. The appointment of the Chief Justice for life is in order that there may be an element of continuity in the court. The other judges are to be selected by the Chief Justice of the United States Supreme Court from the various district and circuit judges throughout the land, and each is to sit on the Court of Patent Appeals for a period of six years, or longer, if reappointed.

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[1] Submitted December 13, 1918. Approved January 14, 1919.

[1] The proposed bills are not printed with this report.

There are many advantages in this plan. Among them are the following:

The judges would not be men who were appointed as judges primarily to deal with patent matters. There could be no charge that special interests had a hand in their selection or that they were chosen to promote special views as to the patent law and its application. They would be men who had been primarily selected by the President as fit to be federal judges in the localities where they live. Federal judges are men of a high type, and many of them are broad-minded men, much respected in the communities which they serve. They would take up the work of the Court of Patent Appeals with a breadth coming from the performance of their general duties of judges in their own circuits or districts and would, therefore, escape the narrowing which so often comes from continuous work in a specialized field.

The Chief Justice of the United States Supreme Court would select from the district and circuit judges throughout the land men whom he thought most competent to serve for a term on the Court of Patent Appeals. He would seldom, if ever, take more than one judge at a time from any one circuit. The Court, therefore, would be made up of men who were primarily judges and who would be recognized as bringing to the Court of Patent Appeals the instincts and feelings, on the subject of the interpretation of the patent law, of the courts and of the people in the communities in which they live.

Undoubtedly many of them would be on the appellate court for one term only and after that they would go back to their circuits or district with a training as patent judges such as could be obtained only by sitting for a period of years in such an appellate court. They would not only be qualified as patent judges, but they would reflect the atmosphere of the appellate court and cause that atmosphere to pervade their own neighborhood. They would thereafter undoubtedly be selected to hear patent cases in the lower courts in preference to judges who had not had training in the Court of Patent Appeals. The courts throughout the country would, in time, become educated to the high and definite standards established by the Court of Patent Appeals, not only by study of the decisions of that court, but by the presence in the lower courts of men who had had this special training in the upper court.

It is of the utmost importance that these judges in the Court of Patent Appeals should be well paid. Otherwise they might not be willing to break up their homes and go to Washington for a limited term. We think that their salaries should be higher than those of the judges of any court in the United States except the United States Supreme Court.

The increased expense due to such a court would be small. The aggregate amount of work to be done by the judges of the United States courts as a whole would not be changed to any substantial extent, because all appeals must now be heard by the present courts and judges and, if there were a single Court of Patent Appeals, the Court of Appeal in the nine circuits would be relieved of just as many appeals as were heard by it. The judges in some of the circuits are much overworked, but this is not true of many of the circuits. The Chief Justice of the United States Supreme Court, in selecting these judges, could, if he chose, take into account the work of the different circuits and whether one circuit or another could best spare a judge.

As the law now stands, judges from one circuit may be called upon, and not infrequently are called upon, to go into other circuits which are short-handed. In this way, any undue pressure upon the judges in any particular circuit, by reason of the loss of any single judge who went to the Court of Patent Appeals for six years, could be relieved.

Moreover, it is no hardship to increase the number of judges where necessary. The whole judicial system of the United States is said not to cost as much as it does to run one first-class battleship, and the addition of a few judges would be a negligible burden upon the Treasury.

A further advantage of a single Court of Patent Appeals would be that it would see clearly where there were defects in the statute and in the conditions and practice in the Patent Office, and could speak with authority on all matters which affect the theory and practical working of the patent system.

THE PATENT OFFICE A SEPARATE INSTITUTION AND INDEPENDENT OF THE DEPARTMENT OF THE INTERIOR

The second proposal which your Committee recommends is that the Patent Office be made a separate institution, independent of the Interior or any other department.

The Patent Office was originally in the State Department, but, on the formation of the Interior Department in 1849, it was made a bureau of that department and has been so ever since.

The only matters connected with the Patent Office with which the Secretary of the Interior has anything to do are the following: The Secretary of the Interior must submit to Congress all estimates for appropriations. All appointments, excepting those of the Commissioner, two Assistant Commissioners, and five Examiners-in-Chief, are made by the Secretary but only on the recommendation of the Commissioner. The eight places named are presidential appointments, but the Secretary makes recommendations to the President. All matters of disbarment or reinstatement after disbarment of attorneys are passed upon finally by the Secretary. All matters of discipline are under the Secretary's jurisdiction. The Secretary of the Interior must approve all changes in the Rules of Practice of the Patent Office, but he cannot compel the Commissioner to make any change whatsoever.

No appeal lies to the Secretary from any decisions of the Commissioner, either in matters of merit or practice. All such matters, as far as they are reviewable, rest with the courts of the District of Columbia.

The Secretary of the Interior no longer signs the patents, and has no jurisdiction to grant or refuse them.

Thus, it will be seen that the Secretary of the Interior is not required to know anything about patents or patent law. He is not selected because of any qualifications for the granting of patents or supervision over the Patent Office. The Secretary of the Interior has less influence over the Patent Office than over any other bureau of the Interior Department, because there are appeals to him from all the other bureaus. Nor is the Patent Office related to any other bureau of the Interior Department.

The Secretary of the Interior has recently moved out of the Patent Office building, thus severing physical contact with the Patent Office, which is but a type of the lack of mental contact between the office of the Secretary of the Interior and the Patent Office.

The experience of many commissioners over a period of several generations has shown that, no matter how pleasant the personal relations may be, the Commissioner of Patents cannot expect any real benefit to the Patent Office to flow from its connection with the Interior Department. There is nothing in common between the interests of the Interior Department and those of the Patent Office, and, consequently, nothing to produce any advantage from the amalgamation of the Patent Office with the Interior Department.

Your Committee believes that to make the Patent Office an independent bureau would greatly increase the respect of the public and Congress and the courts for it, and would make it easier to procure enlarged appropriations and better salaries than under present conditions.

As to appropriations, under present conditions the demands of the Patent Office for equipment, personnel, and salaries are necessarily subjected to comparison both by the Secretary of the Interior and by Congress with those of several other unrelated bureaus, each pressing its own demands and criticizing any apparent preference. In the opinion of your Committee, this operates as a severe handicap. In estimating the needs of the Patent Office there should be no discussion of the demands, for example, of the Pension Office or the General Land Office. As an independent institution, the needs of the Patent Office would be judged on their necessity and the appropriations be determined by consideration of general policy.

As to personnel: the enhanced dignity and independence of the Patent Office would render all positions of importance in it more attractive, and particularly would make it easier to secure and retain in office men of the necessary qualifications to fill the difficult office of Commissioner.

A copy of a proposed bill for making the Patent Office an independent bureau is annexed to this report and its enactment is recommended by your Committee.

INCREASE IN FORCE AND SALARIES OF THE PATENT OFFICE

The third proposal which your Committee recommends is a substantial increase in the force and salaries of the Patent Office. The patents granted by the United States Patent Office are of less average probable validity than formerly, because the number of applications for patent and the field of search are constantly increasing, while the examining force for many years has been insufficiently large and has not been increased proportionately. The inducements are so unattractive that 25 per cent of the examining force has resigned within the past three years. Your Committee finds that the Patent Office is suffering both from lack of examiners and from inadequate compensation.

The salaries of the Patent Office examiners have been increased only 10 per cent since they were fixed in 1848, when they were approximately the same as those of members of Congress. At the time the salaries of the Examiners-in-Chief were fixed, they were the same as those of Federal District Judges. During the past 70 years, the compensation for technical service in almost all other directions has been increased very largely. Congress, in creating new positions, is willing to pay technical men salaries more nearly approximating the usual compensation of such men in private service, but, having started a position at a given salary, is very loath to increase the salary. A Principal Examiner, to pass the entrance examination for the Patent Office, must himself have an education equivalent to that of a college graduate, and yet his salary is so low ($2,700 a year) that it is practically impossible for him to give his own sons a college education.

Your Committee believes that salaries should be paid to the examiners proportionate to those paid for equally high technical work in other departments created recently; such, for example, as are paid in the Army and Navy and in the office of the Attorney General. The examiners are passing upon questions often involving millions of dollars, and they cannot be at their best in this vitally important work unless their salaries are large enough for them to live comfortably and without strain. The chances of making mistakes in the granting of patents are great enough even under the most favorable circumstances, and they should not be increased by compelling the examiners to work for inadequate salaries. The inducements should be such as to present compensation and a career which would attract and hold men of the highest ability. The payment of adequate salaries and the creation of provisions tending to hold out attractive prospects to the examiners would also tend to raise the dignity of the Patent Office and to increase its standing in the estimation of the public and of Congress and the courts, and so would tend to enhance the value to the public of the patent system.

The work of the Patent Office has grown so much more rapidly than has the examining force that the examination to determine whether or not the invention claimed in an application for patent is novel is imperatively restricted to the field of search where it is most likely that the invention will be found. Many patents are granted which would not be granted if the examiner had time to make a thorough search. One of the Assistant Commissioners of Patents is compelled to devote a large amount of his time to speeding the work of the examiners in order to prevent further falling behind in the number of unexamined cases. Money is often invested on the strength of patents, only to find later that the patent is upset in the courts, because the Patent Office search did not go far enough to discover that the invention had already been disclosed in some earlier patent or publication. The granting of a patent with invalid claims or claims which are too broad or which are nebulous is a menace to the art to which it relates, and until such a patent has been adjudicated and its effect judicially determined, it tends to prevent manufacturing and commerce in that art. Such a patent may, in this way, cost the public many millions of dollars beside the cost of establishing its invalidity or its true breadth or meaning by litigation, and the prevention of the granting of such patents by any reasonable increase in the examining force of the Patent Office would, in many cases, be a very large saving. The inducement to inventors and investors in patents is consequently lessened, the standing of patents before the courts and the public is impaired, and the production of inventions discouraged.

Your Committee accordingly recommends a substantial increase in the salaries of the Patent Office officials, and in the number and salaries of the Examiners, as provided in the draft of a bill for that purpose which is attached hereto.

While your Committee believes the Patent Office so fully justifies its existence that it would be an exceedingly profitable investment, even though all expenses were paid from the public income, the Patent Office has always been self-supporting and the increase in salaries and examining force which the Committee recommends can easily be entirely taken care of by the Patent Office income, if necessary.

COMPENSATION FOR INFRINGEMENT OF PATENTS

While an injunction can ordinarily be obtained against an infringer in a case where a patent is adjudged valid, except where it would interfere with government work, a money recovery had not heretofore been generally possible except under most favorable circumstances. In a case where it cannot be said that the entire salability of the article depends upon the invention, it has been necessary to show just how much of the price of the article is attributable to the invention, and as it is ordinarily impossible to make such a separation, and as most patent cases are ones in which it cannot be said that the whole salability of the article depended upon the invention, it has resulted that recovery of money is seldom obtained in a patent suit.

Recently there have been two or three decisions in which the courts have taken a more liberal attitude, holding in effect that where an invention has been used by an infringer a reasonable royalty may be awarded to the patentee based on a mere estimation or on opinion evidence, even though no exact computation can be made. This is analogous to the attitude of the courts in personal injury cases and is entirely just and reasonable. While, as stated, there have been two or three decisions to this effect, it may take a generation to induce United States courts generally to adopt this position, if at all, and the Committee therefore proposes that the law be amended to provide, that as damages to the complainant, the court, on due proceedings had, may adjudge and decree to the owner payment of a reasonable royalty or other form of general damages. Such an amendment has been provided in the attached bill amending Section 4921, the Revised Statutes of the United States, and reading as follows:

> If proof is not offered or, in the absence of adequate proof of the amount that should be awarded as damages or profits, the

court, on due proceedings had, may adjudge and decree to the owner payment of a reasonable royalty or other form of general damages.

This proposed amendment would enable the patentee in all suits where the patent has been found valid and infringed to recover at least a reasonable royalty, and would provide a money recovery in the great majority of patent suits where no recovery would otherwise be possible. The Committee believes that the comparative certainty of financial return would answer one of the most common and strongest reproaches against the patent system, namely, that a patent does not ordinarily pay the inventor any money, and it believes that the incentive to invent would accordingly be greatly increased.

There are some cases in which it seems to many who are familiar with such matters as though the courts were inclined to go to the other extreme and award damages out of all proportion. Where a complainant has shown that profits have been made by the use of an article patented as an entirety, the infringer is liable for all the profits unless he can show—and the burden of proof is on him to show—that a portion of them is a result of some other invention used by him. If the infringer cannot show what proportion of the profits is due to such other invention, then all his profits must go to the complainant. Any rule by which the entire profits are given to a patentee in the absence of proof that they are all due to the invention of the patent sued upon, is unfortunate and sometimes very unjust. The proposed amendment to the statute would permit a court under these circumstances to do substantial justice even though it could not be mathematically exact. In other words, the amendment to the statute would enable a court to avoid awarding either too much or too little.

CONCLUSION

Your Committee, believing that the American patent system is vitally useful in our system of Government, therefore recommends that the reforms herein discussed be enacted into law.

Your Committee also recommends that this report be approved by the National Research Council and that the Committee be continued for the purpose of arousing and coördinating interest in and support for the necessary legislation of various national societies, manufacturing interests, bar associations, and other elements of the public.

L. H. Baekeland, *Acting Chairman*
William F. Durand, *Chairman* (absent in France)
M. I. Pupin
R. A. Millikan
S. W. Stratton (see reservation below)
Reid Hunt
Frederick P. Fish (see reservation below)
Thomas Ewing

Approved: James T. Newton, Commissioner of Patents

RESERVATION BY DR. STRATTON

I agree to the terms of the report with the exception of that portion which refers to the establishment of the Patent Office as a separate government institution. It is not quite clear in my own mind that this would be the best thing to do since in general it is best for all government establishments to be represented in the Cabinet.

(Signed) S. W. Stratton

RESERVATION BY MR. FISH

I entirely concur in the substance of the conclusions set out in the above report.

I think, however, that the words "if proof is not offered, or" in that portion of proposed Section 4921 which deals with damages and profits, should be omitted so that the sentence in which those words appear should read:

> In the absence of adequate proof of the amount that should be awarded as damages or profits, the Court, on due proceedings had, may adjudge and decree to the owner payment of a reasonable royalty or other form of general damages.

I do not think that a statute should directly or indirectly contemplate a condition in litigation in which "proof is not offered." I believe that the clause which I suggest would accomplish the desired purpose and that the courts in applying the clause would be embarrassed if the phrase "if proof is not offered" were in the statute.

I think also that general damages by way of a reasonable royalty or otherwise should not be awarded unless it appeared that actual damages or actual profits due to the unlawful use of the invention could not be determined and that there should not be any language in the statute which implied that no effort be made to determine such actual damages and profits.

(Signed) Frederick P. Fish

PROMPT ACTION BY CHEMISTS NEEDED ON PROHIBITION LEGISLATION

Editor of the Journal of Industrial and Engineering Chemistry:

The passage of the prohibition amendment relegated to the category of history most discussions of morals connected with this subject. With this passage, however, two kinds of chemical responsibility present themselves. We should concern ourselves at once with both of them. They deal with effective enforcement of the will of the people and neither of them can be shouldered by any one but the chemist.

The first responsibility is that of watchful care over both national and state legislation so that those in charge of this legislation may be supplied with honest information which will prevent its lack bringing unnecessary hardship upon chemistry and those utilizing it, by unwise restrictions.

The other responsibility is involved in the importance of every chemist eliminating, as rapidly as may be, the need for un-denatured alcohol in every laboratory and manufacturing operation.

Most legislative bodies now in session have under consideration bills to put into effective operation prohibition of the manufacture, sale, possession, and use of intoxicants or intoxicating liquors. Many of these bills will be enacted. These bills are necessarily drastic in character because of the evasions which they anticipate. The legislative committees in charge of these bills are usually selected because of their interest in prohibition rather than with a view to protecting the toes of science or industry. If the present Ohio legislature is any guide, however, these committees are unusual in their willingness to listen to citation of unnecessary interference with scientific work or with the manufacture of non-beverage products. This does not mean that the committees are in any sense lax. They are not. They do not hesitate to ask a petitioner, for instance, if he is "aware that Ohio is dry;" and to tell him that "this bill is going to keep it dry."

This latter is the keynote or purpose of the legislation. The Ohio Senate Bill No. 4 and House Bill No. 24, for instance, are entitled "A bill to prohibit the liquor traffic and to provide for the enforcement of such prohibition." This bill is an emergency act made necessary to provide enforcement of the prohibition amendment to the Constitution of Ohio adopted by vote of the people November 5, 1918, which becomes effective May 27, 1919. The Ohio bill is very carefully drawn, very simple, and comparatively brief. It makes a very obvious effort to protect non-beverage industry.

The authors of the bill, however, did not have chemical knowledge or advice, and were unacquainted with the extent to which ethyl alcohol is used in chemical and other scientific work. For this reason, careful inspection of such bills by chemists and chemical manufacturers is imperative to avoid irritation in the working of the acts. There are, doubtless, those who would not be displeased at irritating operation of these acts but those of us who must act as the sand in the gears do not care to officiate if we can retrieve ourselves in advance. Whether prohibition has come to stay or not is a matter for debate or watchful waiting. Chemistry must not suffer in the interim or it is our fault as chemists.

Taking an active part personally in hearings on the Ohio bill makes it simple as an illustration in point to furnish warnings. The bill, as presented, contained the following undesirable features:

1—No provision was made for the manufacture, sale, and use of "unmedicated" ethyl alcohol for scientific or any other purpose. In fact, ethyl alcohol as such ceased to exist in Ohio under the provisions of the bill. Provision was made for "medicated" alcohol only.

2—No machinery was provided for the dispensing of alcohol in any form "medicated" or "unmedicated" to scientific workers and students in chemical and other scientific laboratories in universities or other organizations.

3—The possession of "any equipment for the manufacture of intoxicating liquor" was forbidden, except as therein provided. Provision was then made for the non-interference of the act with a number of items omitting, however, the ordinary distillation equipment of scientific laboratories or of dye, chemical, and other manufacturing plants not engaged in beverage preparation.

4—The words "medicated alcohol" were used and not clearly coördinated with "denatured alcohol."

5—Alcohol manufacture in Ohio was permitted by the bill but it could actually not be manufactured in the state for the reason that it was "unlawful * * * to possess any equipment for the manufacture of intoxicating liquors * * * * except as herein provided." The provision was subsequently made for permission to manufacture but no provision was made for "possession" of the "unlawful" equipment.

6—General permission only and no explicit permission was given for the use of alcohol in the manufacture of "chemicals, dyes, and other preparations" of a non-beverage character. Since the administration of the act is to repose in a commissioner, all ostensible latitude allowed him in general terms obviously gives him power to tighten the operation of the act but it is doubtful whether he is thereby empowered to do things not specifically permitted, especially in an act whose effects rest on permissions and omissions.

7—The fixing of affidavits to record books and labels of containers provided for retail drug dispensing becomes highly cumbersome in a scientific or educational laboratory and the required variation was not provided.

8—The bond assessed for "other persons" not physicians and druggists, which would include chemists and other scientific workers in educational and plant laboratories, because of no other provision for them, was excessive. It was aimed to cover irresponsible users. It was not less than $2000 and not more than $3000, as against the manufacturer of patent medicines, toilet articles, flavoring extracts of $100 to $5000, and physicians $200 to $1000. It should be omitted entirely or applied to directors of laboratories and then on at least as favorable terms as the petty manufacturer or physician.

It is important that those in charge of such bills as we are discussing should scrutinize carefully every effort at amendment to avoid accidental or deliberate interference with its effectiveness. It is evident, however, that any assistance which chemists and others can give to those in charge of such bills will tend to prevent unnecessary irritation in chemical and manufacturing work, thus helping ourselves and assisting in an honest effectiveness of the legislation.

The second point emphasized herein is at once a responsibility and an opportunity. We, as chemists, should eliminate all unnecessary use of un-denatured ethyl alcohol. We have for years been pleading with the internal revenue bureau for a sane policy in the denaturing of alcohol for use in the arts because of the otherwise dead load thrown upon certain manufactures. There are probably few, if any, chemical manufactures which really require un-denatured alcohol or alcohol usable as a beverage or which cannot find a suitable denaturant. We now have the need for reducing cumbersome tape in the hands of "prohibition commissioners" in the operation of our laboratories. This is the need and our responsibility. The opportunity lies in the field for research thus opened up in analytical and other forms of chemistry for the replacement of ethyl alcohol by a denatured product or a substitute. If our chemists attack the question of the influence of these other mixtures and substances on our chemical methods and operations, we will likely eliminate entirely the need for un-denatured ethyl alcohol and our laboratories will be thus largely removed from the field of law enforcement tedium. To a lesser extent these ideas also apply in industry. The ultimate beneficial influence of irritating or adverse legislation on chemical manufactures is well known and was ably handled but recently by Dr. T. B. Wagner in THIS JOURNAL, **6** (1914), 71.

Without wishing to enter the prohibition controversy as such, it is the opinion of the writer that in the interest of the public welfare, chemists everywhere should interest themselves in making these prohibitory laws cover such frightful intoxicants as ether which the unscrupulous will pander in the absence of alcohol. Bills should cover all "liquid intoxicants" at least. The tendency is to mention alcoholics solely.

If we are concerned about the opportunities of the chemist for public service this whole matter is a case where we must help ourselves and where we will be rendering useful service.

JAMES R. WITHROW

LABORATORY OF INDUSTRIAL CHEMISTRY
THE OHIO STATE UNIVERSITY
COLUMBUS, OHIO
February 12, 1919

AMERICAN DYES INSTITUTE

At the meeting on February 7, 1919, of the American Dyes Institute, the association formed recently by the combination of the American Dyestuff Manufacturers Association and the American Dyes Institute, announcement was made of the election and appointment of the following officers and committees:

President: W. H. Cottingham, The Sherwin-Williams Company.

Secretary-Treasurer: H. E. Danner.

Counsel: Arthur J. Eddy.

Executive Committee: L. A. Ault, The Ault & Wiborg Company; J. Merritt Matthews, The Grasselli Chemical Company; Frank Hemingway, Frank Hemingway, Inc.; August Merz, The Heller & Merz Company; R. C. Jeffcott, Marden, Orth & Hastings Corporation; W. T. Miller, National Aniline & Chemical Company; M. R. Poucher, E. I. du Pont de Nemours & Company.

Board of Governors: C. S. Althouse, The Althouse Chemical Co., Reading, Pa.; B. R. Armour, American Aniline Products, Inc., New York City; L. A. Ault, The Ault & Wiborg Co., Cincinnati, Ohio; R. P. Dicks, Dicks, David Co., Inc., New York City; B. P. Donnelly, Holland Aniline Co., Holland, Mich.; Frank Hemingway, Frank Hemingway, Inc., New York City; R. C. Jeffcott, Marden, Orth & Hastings Corp., New York City; R. W. Kemp, Holliday-Kemp Co., New York City; G. A. Martin, The Sherwin-Williams Co., Cleveland, Ohio; J. M. Matthews, The Grasselli Chemical Co., Cleveland, Ohio; August Merz, The Heller & Merz Co., Newark, N. J.; W. T. Miller, National Aniline & Chemical Co., Inc., New York City; J. T. Pardee, Dow Chemical Company, Inc., Midland, Mich.; E. W. Pierce, Zobel Color Works, Inc., New York City; M. R. Poucher, E. I. du Pont de Nemours & Co., Wilmington, Del.; G. S. Whaley, John Campbell & Co., New York City; S. W. Wilder, Merrimac Chemical Co., Boston, Mass.

CHEMICAL WARFARE SERVICE ASSISTS IN SECURING EMPLOYMENT

An invitation is extended to civilian chemists of the Ordnance and Quartermaster Departments to make use of the services of the Chemical Warfare Service for securing employment.

MARSTON T. BOGERT
Colonel, C. W. S., U. S. A.
Chief, Relations Section

WASHINGTON, D. C.
January 24, 1919

BACK TO THE COLLEGES AND UNIVERSITIES

Editor of the Journal of Industrial and Engineering Chemistry:

Your educational editorial in the February number of THIS JOURNAL leads me to think that you may be interested in the following estimation of the value to the chemical industries of men having had graduate training as compared with those having only the bachelor's training in chemistry.

Some four years ago I attempted to arrive at an estimate of the value to the industries of men with graduate chemical training. The estimates were made in various terms by men experienced in the chemical industries. Consideration was limited to chemically trained men of equal age but of less than 45 years, as too few men over 45 have had graduate work to permit a fair comparison. In considering a man's value to an industry, responsibility for the advances of that industry, and the occupation of a position of influence in the industry were given the highest consideration.

The results finally arrived at were: that a man with one year of graduate training is of approximately double the value of a man having only the bachelor's degree, that with two years of graduate training he is three times as valuable, and that with the doctor's degree, ordinarily representing three years graduate training, he is on an average five times as valuable as the man with only the bachelor's degree.

Also it was the general opinion that for a given age the salaries paid, beyond that necessary for a bare living (about $800 a year then), were not far from those indicated in the ratio just mentioned. RALPH H. MCKEE

DEPARTMENT OF CHEMICAL ENGINEERING
COLUMBIA UNIVERSITY, NEW YORK CITY
February 10, 1919

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Editor of the Journal of Industrial and Engineering Chemistry:

Permit me to congratulate you on the editorial "Back to the Colleges and Universities." It would be a most unfortunate proceeding for the younger chemists, and one which would later on cause them much regret, were they to leave their studies unfinished and seek employment in the industries at this time. The chemical industries are in a most unsettled state, and while the readjustment is going on the supply of junior chemists ought not to be increased by those who, because of their anxiety to secure an income, are willing to forego the completion of their interrupted education; if these young men will turn back to their old colleges and universities, complete their studies, and leave these institutions with an appropriate degree bearing testimony to their attainments they will the better be able to meet the demands of the chemical industries and in that way contribute their share toward our goal—the building up of a great chemical industry in this country. T. B. WAGNER

CORN PRODUCT REFINING COMPANY
17 BATTERY PLACE, NEW YORK CITY
February 13, 1919

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Editor of the Journal of Industrial and Engineering Chemistry:

I want to thank you for your editorial "Back to the Colleges and Universities." It is very timely and much needed. I know of no profession where there is so much room at the top as in that of chemistry, and I know of no other way of getting there than the way you so well suggest in your editorial. Any young man who has started in chemistry, and has been called away to serve his country, and who can in any way get the opportunity now to go on with his work, would make the mistake of his life if he doesn't do what is necessary to make that push for the top. I hope that many young men will take advantage of the splendid advice you have given.

GENERAL CHEMICAL COMPANY WM. H. NICHOLS
NEW YORK CITY
February 11, 1919

Editor of the Journal of Industrial and Engineering Chemistry:

I have read your editorial in the February issue of the JOURNAL, and wish to say that I heartily agree with you in your advice to young chemists to return to the colleges and universities, in case they are unable to find industrial employment. I am convinced that our country needs completely trained chemists and chemical engineers, and that the future for men of this profession is most promising. At this juncture many of them will find difficulty in securing employment. In my opinion the demand for thoroughly trained research chemists in this country will grow very rapidly, and no better advice can be given to the large number of men with the bachelor's or chemical engineer's degree than to utilize their time in further education, or even in teaching, until suitable opportunities come to them for other employment. I cannot emphasize too strongly the importance of a certain amount of teaching experience for chemists, as many of the successful men not only in this, but in other professions, have been greatly benefited by such experience. For those who have been successfully trained to enter the teaching profession, and are suited for such work, there is no nobler work, and we must not forget that unless our teaching force is well manned, the chemical industries of this country will not be able to secure men of sufficient training to carry on the great work which the future of this country demands.

CHEMICAL DEPARTMENT CHAS. L. REESE
E. I. DU PONT DE NEMOURS & COMPANY
WILMINGTON, DELAWARE
February 11, 1919

ORDNANCE DEPARTMENT

SALE OF SURPLUS MATERIALS AND SCRAP

1—All surplus, unused, or obsolete construction and manufacturing materials, semifinished and completed parts, miscellaneous supplies, etc., left over at time of cancellation or termination of Ordnance contracts, or surplus, at arsenals and supply depots, will be ordered sold or stored as conditions require, by the subcommittee on sale of material of the Salvage Board. The actual sale of this material will be handled by the Material Branch of the Stores and Scrap Section of the Ordnance Department, through the District Stores and Scrap Managers, located in each District Ordnance Office.

2—Capt. Ralph C. Shaw, Chief, Material Branch, located in Group B, Section 1, Room 303, of the Ordnance Building at Seventh and B Streets, Washington, D. C., is compiling lists of the materials to be disposed of as promptly as these materials are reported for sale. Likewise, he is compiling lists of buyers of given classifications of materials. This information is being imparted to the District Managers. Any government agencies, or others interested in the purchase of any materials having been or to be ordered sold by the Salvage Board, should communicate with the Material Branch.

3—All scrap left over from the operation of Ordnance contracts will be sold by the Scrap Branch of the Stores and Scrap Section, operating through the Stores and Scrap Managers of the District Ordnance Offices. This scrap consists of different kinds of steel in sheets, billets and turnings, scrap steel parts, cupro-nickel scrap, antimonial lead dross, silk and cotton waste, burlap, spent acids, etc.

4—District representatives of the Stores and Scrap Section can give information as to scrap available. Likewise, Lt. Schleck, Chief, Scrap Branch, Group B, Section 1, Room 305, will be glad to advise as to amount of scrap on hand at any point, price at which it is being held, etc. Likewise, he will be glad to receive names of government agencies or other possible buyers of these materials.

GASES USED IN WARFARE

REFERENCES TO THE STANDARD REFERENCE BOOKS[1]

By D. D. Berolzheimer, Assistant Technical Editor, The Chemical Catalog Company, New York City

ABBREVIATIONS	
Acad. Belg.	*Bulletin de l'academie royale de belgique*
Beilstein	Handbuch der organischen Chemie
Beilstein Suppl.	Supplementary volumes to Beilstein (Ergaenzungsbaende)
Ber.	*Berichte der deutschen chemischen Gesellschaft*
Chem. Zentr.	*Chemisches Zentralblatt*
Mayer and Jacobson	Lehrbuch der organischen Chemie

ABBREVIATIONS	
Molinari	General and Industrial Chemistry: Inorganic
Moissan	Traité de chimie minerale
Richter	Lexikon der Kohlenstoffverbindungen
Stelzner	Literatur-Register der organischen Chemie 1910–11
Thorpe	Dictionary of Applied Chemistry
Ullmann	Enzyklopaedie der technischen Chemie

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Allyl isothiocyanate (C_3H_5CNS)
Beilstein, **1**, p. 1283
Beilstein Suppl., **1**, p. 725
Richter, **1**, p. 167
Stelzner, p. 148

Allyl mustard oil
See allyl isothiocyanate

Arsine (AsH_3)
Molinari, p. 330
Thorpe, **1**, p. 296

Benzyl bromide ($C_6H_5CH_2Br$)
Beilstein, **2**, p. 60
Richter, **1**, p. 549
Stelzner, p. 320

Brominated methyl-ethyl ketone
($CH_2BrCOC_2H_5$ or $CH_3COCHBrCH_3$)
Acad. Belg., **1900**, p. 724
Chem. Zentr., **1901**, (I), p. 95
Richter, **1**, p. 177
Stelzner, p. 152

Bromoacetone ($CH_2BrCOCH_3$)
Beilstein, **1**, p. 989
Beilstein Suppl., **1**, p. 502
Richter, **1**, p. 100

***o*-Bromobenzyl cyanide** ($C_6H_4CH_2CNBr$)
Beilstein, **2**, p. 1316
Ber., **43** (1910), 2234
Chem. Zentr., **1910**, (II), p. 643
Stelzner, p. 433.

Bromoketone
See brominated methyl-ethyl ketone

***o*-Bromo-2-phenyl-acetonitrile**
See bromobenzyl cyanide

Butyl mercaptan (C_4H_9SH)
Beilstein, **1**, p. 350
Richter, **1**, p. 148
Meyer and Jacobson, **1**, p. 221

Carbonyl chloride[2] ($COCl_2$)
Beilstein, **1**, p. 546
Beilstein Suppl., **1**, p. 219
Richter, **1**, p. 36
Stelzner, p. 26

Chloroacetone ($CH_2ClCOCH_3$)
Beilstein, **1**, p. 986
Beilstein Suppl., **1**, p. 502
Richter, **1**, p. 100
Stelzner, p. 107

Chloromethyl chloroformate ($ClCOOCH_2Cl$)
Beilstein, **1**, p. 469
Beilstein Suppl., **1**, p. 168
Richter, **1**, p. 53

Chloropicrin
See nitrotrichloromethane

Chlorosulfonic acid (SO_3ClOH)
Moissan, **1**, p. 401
Molinari, p. 284
Ullmann, **2**, p. 350

Dibromoketone ($CH_3COCHBrCH_2Br$)
Ber., **42** (1909), 2563
Chem. Zentr., **1909** (II), p. 507
Richter, **1**, p. 169
Stelzner, p. 149

Dichlorodiethyl sulfide ($(CH_2ClCH_2)_2S$)
Beilstein, **1**, p. 358
Ber., **19** (1886), 630, 3260
Meyer and Jacobson, **1**, p. 621
Richter, **1**, p. 190

Dichloroethylarsine ($As(C_2H_5)Cl_2$)
Beilstein, **1**, p. 1512
Richter, **1**, p. 64

Dichloromethyl ether ($(CH_2Cl)_2O$)
Beilstein, **1**, p. 292
Beilstein Suppl., **1**, p. 108
Richter, **1**, p. 58
Stelzner, p. 74

Dimethyl sulfate ($(CH_3)_2SO_4$)
Beilstein, **1**, p. 331
Richter, **1**, p. 66
Stelzner, p. 80

Dimethyltrithiocarbonate ($CS_3(CH_3)_2$)
Beilstein, **1**, p. 887
Richter, **1**, p. 86

Diphenylchloroarsine ($(C_6H_5)_2AsCl$)
Beilstein, **4**, p. 1687
Beilstein Suppl., **4**, p. 1188
Richter, **2**, p. 2192

Diphenylcyanarsine ($(C_6H_5)_2AsCN$)
Not in the literature

Diphosgene
See trichloromethyl chloroformate

Methyl chlorosulfonate (CH_3ClSO_3)
Beilstein, **1**, p. 370
Richter, **1**, p. 42

Methyldichloroarsine (CH_3AsCl_2)
Beilstein, **1**, p. 1510
Meyer and Jacobson, **1**, p. 270
Richter, **1**, p. 38
J. Ind. Eng. Chem., **11** (1919), p. 105

Mustard gas
See dichlorodiethyl sulfide

Nitrochloroform
See nitrotrichloromethane

Nitrochloromethane (CCl_3NO_2)
Beilstein, **1**, p. 203
Beilstein Suppl., **1**, p. 61
Richter, **1**, p. 41
Stelzner, p. 36

Palite
See chloromethyl chloroformate

Phenylcarbylamine chloride ($C_6H_5NCCl_2$)
Beilstein, **2**, p. 360
Beilstein Suppl., **2**, p. 169
Richter, **1**, p. 621

Phosgene
See carbonyl chloride

Superpalite
See trichloromethyl chloroformate

Tolyl bromide
See xylyl bromide

Trichloromethyl chloroformate ($ClCOOCCl_3$)
Beilstein, **1**, p. 465
Richter, **1**, p. 50

Xylyl bromide ($CH_3C_6H_4CH_2Br$ (*o*-, *m*-, *p*-))
Beilstein, **2**, p. 63, 64, 65
Richter, **1**, p. 805
Stelzner, p. 406, 407

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[1] Bromine, chlorine, and hydrocyanic acid are not included, references to these being readily available.

[2] For bibliography covering production, properties, reactions, and uses, see p. 263, this issue.

AMERICAN DRUG MANUFACTURERS ASSOCIATION

The eighth annual meeting of the American Drug Manufacturers Association will be held at the Waldorf-Astoria, New York City, March 24 to 27, 1919. Monday, March 24, will be given over to the Committee on Standards and Deterioration, and the morning of March 25 to the Biological Section, the regular sessions of the Association beginning on the afternoon of the 25th.

There will be a series of round tables for the discussion of fire insurance, returned goods, credit matters, elimination of monthly statements, etc., and a debate by authorities of national reputation on the question of trade acceptances as applied specifically to drug manufacturers.

Dr. Charles H. Herty will speak on the proposed national institute for drug research.

Consideration will be given the problem of the future of alcoholic medicinal preparations, which, with national prohibition, will become the subject of regulation in practically every state and, in many cases, of regulations so drastic as to seriously embarrass their legitimate manufacture and sale.

BUREAU OF MINES MISSION TO EUROPE

The U. S. Bureau of Mines has sent a special mission to Europe to collect information on matters pertaining to mining, minerals, chemicals, conservation of natural resources, etc. The members of the mission are F. G. Cottrell, chief metallurgist; G. S. Rice, chief mining engineer; W. Perdue, petroleum technologist; and F. S. Probert, dean of the School of Mining of the University of California, who goes as consulting mining engineer. The mission will operate from headquarters in London.

Dr. Cottrell will investigate the matter of international helium requirements, will probably confer with the mining experts of France and Alsace-Lorraine regarding the potash supply, and is prepared to negotiate with the authorities of the countries visited regarding patent rights on mechanical and scientific inventions and discoveries made by employees of the United States Government during the war.

MORE DETAILED STATISTICS OF CHEMICAL COMMODITIES

Report of a Committee on Reclassification of Commodities Imported and Exported

The war has made evident the need of more detailed statistics of imports and exports both from the point of view of the Government and of private business men. An attempt is being made to reclassify commodities for this purpose by a committee composed of representatives from the Bureau of Foreign and Domestic Commerce, the Census of Manufactures, the Treasury, the Shipping Board, the Tariff Commission and the War Trade Board. Mr. G. B. Roorbach of the Shipping Board is chairman of this committee.

The committee expects to recommend a definite plan which, if approved by the Secretary of Commerce and the Secretary of the Treasury, will be put into effect on January 1, 1920. It is also expected that beginning on the same date all import and export statistics will be based on the calendar year instead of the fiscal year as at present.

Although this plan of classification is made primarily for statistics of imports and exports it is hoped that it may be used, as far as possible, in other statistical studies dealing with commodities or industries, such as statistics of domestic production. It is proposed to use the same classification for both imports and exports although there is provision under the scheme for showing imports in much greater detail than exports. More detailed import classification is necessary to meet the requirements of the tariff act and the wishes of business men.

The proposed classification is based upon a decimal system which is expected to greatly facilitate the collection and tabulation of the statistics by the use of mechanical tabulating machines, and will also give elasticity to the classification, allowing additions and eliminations of items as trade conditions change.

In order to show the general scheme of the whole classification, the 10 main groups and the first subdivisions are given below.

The subdivision in the classification is carried to five figures. Individual commodities may be listed in either a "four-figure" class or in a "five-figure" class depending on their relative importance, or whether or not they are of interest only in imports. Space is provided in the classification so that commodities can be transferred from the five- to the four-figure classification, as their importance changes from time to time. A commodity given a four-figure classification will appear in (1) the tables of

CLASSIFICATION OF COMMODITIES

FOR USE IN FOREIGN TRADE STATISTICS

MAIN GROUPINGS

0—Vegetable Products, Principally Foods; and Beverages
- 00 Grains, flours, and starches
- 01 Vegetables
- 02 Fruits and nuts
- 03 Vegetable oils, and fats, and oil seeds
- 04 Tea, coffee, cocoa, and spices
- 05 Sugar, molasses, syrups, and confectionery
- 06 Fodders
- 08 Beverages
- 09 Miscellaneous vegetable food products

1—Animals and Animal Products (except fibers)
- 10 Live animals
- 11 Meats and meat products including poultry
- 12 Milk and milk products
- 13 Fish and fish products
- 14 Animal oils, fats, waxes, and greases
- 15 Hides and skins
- 16 Leather, and manufactures of
- 17 Furs and fur skins
- 18 Hair, bristles, and manufactures of
- 19 Other animal products

2—Fibers and Textile Products
- 20 Cotton and cotton manufactures
- 21 Flax and linen
- 22 Hemp and ramie
- 23 Jute and jute products
- 24 Other vegetable fibers, manufactures of
- 26 Wools, and manufactures of
- 27 Silk, and manufactures of
- 28 Other animal fibers
- 29 Miscellaneous textile products

3—Wood, Wood Products, and Paper
- 30 Timber: Logs, hewn and sawed timber, etc.
- 31 Lumber: Lumber, lath, shingles, and veneers
- 32 Manufactures of wood
- 36 Paper base stocks
- 37 Paper and paper products
- 38 Books and all printed matter

4—Plant Products, Other than Foods, Fibers, and Woods
- 40 Rubber, guttas, chicle, and manufactures of
- 41 Gums, n. e. s., resins, and balsams (including naval stores and camphor)
- 42 Crude drugs, n. e. s., and essential oils
- 43 Dyes and tanning materials of vegetable origin
- 44 Seeds for sowing
- 45 Plants, trees, shrubs, and vines
- 46 Tobacco
- 49 Other plant products and manufactures

5—Non-Metallic Minerals and Products
- 50 Coal, petroleum, asphalt and products
- 51 Stone, sand, cement, lime, and plaster
- 52 Glass and glass products
- 53 Clays, pottery, brick tile, and other ceramic products
- 54 Abrasive materials and products
- 55 Chemical and fertilizer raw materials
- 56 Precious and semi-precious stones, rare minerals and products
- 59 Graphite, asbestos, magnesia, and all other non-metallic minerals

6—Ores, Metals, and Metal Manufactures
- 60 Iron and steel ores and crude or semi-crude forms
- 61 Iron and steel, manufactures of, except machinery and vehicles
- 62 Manganese, chromium, vanadium, tungsten, molybdenum, and other ferro-alloying metals and their ores
- 63 Aluminum, tin, and antimony
- 64 Nickel, cobalt, bismuth, and cadmium
- 65 Lead and zinc
- 66 Copper
- 67 Brass and bronze and all other alloys of metals, n. e. s.
- 68 Precious metals and manufactures of, including jewelry
- 69 Mercury and all other metals, n. e. s.

7—Machinery and Vehicles
- 70 Farm equipment
- 71 Metal working machinery
- 72 Electrical machinery and electrical apparatus
- 73 Engines and parts
- 74 Mining, excavating, and road machinery
- 75 Textile machinery and shoe
- 76 Factory and other industrial machinery
- 77 Office machinery, printing machinery, clocks and watches
- 78 All other machinery
- 79 Vehicles (carriages, automobiles, cars, airplanes, boats, etc.)

8—Chemicals and Chemical Products
- 80 Inorganic chemicals (except minerals, 55 and 56; and pigments, 84)
- 81 Inorganic chemicals (*continued*)
- 82 Coal-tar chemicals
- 83 Organic chemicals (except coal tar)
- 84 Pigments, paints, and varnishes
- 85 Pharmaceutical preparations and medicines
- 86 Soaps, perfumery, cosmetics, and other toilet preparations
- 87 Fertilizers
- 88 Explosives
- 89 Other chemical products (inks, cellulose, etc.)

9—Miscellaneous
- 90 Toys, games, athletic and sporting goods
- 91 Musical instruments
- 92 Photographic apparatus and supplies
- 93 Optical instruments (other than photographic) and accessories
- 94 Professional, educational, and scientific instruments and apparatus, n. e. s.
- 95 Firearms and ammunition
- 99 All other

General Imports which show countries of origin and are published monthly and annually, (2) the tables of Domestic Exports showing countries of destination which are published monthly and annually, (3) the tables of Imports for Consumption which are published quarterly and annually showing quantity, value, and revenue collected without showing the country of origin. A commodity given a five-figure classification will appear only in the table of Imports for Consumption. The details for the five-figure headings will not be asked for exports.

The classification of the main grouping, "8—Chemicals and Chemical Products," here given is strictly provisional. Many of the items may be eliminated from the final revision, or others added. The detail is now published for the purpose of obtaining constructive criticisms and suggestions from the chemists, chemical manufacturers, importers, and exporters of the country. Any suggestions will be fully considered that will aid in making the classification itself more serviceable as a means of grouping chemical commodities; that will give additional items that are of sufficient importance to be included either in our export or import statistics; or that will eliminate items that are not of enough importance to be recorded in our trade returns. It is important that any suggestions should be submitted at once. All communications should be addressed to Mr. G. B. Roorbach, U. S. Shipping Board, Room 714, Munsey Building, Washington, D. C. In addition to the chemical group there are also published details from other main groupings which are closely allied to the chemical industry but which appear under other headings as given in the classification printed above.

4—PLANT PRODUCTS, OTHER THAN FOODS, FIBERS, AND WOODS

41 GUMS, RESINS AND BALSAMS, n. e. s. (including naval stores and camphor)

410 Varnish gums, resins, copals, and lac

- 4100 Damar
- 4101 Kauri
- 4102 East India gum
- 4105 Lac
    - 41050 Stick lac
    - 41051 Seed or grain lac
    - 41052 Button lac
    - 41053 Shell lac
    - 41054 Crude lac
    - 41059 All other lacs
- 4109 Other
    - 41090 Pontianack
    - 41091 Congo gum
    - 41092 Sandarac
    - 41093 Manila
    - 41099 All other copals and varnish gums

411 Naval stores

- 4110 Turpentine, spirits of
- 4111 Turpentine, crude
- 4112 Tar and pitch of wood
- 4113 Rosin, crude
- 4119 Other
    - 41191 Burgundy pitch
    - 41192 Turpentine, Venice
    - 41193 Candle pitch or tar
    - 41194 Marine glue pitch

412 Balsams

- 4120 Copaiba
    - 41200 Crude
    - 41201 Advanced in value
- 4121 Canada
    - 41210 Crude
    - 41211 Advanced in value
- 4122 Spruce gum
    - 41220 Crude
    - 41221 Advanced in value
- 4129 Other
    - 41290 Peru, crude
    - 41291 Peru, advanced in value
    - 41292 Tolu, crude
    - 41293 Tolu, advanced in value
    - 41294 Storax, crude
    - 41295 Storax, advanced in value
    - 41299 Other

413 Camphor

- 4130 Crude, natural
- 4131 Refined natural
- 4132 Synthetic camphor

414 Other gums, n. e. s.

- 4140 Acacia (Arabic or senegal)
- 4141 Aloes
- 4142 Agar-agar
- 4143 Amber
    - 41430 Amber, crude
    - 41431 Amber chips, valued at not more than 50 cents per lb.
    - 41432 Manufactures of amber
- 4144 Karaya
- 4145 Tragacanth

414—Other Gums *(Concluded)*

- 4148 All other gums and resins
    - 41480 Asafetida
    - 41481 Benzoin
    - 41482 Dragon's blood
    - 41483 Gamboge
    - 41484 Jalap
    - 41485 Lupulin
    - 41486 Mastic
    - 41487 Myrrh
    - 41488 Salep
    - 41489 Tragasol

42 DRUGS, CRUDE, AND ESSENTIAL OILS

420-421 Drugs (herbs, leaves, roots, etc., crude or partly advanced)

- 4200 Cascara sagrada bark
- 4201 Cinchona bark
- 4202 Ginseng
- 4203 Goldenseal root
- 4204 Insect flowers (insecticide flowers or pyrethrum)
- 4205 Licorice root
- 4206 Nux vomica
- 4207 Opium
    - 42070 Crude, over 9 per cent morphine
    - 42071 Dried, powdered or otherwise advanced, over 9 per cent morphine
    - 42072 Crude, less than 9 per cent morphine (for aqueous solutions of opium, see Pharmaceuticals, 8699)
- 4210 All other crude drugs of vegetable origin
    - 42100 Aconite
    - 42102 Althea
    - 42104 Areca nut
    - 42106 Arnica
    - 42108 Belladonna
    - 42110 Buchu
    - 42112 Cannabis
    - 42114 Chamomile
    - 42116 Coca
    - 42118 Colchicum
    - 42120 Colocynth
    - 42122 Conium
    - 42124 Cubeb
    - 42126 Dandelion
    - 42128 Digitalis
    - 42130 Ergot
    - 42132 Gentian
    - 42134 Hellebore
    - 42136 Henbane
    - 42138 Ipecac
    - 42140 Jaborandi
    - 42146 Lavender
    - 42148 Manna
    - 42150 Orris
    - 42152 Rhubarb
    - 42154 Rose
    - 42156 Sarsaparilla
    - 42158 Scammony
    - 42160 Senna
    - 42162 Soap bark
    - 42164 Stramonium

420-421—Drugs (herbs, etc.) *(Concluded)*

- 42166 Valerian
- 42168 Wormseed, Levant
- 42180 All other drugs of vegetable origin, crude, n. s. p. f.
- 42190 All other drugs of vegetable origin, advanced, n. s. f. p.

(For medicinal and pharmaceutical preparations see Chemicals, 86)

426 Essential oils and essences

- 4260 Lemon (not containing alcohol)
- 4261 Peppermint (not containing alcohol)
- 4265 Others, not containing alcohol
    - 42650 Birch tar
    - 42651 Cajeput
    - 42652 Bitter almond
    - 42653 Anise
    - 42654 Bergamot
    - 42655 Camomile
    - 42656 Camphor
    - 42657 Caraway
    - 42658 Cassia and cinnamon
    - 42659 Cedrat
    - 42660 Citronella
    - 42661 Lemon grass
    - 42662 Fennel
    - 42663 Jasmine
    - 42664 Juniper
    - 42665 Lavender
    - 42666 Limes
    - 42667 Mace
    - 42668 Orange flower or neroli
    - 42669 Orange
    - 42670 Origanum
    - 42671 Rosemary
    - 42672 Roses, attar of
    - 42673 Thyme
    - 42674 Valerian
    - 42690 All other, not containing alcohol
- 4269 Essential oil and essences ,containing alcohol
    - 42690 20 per cent or less alcohol
    - 42691 More than 20 per cent and not more than 50 per cent
    - 42692 More than 50 per cent alcohol

43 DYES AND TANNING MATERIALS OF NATURAL ORIGIN

430 Dye materials, crude

- 4300 Annatto
- 4301 Fustic or Cuba wood
- 4302 Logwood
- 4303 Osage orange
- 4304 Quercitron bark
- 4308 Others
    - 43080 Brazil wood
    - 43081 Camwood
    - 43082 Cudbear
    - 43083 Cochineal
    - 43084 Lac dye
    - 43085 Litmus
    - 43086 Orchil
    - 43087 Madder
    - 43088 Saffron
    - 43089 Turmeric
    - 43099 Others

431 Dye extracts, and decoctions for dyeing, not medicinal
- 4310 Logwood extract
- 4318 Other extracts
  - 43180 Persian berries
  - 43181 Cutch (used exclusively for dyeing)
  - 43188 All extracts containing alcohol
  - 43189 Others (not containing alcohol)

432 Tanning materials, crude
- 4320 Divi-divi
- 4321 Mangrove bark
- 4322 Myrabolans fruit
- 4323 Nuts and nutgalls
- 4324 Quebracho
- 4325 Sumac
- 4329 Others
  - 43290 Bate
  - 43291 Gambier
  - 43292 Valonia

433 Tanning extracts (not containing alcohol)
- 4330 Gambier
- 4331 Quebracho
- 4332 Gambier
- 4339 Others
  - 43390 Mangrove bark
  - 43391 Myrabolans

55 Chemical and Fertilizer Raw Materials

550 Sulfides and sulfur
- 5500 Pyrites, sulfur ore, or sulfuret of iron, crude, containing in excess of 25 per cent sulfur
- 5501 Sulfur or brimstone
  - 55010 Precipitated sulfur
  - 55011 Flowers of sulfur or sublimed
  - 55019 All other forms

(See Chemicals for other sulfur compounds)

551 Nitrate and potash-bearing materials
- 5510 Crude nitrate of sodium, including Chile nitrate
- 5511 Potash fertilizer materials
  - 55110 Kainite
  - 55111 Manure salts
  - 55112 Hard salts
  - 55113 Potash-bearing dusts used as such for fertilizers
- 5519 All other nitrate or potash materials
  - 55190 Other potash-bearing substances such as alunite, leucite, etc.

(For other potash and nitrate chemicals see Chemicals, 80)

- 55191 Other crude nitrate-bearing materials

(For guano, see Fertilizers, 870)

(For crude nitrate of potassium (saltpeter) see Chemicals, Inorganic)

553 Phosphate-bearing materials
- 5530 Phosphate rock, high-grade, ground or unground
- 5531 Phosphate rock, land pebble, ground or unground
- 5532 Phosphate rock, all other, ground or unground
- 5534 All other phosphate-bearing materials
  - 55340 Apatite, crude
  - 55341 Apatite, ground
  - 55342 Wavellite

554 Salt, borax, and all other
- 5540 Common salt

(For borax, boric acid, all other compounds, see Chemicals, 80)

(For ferroboron, see 62)

- 5549 All others
  - 55490 Strontium ores
  - 55491 Witherite, crude or ground (natural barium carbonate)
  - 55492 Lithium ores, crude or ground

8—Chemicals and Chemical Products

80 and 81 Chemicals, Inorganic (except minerals and pigments)

800 Acids
- 8000 Sulfuric acid (oil of vitriol)
  - 80000 Sulfuric
  - 80001 Fuming sulfuric (oleum)
- 8001 Arsenic and arsenious acid (white arsenic)
- 8002 Boric or boracic acid
- 8003 Phosphoric acid
- 8008 Other inorganic acids
  - 80080 Nitric acid
  - 80081 Hydrochloric acid (muriatic)
  - 80082 Mixed acid
  - 80083 Fluoric or hydrofluoric
  - 80084 Chromic
  - 80085 Prussic
  - 80086 Silicic
  - 80089 All other inorganic acids

801 Ammonia and compounds
- 8010 Ammoniacal liquor
- 8011 Nitrate of ammonia
- 8012 Muriate of ammonia (sal ammoniac)
- 8015 Other ammonia compounds
  - 80150 Phosphate of ammonia
  - 80151 Bromide of ammonia
  - 80152 Fluoride of ammonia
  - 80153 Persulfate of ammonia
  - 80154 Perchlorate of ammonia
  - 80155 Bifluoride of ammonia
  - 80156 Liquid anhydrous ammonia

802 Cyanogen compounds
- 8026 Cyanide of soda
- 8027 Prussiate of soda (yellow)
- 8028 Prussiate of potash (yellow)
- 8029 Other cyanogen compounds
  - 80290 Potassium cyanide
  - 80291 Potassium thiocyanate
  - 80292 Ammonium thiocyanate
  - 80293 Potassium ferricyanide (red prussiate)
  - 80294 Calcium ferrocyanide
  - 80295 Barium sulfocyanide
  - 80296 Lead sulfocyanide

(For ferro-ferricyanide blues, see Pigments, 84)

803 and 804 Sodas and sodium compounds
- 8030 Soda ash
- 8031 Caustic soda
- 8032 Silicate of soda
- 8033 Sulfide of soda
- 8034 Borate of soda (borax)
  - 80340 Crude
  - 80341 Refined
- 8035 Nitrite of soda
- 8036 Phosphate of soda
- 8045 Other sodium compounds
  - 80450 Sal soda (washing soda)
  - 80451 Bicarbonate of soda (baking soda)
  - 80452 Sodium sulfate, crystallized (Glauber's salt)
  - 80453 Sodium sulfate, anhydrous
  - 80454 Sulfite of soda
  - 80455 Thiosulfate of soda ("hypo" or hyposulfite)
  - 80456 Hydrosulfite of soda
  - 80457 Bisulfite of soda
  - 80458 Crystal carbonate
  - 80459 Perborate of soda
  - 80460 Fluoride of soda
  - 80461 Sesquicarbonate of soda
  - 80462 Perchlorate of soda
  - 80463 Silicofluoride of soda
  - 80464 Bisulfate of soda
  - 80465 Sodium aluminum silicate

(For sodium nitrate, see Minerals, 55)

805 Potash and potassium compounds
- 8050 Caustic potash (hydrate of)
- 8051 Nitrate of potash
  - 80510 Nitrate of potash, crude or saltpeter

805—Potash, etc. (*Concluded*)
  - 80511 Nitrate of potash, refined
- 8052 Potash, crude or "black salts"
- 8053 Carbonate of potash, crude
- 8054 Carbonate of potash, refined
- 8055 Chloride of potash, refined
- 8058 Other potassium compounds
  - 80580 Chlorate of potash
  - 80581 Bicarbonate
  - 80582 Silicate
  - 80583 Sulfite
  - 80584 Bisulfite
  - 80585 Perchlorate
  - 80586 Iodide
  - 80587 Nitrite
  - 80588 Persulfate

(For muriate of potash, crude; sulfate of potash, crude, see Fertilizers, 87; for kainite, manure salts, and hard salts, see Minerals, 55)

806 Bromine, iodine, chlorine, and compressed or liquefied gases (other than hydrocarbons)
- 8060 Iodine
  - 80600 Iodine, crude
  - 80601 Iodine, resublimed
- 8067 Others
  - 80670 Carbonic acid (carbon dioxide)
  - 80671 Nitrous oxide (laughing gas)
  - 80672 Oxygen
  - 80673 Sulfur dioxide
  - 80674 Phosgene (carbonyl chloride)
  - 80675 Bromine
  - 80676 Chlorine

807 and 808 Compounds of calcium, barium, strontium, and magnesium
- 8070 Chloride of lime (bleaching powder)
- 8071 Calcium carbide
- 8075 Other calcium chemicals
  - 80750 Calcium oxide (other than quicklime)
  - 80751 Calcium hydroxide (other than hydrated lime)

(For quicklime and hydrated lime, see 51)

  - 80752 Calcium carbonate (precipitated)
  - 80753 Calcium chloride, crude
  - 80754 Calcium chloride, purified
  - 80755 Calcium sulfate (pure, precipitated)
  - 80756 Calcium sulfide
  - 80757 Calcium phosphate (tribasic)
  - 80759 Calcium hypophosphite
  - 80760 Calcium hypophosphate
- 8077 Barium chloride
- 8078 Barium carbonate (precipitated)

(Witherite, mineral carbonate of barium, see 55)

- 8079 Barium dioxide (peroxide or binoxide)
- 8080 All other barium chemicals
  - 80820 Barium nitrate, crystals
  - 80821 Barium hydroxide
  - 80822 Barium chlorate
  - 80823 Barium sulfide, crude lumps
  - 80824 Barium sulfide, pure

(For barytes, or barium sulfate, see Pigments, 84)

- 8083 Strontium nitrate
- 8085 All other strontium salts
  - 80850 Strontium sulfate (precipitated)
  - 80851 Strontium carbonate (commercial)
  - 80852 Strontium carbonate (precipitated)
  - 80853 Strontium bromide
- 8086 Magnesium sulfate (Epsom salts)
- 8087 Magnesium chloride
  - 80870 Commercial crystals
  - 80871 Pure, crystal
  - 80872 Anhydrous

807 and 808 Compounds of calcium, etc. (*Concluded*)

- 8089 Other magnesium salts
  - 80890 Magnesia, calcined, purified

(For magnesite or magnesia, crude, see Minerals, 59)

  - 80891 Carbonate (precipitated)
  - 80892 Nitrate
  - 80893 Fluoride

809 Alums and compounds of aluminum, iron, and chromium

- 8090 Sulfate of alumina
- 8094 Other alums and aluminum salts
  - 80940 Soda alum
  - 80941 Potash alum
  - 80942 Iron alum
  - 80943 Ammonia alum
  - 80944 Aluminum chloride
- 8095 Compounds of iron
  - 80950 Ferrous sulfate (copperas)
  - 80951 Ferrous sulfide
  - 80952 Iron perchloride (ferric chloride)
  - 80953 Iron protochloride (ferrous chloride)
- 8097 Compounds of chromium
  - 80970 Chromate and bichromate of potash
  - 80971 Chromate and bichromate of soda
  - 80972 Chromium hydroxide
  - 80973 Chromium sulfate (liquid)

810 Compounds of bismuth, lead, and manganese

- 8100 Compounds of bismuth
  - 81000 Subnitrate
  - 81001 Oxide (powder)
  - 81002 Oxide (hydrated)
  - 81003 Chloride
  - 81004 Nitrate
  - 81005 Subcarbonate
- 8102 Lead compounds (not ores or pigments)
  - 81020 Nitrate
  - 81021 Peroxide
  - 81022 Sulfide
  - 81023 Hyposulfite (thiosulfate)

(See also Ores and Pigments)

- 8104 Permanganate of potash
- 8109 Other manganese compounds
  - 81090 Permanganate of soda
  - 81091 Manganese chloride
  - 81092 Manganese oxide (hydrated)
  - 81093 Manganese oxide (other than ore)
  - 81094 Manganese sulfate

811 Compounds of cobalt, nickel, copper, and silver

- 8111 Compounds of cobalt
  - 81110 Oxide
  - 81111 Sulfate
  - 81112 Carbonate
  - 81113 Nitrate
- 8113 Compounds of nickel
  - 81130 Nickel sulfate
  - 81131 Nickel nitrate
  - 81132 Nickel oxide
  - 81133 Nickel phosphate
- 8114 Sulfate of copper (blue vitriol)
- 8116 Other copper compounds
  - 81160 Copper oxide
  - 81161 Copper chloride
  - 81162 Copper carbonate
  - 81163 Copper sulfide
- 8119 Compounds of silver
  - 81190 Silver nitrate
  - 81191 Silver bromide
  - 81192 Silver chloride

812 Compounds of mercury, zinc, cadmium, arsenic, antimony, and tin

- 8121 Compounds of mercury
  - 81210 Mercuric chloride (corrosive sublimate)

812 Compounds of mercury, etc. (*Concluded*)

  - 81211 Mercurous chloride (calomel)
  - 81212 Mercury iodide
  - 81213 Mercuric oxide (red precipitate)
  - 81214 Mercury ammonium chloride (white precipitate)
  - 81215 Mercury nitrate
- 8122 Zinc chloride
- 8123 Other zinc compounds
  - 81230 Zinc oxide, U. S. P. (See Pigments, 84, for other)
  - 81231 Zinc sulfate (white vitriol)
  - 81232 Zinc carbonate (precipitated)
  - 81233 Zinc ammonium chloride
- 8124 Compounds of cadmium
  - 81240 Cadmium sulfate
  - 81241 Cadmium chloride
  - 81242 Cadmium carbonate
- 8127 Antimony oxide
- 8128 Other antimony compounds
  - 81280 Antimony sulfide, red
  - 81281 Antimony pentasulfide, golden
  - 81282 Antimony chloride (solution)
  - 81283 Antimony sulfate
  - 81284 Antimony sulfite
- 8129 Compounds of tin
  - 81290 Tetrachloride of tin
  - 81291 Bichloride of tin
  - 81292 Tin oxide (other than ore)
  - 81299 All other

818 All other inorganic chemicals, n. e. s.

- 8180 Phosphorus, phosphorus compounds, and sulfur compounds
  - 81800 Phosphorus
  - 81801 Phosphorus chloride
  - 81806 Sulfur chloride
  - 81807 Sulfur bromide
- 8181 Salts of gold and platinum group of metals
  - 81810 Gold chloride
  - 81813 All other gold salts
  - 81814 Platinic chloride, solution (chloro-platinic acid)
  - 81816 All other platinum compounds
  - 81817 Osmium compounds
- 8183 Thorium nitrate
- 8184 Other thorium salts
  - 81840 Thorium oxide (thoria)

(For thorium ores, monazite sand, etc., see Minerals, 55)

- 8186 Cerium and other rare earths
  - 81860 Cerium sulfate
  - 81861 Cerium nitrate
- 8187 Radium and radium salts
- 8188 Other radioactive substances
  - 81880 Mesothorium
- 8189 Uranium salts
  - 81890 Uranium oxide
  - 81891 Uranium nitrate
- 8198 All other inorganic compounds
  - 81980 Beryllium nitrate
  - 81982 Titanium chloride
  - 81983 Titanium sulfate
  - 81985 Hydrogen peroxide
  - 81986 Lithium carbonate
  - 81987 Lithium iodide
  - 81999 All other inorganic compounds, n. s. p. f.

82 COAL-TAR CHEMICALS

820 Coal-tar crudes (Group I, Free List)

- 8200 Benzol
- 8201 Cresol (cresylic acid)
- 8202 Crude tar
- 8203 Dead or creosote oil
- 8204 Naphthalene (solidifying at less than 79° C.)
- 8205 Tar pitches
- 8206 Toluol
- 8207 Distillates
  - 82070 Anthracene oil
  - 82071 Solvent naphtha

820 Coal-tar crudes (*Concluded*)

  - 82079 All other distillates which on being subjected to distillation yield in the portion distilling below 200° C. a quantity of tar acids less than 5 per cent of the original distillate
- 8208 All other products that are found naturally in coal tar, whether produced or obtained from coal tar or other source
  - 82080 Acenaphthene
  - 82081 Anthracene having a purity of less than 25 per cent
  - 82082 Carbazol having a purity of less than 25 per cent
  - 82083 Cumol
  - 82084 Ortho cresol having a purity of less than 90 per cent
  - 82085 Meta cresol having a purity of less than 90 per cent
  - 82086 Para cresol having a purity of less than 90 per cent
  - 82087 Methyl anthracene
  - 82088 Methyl naphthalene
  - 82089 Pyridine
  - 82090 Quinoline
  - 82091 Xylenols
  - 82092 Xylol
  - 82099 All others

821–824 Coal-tar intermediates (Group II, Dutiable)

- 8210 Aniline oil
- 8211 Aniline salt
- 8212 Anthracene (having a purity of 25 per cent or more)
- 8213 Beta naphthol
- 8214 Carbazol (having a purity of 25 per cent or more)
- 8215 Dinitrotoluol
- 8216 Naphthalene (solidifying at 79° C. or above)
- 8217 Naphthylamine monosulfonic acids and salts (Tobias and Cleves)
- 8218 Nitrobenzol (oil of myrbane)
- 8219 Phenol
  - 82190 Crude
  - 82191 Refined
- 8239 Other intermediates
  - 82390 Acetanilide, technical
  - 82391 Alpha naphthylamine
  - 82392 Amidophenol
  - 82393 Amidonaphthol
  - 82394 Anthraquinone
  - 82395 Benzidine and benzidine sulfate
  - 82396 Benzyl chloride
  - 82397 Benzal chloride
  - 82398 Benzoyl chloride
  - 82399 Benzaldehyde
  - 82400 Benzoic acid
  - 82401 Benzanthrone
  - 82402 Benzoquinone
  - 82403 Beta naphthol monosulfonic acid and salts (Schaeffer and Crocein)
  - 82404 Beta naphthol disulfonic acids and salts (R and G)
  - 82405 Cinnamic acid
  - 82406 Chlorphthalic acid
  - 82407 Ortho cresol, 90 per cent pure or above
  - 82408 Meta cresol, 90 per cent pure or above
  - 82409 Para cresol, 90 per cent pure or above
  - 82410 Cumidine
  - 82411 Dinitrobenzol
  - 82412 Dinitrochlorbenzol
  - 82413 Dimethylaniline
  - 82414 Dinitrophenol
  - 82415 Dimethylaniline
  - 82416 Diphenylamine
  - 82417 Dimethylphenylenediamine
  - 82418 Dianisidine

821–824 Coal-tar intermediates (*Concluded*)

- 82419 Diamidostilbene
- 82420 Dichlorphthalic acid
- 82421 Dichlorphthalic acid
- 82422 Ethylbenzylaniline
- 82423 H-acid (amido naphthol disulfonic acid)
- 82424 Monochlorbenzol
- 82425 Monobrombenzol
- 82426 Methylanthraquinone
- 82427 Nitrophenol
- 82428 Nitrophenylenediamine
- 82429 Nitrotoluol
- 82430 Naphthylenediamine
- 82431 Nitroanthroquinone
- 82432 Nitrocresol
- 82433 Para nitraniline
- 82434 Meta phenylenediamine
- 82435 Picramic acid
- 82436 Phenylglycine
- 82437 Phenylhydrazine
- 82438 Phthalic acid or anhydride
- 82439 Phenylglycocoll orthocarboxylic acid
- 82440 Phthalimide
- 82441 Phenylnaphthylamine
- 82442 Resorcin, technical
- 82443 Salicylic acid
- 82444 Sulfanilic acid
- 82445 Toluidine
- 82446 Tribromphenol
- 82447 Tetramethyldiamidobenzophenone
- 82448 Tetramethyldiamidodiphenylmethane
- 82449 Thiocarbanilide
- 82450 Tolidine
- 82451 Meta toluylenediamine
- 82452 Toluolsulfamide
- 82453 Toluolsulfochloride
- 82454 Tetrachlorphthalic acid
- 82455 Xylidine
- 8249 All others
    - 82490 Any sulfoacid or sulfoacid salt of any of the foregoing, n. e. s.
    - 82491 All similar products obtained, derived, or manufactured in whole or in part from the products provided for in Group I
    - 82492 All distillates which on being subjected to distillation yield in the portion distilling below 200° C. a quantity of tar acids equal to or more than 5 per cent of the original distillate

825 Coal-tar colors, dyes, stains whether soluble or not in water, color acids, color bases, color lakes (Group III, Dutiable)

- 8250 Alizarin and alizarins
    - 82500 Natural alizarin
    - 82501 Synthetic alizarin
    - 82502 Colors derived or manufactured in whole or in part from alizarin
- 8251 Anthracene and carbazol derivatives (other than alizarin)
- 8252 Indigo
    - 82520 Natural
    - 82521 Synthetic
    - 82522 Indigoids, whether or not obtained from indigo
- 8253 Color lakes
    - 82530 Yellow
    - 82531 Orange
    - 82532 Red
    - 82533 Violet
    - 82534 Blue
    - 82535 Green
    - 82539 All other color lakes
- 8259 All other colors, dyes, stains, color acids, and color bases

826 Photographic chemicals and medicinals

- 8260 Medicinals (Par. 18, Act of 1913)
    - 82600 Acetanilide
    - 82601 Acetphenetidin (phenacetin)
    - 82602 Acetylsalicylic acid (aspirin)
    - 82603 Antipyrine
    - 82604 Phenolphthalein
    - 82605 Salol
    - 82606 Arsphenamine (salvarsan and neo-arsphenamine)
    - 82609 All other coal-tar medicinals
- 8262 Photographic chemicals
    - 82620 Hydroquinone
    - 82621 Metol
    - 82629 All other coal-tar photographic chemicals

829 All other finished coal-tar products

- 8290 Disinfectants
- 8291 Flavors
    - 82910 Saccharin
    - 82911 Coumarin (synthetic)
    - 82912 Methyl salicylate (artificial oil of wintergreen)
- 8292 Synthetic perfume bases
- 8293 Synthetic phenolic resins
- 8294 Synthetic tanning materials
- 8299 All other finished coal-tar products

83 ORGANIC CHEMICALS (exclusive of coal-tar)

830 and 831 Acids, acid anhydrides, and salts of organic acids

- 8300 Acetic or pyroligneous acid (commercial)
- 8301 Formic acid
- 8302 Oxalic acid
- 8305 and 8306 Other organic acids and acid anhydrides
    - 83050 Acetic acid, glacial
    - 83051 Acetic anhydride
    - 83052 Barbituric or diethylbarbituric acid
    - 83053 Butyric acid
    - 83054 Citric acid
    - 83055 Gallic acid
    - 83056 Glycerophosphoric acid
    - 83057 Lactic acid
    - 83058 Oleic acid
    - 83059 Pyrogallol or pyrogallic acid
    - 83060 Ricinoleic acid
    - 83061 Sulforicinoleic acid
    - 83062 Stearic acid
    - 83063 Tartaric acid
    - 83064 Tannic acid
    - 83069 All other
- 8307 Argols (crude tartar or wine lees)
    - 83070 Containing not more than 90 per cent potassium bitartrate
    - 83071 Containing more than 90 per cent potassium bitartrate
- 8308 Calcium acetate (acetate of lime)
- 8309 Calcium citrate (citrate of lime)
- 8310 Sodium formate
- 8316 All other salts of organic acids
    - 83160 Acetate of soda
    - 83161 Acetate of lead, white
    - 83162 Acetate of lead, brown, gray, or yellow
    - 83163 Acetate and subacetate of copper (verdigris)
    - 83165 Citrate of magnesia
    - 83166 Citrate of soda
    - 83167 Citrates of iron and iron-ammonium
    - 83169 Tartrate, potassium acid (cream of tartar)
    - 83170 Tartrate, sodium potassium (Rochelle salts)
    - 83171 Tartrate of calcium
    - 83172 Tartrate, antimony potassium (tartar emetic)
    - 83174 Potassium oxalate
    - 83175 Potassium titanium oxalate
    - 83176 Potassium binoxalate

830 and 831—Acids, acid anhydrides, etc. (*Concluded*)

- 83178 Manganese resinate
- 83179 Lead resinate
- 83180 Manganese linoleate
- 83181 Lead linolate
- 83182 Manganeese oleate
- 83199 All other salts of organic acids

832 Hydrocarbons and derivatives

- 8320 Hydrocarbons
    - 83200 Acetylene
    - 83201 Ethylene
    - 83209 All other hydrocarbons
- 8321 Halogen derivatives of hydrocarbons
    - 83210 Acetylene tetrachloride
    - 83211 Carbon tetrachloride
    - 83212 Chloroform
    - 83213 Dichlorethylene (Dutch liquor)
    - 83214 Iodoform
    - 83215 Methyl chloride
    - 83216 Trichlorethylene

833 Alcohols

- 8330 Alcohol, denatured
- 8331 Alcohol, ethyl (grain)
- 8332 Alcohol, methyl (wood)
- 8333 Fusel oil or amylic alcohol
- 8334 Glycerin, crude
- 8335 Glycerin, refined
- 8338 Other alcohols
    - 83380 Butyl alcohol
    - 83381 Propyl alcohol
    - 83382 Glycol alcohol
    - 83383 Cetyl alcohol

834 Aldehydes and ketones

- 8340 Formaldehyde or formalin
- 8342 Other aldehydes
    - 83420 Acetaldehydes
    - 83421 Chloral and chloral hydrate
    - 83422 Paraldehyde
- 8343 Acetone
- 8344 Other ketones
    - 83440 Acetone oil
    - 83441 Methyl acetone
    - 83442 Methyl ethyl ketone (ketone)

835 Ethers and esters

- 8350 Ethers
    - 83500 Ethyl ether (ether or sulfuric ether)
    - 83501 Ethyl chloride
    - 83502 Ethyl bromide
    - 83503 Ethyl iodide
    - 83504 Methyl ether
    - 83505 Methyl iodide
- 8351 Esters
    - 83510 Amyl acetate
    - 83511 Amyl nitrite
    - 83512 Dimethyl sulfate
    - 83513 Ethyl nitrate
    - 83514 Ethyl nitrite (sweet spirits of niter)
    - 83515 Ethyl acetate
    - 83516 Ethyl formate
    - 83517 Ethyl butyrate
    - 83518 Ethyl hydrogen sulfate
    - 83519 Others

839 Other organic chemicals (except coal-tar)

- 83900 Camphene
- 83901 Cacodylates
- 83902 Dimethylamine
- 83903 Ethylamine
- 83904 Eucalyptol
- 83905 Guaiacol
- 83906 Guaiacol carbonate
- 83907 Ichthyol
- 83908 Methylamine
- 83909 Menthol
- 83910 Pinene
- 83911 Pinene hydrochloride
- 83912 Sulfone methanes (sulfonal, trional, etc.)
- 83913 Terpin hydrate
- 83914 Terpinene

839 Other organic chemicals (*Concluded*)

- 83915 Terpineol
- 83916 Thymol
- 83917 Urea and derivatives
- 83918 Vanillin
- 83919 Wood creosote

84 PIGMENTS, PAINTS, AND VARNISHES

840 Mineral earth pigments

- 8400 Ocher
- 8401 Sienna
- 8402 Umber
- 8403 Cassel brown and Vandyke brown
- 8404 Whiting (calcium carbonate)
  - 84040 Dry
  - 84041 Ground in oil (putty)
- 8405 Zaffer
- 8406 Indian red, Venetian red, or colcothar
- 8407 Silica and silicate pigments

841 Chemical pigments

- 8410 Zinc oxide
  - 84100 Ground dry
  - 84101 Ground in or mixed with oil or water
- 8411 Lithopone
- 8412 Barium sulfate (barytes)
  - 84120 Crude, natural
  - 84121 Ground barytes
  - 84122 Blanc fixe (artificial)
- 8413 Lead pigments
  - 84130 Litharge
  - 84131 Orange mineral
  - 84132 Red lead
  - 84133 White lead (basic carbonate)
  - 84134 Sublimed lead (basic sulfate)
  - 84139 Other lead pigments
- 8414 Chrome colors
  - 84140 Chrome yellow
  - 84141 Chrome scarlet (basic chromate of lead)
  - 84142 Chrome greens
- 8415 Vermilion (mercuric sulfide) and vermilionettes
  - 84150 Mercuric sulfide
  - 84151 Eosine vermilions
  - 84152 Scarlet vermilions
- 8416 American blue, Prussian blue, Chinese blue, Berlin blue, Paris blue (ferriferrocyanide)
  - 84160 In pulp, dry, or ground in oil or water
- 8417 Carbon blacks (this includes lampblack, boneblack, or ivoryblack, and other blacks of similar origin)
- 8419 Other chemical pigments
  - 84190 Zinc sulfide
  - 84191 Cadmium sulfide
  - 84192 Ultramarine
  - 84193 Wash blue (containing ultramarine)

843 Paints, stains and enamels

- 8430 Ready, mixed paints
  - 84300 Lead pigments in oil
  - 84301 Zinc pigments in oil
  - 84302 Other pigments in oil
- 8439 Other prepared paints
  - 84390 Artists' paints
  - 84391 Enamel paints
  - 84392 Wood stains, fillers, and polishes
  - 84393 Glazes, fluxes, enamels, and colors, ceramic and glass

844 Varnishes

- 8440 Spirit varnishes
  - 84400 Containing less than 10 per cent of methyl alcohol
  - 84401 Containing 10 per cent or more of methyl alcohol
- 8441 Oil varnishes
  - 84410 Gold size
  - 84411 Japans
  - 84419 Others
- 8449 Other varnishes

85 MEDICINAL AND PHARMACEUTICAL PREPARATIONS

850 Medicinal and pharmaceutical preparations: alkaloids, glucosides, and other active principles of vegetable origin

- 8500 Caffeine, and salts of caffeine
  - 85001 Caffeine
  - 85002 Salts and derivatives of caffeine
- 8501 Cocaine, ecgonine, and salts of cocaine
  - 85010 Crude cocaine
  - 85011 Ecgonine
  - 85012 Cocaine hydrochloride
  - 85013 Cocaine alkaloid
  - 85019 Other salts and derivatives of cocaine
- 8502 Morphine and its salts and derivatives, and other alkaloids and salts of alkaloids derived from opium
  - 85020 Morphine alkaloid
  - 85021 Morphine sulfate
  - 85022 Diacetylmorphine or heroin
  - 85023 All other salts or derivatives of morphine
  - 85024 Codeine and its salts
  - 85025 Apomorphine and its salts
  - 85029 All other alkaloids and salts and derivatives of alkaloids derived from opium
- 8503 Quinine and other alkaloids and salts of alkaloids derived from cinchona bark
  - 85030 Crude quinine
  - 85031 Quinine alkaloid
  - 85032 Quinine sulfate
  - 85033 Other salts and derivatives of quinine
  - 85034 Cinchonidine and its salts
  - 85035 Cinchonine and its salts
  - 85036 Quinidine and its salts
  - 85039 Other alkaloids and salts of other alkaloids of cinchona
- 8504 Strychnine and salts and derivatives of strychnine
  - 85040 Strychnine alkaloid
  - 85041 Strychnine sulfate
  - 85049 Other salts and derivatives of strychnine
- 8507 All other alkaloids and salts and derivatives of
  - 85070 Aconitine and its salts and derivatives
  - 85071 Atropine and its salts
  - 85072 Ergotine and other ergot extractives
  - 85073 Hyoscine or scopolamine and its salts
  - 85074 Hyoscyamine and its salts
  - 85075 Pilocarpine and its salts and derivatives
  - 85076 Theobromine, theophylline, and their salts and derivatives
  - 85079 All other alkaloids, salts and derivatives of alkaloids
- 8508 Glucosides and compounds and derivatives of glucosides and extracted glucosidal principles of vegetable drugs
  - 85080 Digitalis glucosides and active principles of digitalis
  - 85081 Salicin and compounds of salicin
  - 85082 Strophanthus glucosides and active principles of strophanthus
  - 85089 All other glucosidal principles of vegetable drugs
- 8509 All other active principles of vegetable drugs, n. e. s.
  - 85090 Chrysarobin and its salts
  - 85091 Eucalyptol and its salts
  - 85092 Santonin and its salts

850 Medicinal preparations (*Concluded*)

  - 85093 Thymol and its salts
  - 85099 All other active principles of vegetable drugs, n. s. p. f.

851 Medicinal and pharmaceutical preparations: biological medicines all others, n. e. s.

- 8510 Antitoxins, serums, and vaccines
- 8511 Enzyme preparations
  - 85110 Pepsin and preparations of
  - 85111 Papain and preparations of
  - 85112 Trypsin and preparations of
  - 85113 Pancreatin and preparations of
  - 85114 Rennin and preparations of (technical)
  - 85119 Other enzyme preparations
- 8518 All other biological medicinals or medicinals of animal origin
  - 85180 Epinephrine and other suprarenal preparations
  - 85181 Thyroid
  - 85182 Hypophyses and other gland extracts
  - 85183 Ox gall bile salts and bile compounds
  - 85184 Leeches
  - 85185 Cantharis and other blistering beetles
  - 85189 All others, n. e. p. f.
- 8519 All other preparations, n. e. s.
  - 85190 Preparations not containing alcohol
  - 85191 Preparations containing less than 20 per cent alcohol
  - 85192 Preparations containing 20 per cent to 50 per cent
  - 85193 Preparations containing over 50 per cent
  - 85194 Liquid preparations of opium, as laudanum
  - 85195 Preparations in small packages (Par. 17)
  - 85196 Preparations in capsules, pills, tablets, etc. (Par. 17)
  - 85199 All other, n. s. p. f.

(For synthetic and other medicinal chemicals see Chemicals 80, 81, 82, 83)

86 SOAPS, PERFUMERY, COSMETICS, AND OTHER TOILET PREPARATIONS

860 Soaps

- 8600 Toilet or fancy soaps
  - 86000 Perfumed
  - 86001 Unperfumed
- 8609 All other soaps
  - 86090 Castile soap
  - 86091 Medicinal
  - 86092 Soap powders
  - 86099 All other, n. s. p. f. (Includes laundry soap, shaving soaps and creams, soft and liquid soaps, soap chips, scouring soaps, textile soaps, and all others)

861 Perfumery, cosmetics, and other toilet preparations

- 8610 Perfumery, cosmetics, and other toilet preparations
  - 86100 Bay rum or bay water
  - 86101 Floral waters containing no alcohol
  - 86102 Floral essences containing no alcohol
  - 86104 Perfumery and other toilet waters, including sachets
  - 86105 Perfumery and other toilet waters, including sachets, not containing alcohol
  - 86106 Cosmetics and all other toilet preparations, n. e. s., containing alcohol

861 Perfumery, etc. (*Concluded*)

86107 Cosmetics and all other toilet preparations, n. e. s., not containing alcohol. (Includes tooth pastes and powders, face powders, toilet creams, theatrical greases, paints, pomades and pastes, hair tonics, pomades, powders, etc.)
86108 Substances used in preparation of perfumes and cosmetics, n. s. p. f., not containing alcohol

87 FERTILIZERS AND FERTILIZER MATERIALS (other than crude minerals)

870 Nitrogenous fertilizer materials

8700 Calcium cyanamide or lime-nitrogen
8701 Calcium nitrate (nitrate of lime)
8702 Guano
8703 Sulfate of ammonia
8708 Other nitrogenous materials (this includes dried blood, tankage, garbage, fish scrap, hoof meal, animal manures, and castor bean pomace)

871 Phosphate materials (except crude phosphate rock and land pebble)

8710 Superphosphate (acid phosphates)
8711 Basic slag, ground or unground (Thomas slag)
8712 Bone phosphates (bone-ash, bone-dust, bone-meal)

871 Phosphate materials (*Concluded*)

8719 Other phosphate materials (such as spent boneblack)
(Phosphate rock and land pebble are classified under Minerals, 5)

872 Potash fertilizer materials (except crude minerals)

8720 Muriate of potash, crude
8721 Sulfate of potash, crude
8729 Other potash fertilizer materials
(Kainite, manure, and hard salts are classified under Minerals, 5)

875 Mixed fertilizers

8750 Special proprietary mixtures
8759 Other fertilizers

88 EXPLOSIVES (other than coal-tar explosives)

880 Powder

8800 Gunpowder
8801 Smokeless powder
8802 Blasting powder
8809 Other powders

881 Dynamite, nitrocellulose, and other nitric esters

8810 Dynamite
8811 Nitrocellulose (cordite, guncotton)
8819 Other nitric esters

882 Primers and Fuses

8820 Mercury fulminate
8829 Others
88290 Azides
88291 Percussion caps
88292 Running fuses (safety fuses)
88293 Detonating fuses
88294 Detonating cord
88299 Other primers and fuses

889 Other explosives

8890 Cartridges
8899 Others
88990 Fire-crackers and all fire-works

89 OTHER CHEMICAL PRODUCTS

890 Baking powder

891 Inks and ink powders

8910 Writing and copying inks
8911 Printers and lithographic inks
8919 All other inks and products
89190 Ink powders, pellets, and all solid soluble forms
89191 Indelible inks

892 Cellulose and cellulose products (except explosives and medicinal preparations)

8920 Cellulose
8921 Collodion and all other liquid solutions of pyroxylin, or of other cellulose esters, or of cellulose
8922 Pyroxylin plastics (compounds of pyroxylin or of other cellulose esters whether known as celluloid, pyralin, viscoloid, fibriloid, xylonite, or by any other name)
89220 In blocks, sheets, rods, not polished or made up into finished products
89221 Polished or if finished or partly finished articles

893 Casein and casein products

8930 Casein or lacterene
8939 Other casein products
89390 Casein paints
89391 Casein adhesives

BIBLIOGRAPHY ON CARBONYL CHLORIDE (PHOSGENE) AND ITS DERIVATIVES

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This bibliography is based upon that published by the late Dr. Morris Loeb, in his Ph.D. thesis of 1887 (see reference 129), being a revision and amplification of same.

The author will be glad to have any errors or omissions in the bibliography called to his attention.

The numbers following each entry refer to the literature citations in the appended list of references, page 264.

Standard References

Beilstein, **1**, p. 546
Beilstein Suppl., **1**, p. 219
Richter, **1**, p. 36
Stelzner, p. 26

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REFERENCES

1	Davy. *Phil. Trans. Roy. Soc.*, p. 144	1812
2	Berzelius and Marcet. Gilbert's *Ann.*, **48**, 161	1814
3	Dumas. *Ann. chim. phys.*, [2] **56**, 226; *Ber.*, **17** Ref. (1884), 662.	1833
4	Berzelius. *Lehrbuch der Chemie*, 4th Ed., **2**, 114	1835
5	Dumas and Peligot. *Ann. chim. phys.*, [2] **58**, 52	1835
6	Goebel. Berzelius' *Jahresber. Fort. phys. Wiss.*, **16**, 162	1837
7	Gégnault. *Ann. chim. phys.*, [2] **69**, 180	1838
8	Kolbe. *Ann.*, **54**, 148	1845
9	Hofmann. *Ann.*, **57**, 267	1846
10	Cahours. *Ann. chim. phys.*, [3] **19**, 352	1847
11	Hofmann. *Ann.*, **70**, 139	1849
12	Medlock. *Quart. J. Chem. Soc.*, **1**, 368	1849
13	Nathanson. *Ann.*, **98**, 287	1856
14	Hencke. *Ann.*, **106**, 285	1858
15	Harnitz-Harnitzky. *Ann.*, **111**, 192	1859
16	Harnitz-Harnitzky. *Compt. rend.*, **58**, 748	1864
17	Friedel. *Compt. rend.*, **60**, 930	1865
18	Harnitz-Harnitzky. *Compt. rend.*, **60**, 923	1865
19	Butlerow. *Lehrbuch der organischen Chemie*, p. 297	1868
20	Kraut. *Ann.*, **147**, 107	1868
21	Schuetzenberger. *Compt. rend.*, **66**, 747	1868
22	Wilm and Wischin. *Ann.*, **147**, 170	1868
23	Wilm and Wischin. *Z. Chem.*, [2] **4**, 5	1868
24	Wroblewski. *Z. Chem.*, [2] **4**, 565	1868
25	Bouchardat. *Compt. rend.*, **69**, 94	1869
26	Dewar and Cranston. *Chem. News*, **20**, 174	1869
27	Emmerling and Lengyel. *Ann.*, Suppl., **7**, 101	1869
28	Emmerling and Lengyel. *Ber.*, **2**, 547	1869
29	Friedel. *Ann. chim. phys.*, [4] **16**, 403	1869
30	Graebe and Liebermann. *Ber.*, **2**, 678	1869
31	Kekulé and Zincke. *Ann.*, **152**, 125	1869
32	Schuetzenberger. *Ber.*, **2**, 219	1869
33	Schuetzenberger. *Compt. rend.*, **69**, 352	1869
34	Stacewitz. *Z. Chem.*, [2] **5**, 321	1869
35	Wilm and Wischin. *Ann.*, **147**, 151	1869
36	Wurtz. *Compt. rend.*, **68**, 1269	1869
37	Armstrong. *Ber.*, **3**, 730	1870
38	Bertholet. *Ann.*, **156**, 228	1870
39	Bertholet. *Bull. soc. chim.*, N. S., **13**, 9	1870

40 Butlerow. *Ber.*, **3**, 426 ... 1870
41 DeClermont and Fontaine. *Bull. soc. chim.*, N. S., **13**, 494 ... 1870
42 DeClermont and Fontaine. *Ann.*, **156**, 226 ... 1870
43 Heintz. *Ann.*, **154**, 257 ... 1870
44 Kempf. *J. prakt. Chem.*, [2] **1**, 402 ... 1870
45 Meyer. *Ann.*, **156**, 271 ... 1870
46 Gustavson. *Z. Chem.*, [2] **7**, 615 ... 1871
47 Schmidt, Ph.D. Thesis, Leipzig[1] (*J. prakt. Chem.*, [2] **5** (1872), 39) ... 1871
48 Basarow. *Ber.*, **5**, 477 ... 1872
49 Kekulé and Zincke. *Ann.*, **162**, 125 ... 1872
50 Mylius. *Ber.*, **5**, 972 ... 1872
51 Salomon. *J. prakt. Chem.*, [2] **6**, 433 ... 1872
52 Schuetzenberger. *Ann. chim. phys.*, [4] **21**, 358 ... 1872
53 Schuetzenberger. *Ann.*, Suppl., **8**, 242 ... 1872
54 Girard. *Ber.*, **6**, 444 ... 1873
55 Roemer. *Ber.*, **6**, 1101 ... 1873
56 Salomon. *J. prakt. Chem.*, [2] **7**, 254 ... 1873
57 Thomsen. *Ber.*, **16**, 2619 ... 1873
58 Michler. *Ber.*, **8**, 1665 ... 1875
59 Hallmann. *Ber.*, **9**, 846 ... 1876
60 Michler. *Ber.*, **9**, 396 ... 1876
61 Michler. *Ber.*, **9**, 716 ... 1876
62 Michler and Dupertius. *Ber.*, **9**, 1899 ... 1876
63 Michler and Gradmann. *Ber.*, **9**, 1912 ... 1876
64 Wilm and Girard. *Ber.*, **9**, 449 ... 1876
65 Ador and Crafts. *Ber.*, **10**, 2173 ... 1877
66 Friedel, Crafts and Ador. *Ber.*, **10**, 1854 ... 1877
67 Ador and Rilliet. *Ber.*, **11**, 399 ... 1878
68 Bertholet. *Compt. rend.*, **87**, 571 ... 1878
69 Paternò. *Gazz. chim. ital.*, **8**, 233; (*Jahresber. Fort. Chem.*, **1878**, 229) ... 1878
70 Fenton. *J. Chem. Soc.*, **35**, 793 ... 1879
71 Henry. *Ber.*, **12**, 1845 ... 1879
72 Michaelis and Dittler. *Ber.*, **12**, 339 ... 1879
73 Michler and Zimmermann. *Ber.*, **12**, 1165 ... 1879
74 Michler and Escherlich. *Ber.*, **12**, 1162 ... 1879
75 Muehlhaeuser. *Ber.*, **13**, 922 ... 1880
76 Roese. *Ann.*, **205**, 229 ... 1880
77 Birnbaum and Lurie. *Ber.*, **14**, 1754 ... 1881
78 Keller. Ph.D. Thesis, Zurich (*Ber.*, **14** (1881), 2181) ... 1881
79 Michler and Keller. *Ber.*, **14**, 2181 ... 1881
80 Michler and Walder. *Ber.*, **14**, 2174 ... 1881
81 Sarauw. Ph.D. Thesis, Zurich (*Ber.*, **14** (1881), 2180) ... 1881
82 Sarauw. *Ber.*, **14**, 2443 ... 1881
83 Will. *Ber.*, **14**, 1486 ... 1881
84 Klepl. *J. prakt. Chem.*, [2] **26**, 448 ... 1882
85 Otto. Ph.D. Thesis, Rostock ... 1882
86 Sarauw. *Ber.*, **15**, 42 ... 1882
87 Badische A. & S. Fab. Ger. P. 26016 (*Ber.*, **17** (1884), 60) ... 1883
88 Caro (assigned to Badische A. & S. Fab.). Ger. P. 27789 (*Ber.*, **17** (1884), 339) ... 1883
89 Caro and Kern. U. S. P. 290856 (assigned to Badische A. & S. Fab.) (same as Brit. P. 4428 of 1883) ... 1883
90 Hentschel (assigned to Hofmann and Schoetensack), Ger. P. 24151 (Friedlaender, **1** (1888), 230) ... 1883
91 Kelbe and Warth. *Ann.*, **221**, 172 ... 1883
92 Nemirowsky. *J. prakt. Chem.*, [2] **28**, 439 ... 1883
93 Thomsen. *Ber.*, **16**, 2619 ... 1883
94 Badische A. & S. Fab., Ger. P. 29943 (*Ber.*, **18** (1885), 7) ... 1884
95 Francksen. *Ber.*, **17**, 1224 ... 1884
96 Hentschel. *Ber.*, **17**, 1284 ... 1884
97 Hofmann and Schoetensack. Ger. P. 29669 (*Ber.*, **17** (1884), 623) ... 1884
98 Hofmann and Schoetensack. Ger. P. 29929 (*Ber.*, **18** (1885), 12) ... 1884
99 Hofmann and Schoetensack. Ger. P. 30172 (*Ber.*, **18** (1885), 40 and 90) ... 1884
100 Meister, Lucius and Bruening. Ger. P. 34463 (*Ber.*, **19** (1886), 226) ... 1884
101 Ostermayer. *Mitt. Lebensm. Unt. Anst. Wiesbaden*, 137 (*Chem. Ztg.*, **8** (1884), 970) ... 1884
102 Pahl. *Ber.*, **17**, 1240 ... 1884
103 Salomon. *J. prakt. Chem.*, [2] **30**, 416 ... 1884
104 Schoene. *J. prakt. Chem.*, [2] **30**, 416 ... 1884
105 Behla. *Ber.*, **18**, 3169 ... 1885
106 Buchka. *Ber.*, **18**, 2090 ... 1885
107 Ciamician and Magnaghi. *Ber.*, **18**, 414 ... 1885
108 Eckenroth. *Ber.*, **18**, 518 ... 1885
109 Falck. *Ber.*, **18**, 2471 ... 1885
110 Gattermann. *Ber.*, **18**, 3013 ... 1885
111 Gattermann and Wrampelmeyer. *Ber.*, **18**, 2604 ... 1885
112 Gross. *Ber.*, **18**, 2483 ... 1885
113 Hentschel. *Ber.*, **18**, 1177 ... 1885
114 Hofmann. *Ber.*, **18**, 770 ... 1885
115 Kern and Mueller. U. S. P. 327953 (assigned to Badische A. & S. Fab.) (same as Brit. P. 11030 of 1883) ... 1885
116 Loeb. *Ber.*, **18**, 2427 (see Ref. 239) ... 1885
117 Loewenberg. Ph.D. Thesis, Berlin (*Chem. Zentr.*, **1886**, 390) (not available) ... 1885
118 Nemirowsky. *J. prakt. Chem.*, [2] **31**, 173 ... 1885
119 Conrad and Gutzeit. *Ber.*, **19**, 19 ... 1886
120 Elbs and Olberg. *Ber.*, **19**, 408 ... 1886
121 Loeb. *Ber.*, **19**, 2340 (see Ref. 240) ... 1886
122 Loeb. *Ber.*, **19**, 2344 (see Ref. 241) ... 1886
123 Snape. *J. Chem. Soc.*, **49**, 255 ... 1886
124 Behla. *Ber.*, **20**, 701 ... 1887
125 Gattermann and Schmidt. *Ber.*, **20**, 118 ... 1887
126 Gattermann and Schmidt. *Ber.*, **20**, 858 ... 1887
127 Hanssen. *Ber.*, **20**, 781 ... 1887
128 Kern. Brit. P. 5896 (*J. Chem. Soc. Ind.*, **7** (1888), 498) ... 1887
129 Loeb. Ph.D. Thesis, Berlin, 7[1] (*Chem. Zentr.*, **1887**, I, 635) ... 1887
130 Loeb. Ph.D. Thesis, Berlin, 34[1] (*Chem. Zentr.*, **1887**, I, 635) ... 1887
131 Loeb. Ph.D. Thesis, Berlin, 41, 42, 43 (*Chem. Zentr.*, **1887**, I, 635) ... 1887
132 Loeb. Ph.D. Thesis, Berlin, 48[1] (*Chem. Zentr.*, **1887**, I, 635) ... 1887
133 Meister, Lucius and Bruening. Brit. P. 1694 (*J. Soc. Chem. Ind.*, **7** (1888), 205) ... 1887
134 Spica and de Varda. *Gazz. chim. ital.*, **17**, 165 ... 1887
135 Badische A. & S. Fab. Ger. P. 46737 (Friedlaender, **2** (1891), 450) ... 1888
136 Freund and Goldsmith. *Ber.*, **21**, 1240 and 2456 ... 1888
137 Gattermann and Schmidt. *Ann.*, **244**, 30 ... 1888
138 Mueller. Brit. P. 15258 (assigned to Badische A. & S. Fab.) (*J. Soc. Chem. Ind.*, **8** (1889), 772) ... 1888
139 Otto. *Ber.*, **21**, 1267 ... 1888
140 Freund and Kuh. *Ber.*, **23**, 2821 ... 1890
141 Hartmann. *Ber.*, **23**, 1046 ... 1890
142 Heller. Ph.D. Thesis, Wuerzburg (*Ann.*, **263** (1891), 269) ... 1890
143 Kym. *Ber.*, **23**, 427 ... 1890
144 Palm. Ph.D. Thesis, Jena ... 1890
145 Fabricicius. Ph.D. Thesis, Berlin ... 1891
146 Hammerich. Ph.D. Thesis, Basel (*Ber.*, **25** (1892) 1819) ... 1891
147 Kranz. Ph.D. Thesis, Jena ... 1891
148 Nuricsan. *Ber.*, **24**, 2967 ... 1891
149 Paschkowezky. Ph.D. Thesis, Zurich (*Ber.*, **24** (1891), 2905 and 3492) ... 1891
150 Uhl. Ph.D. Thesis, Zurich (*Ber.*, **25** (1892), 1875) ... 1891
151 Wolf. Ph.D. Thesis, Berlin (*Ber.*, **25** (1892), 1456) ... 1891
152 Caro. *Ber.*, **25**, 1062 ... 1892
153 Erdmann. *Ber.*, **26**, 1990 ... 1893
154 Haase. *Ber.*, **26**, 1054 ... 1893
155 Halle. Ph.D. Thesis, Basel ... 1893
156 Meyer and Jacobson. *Lehrbuch der organischen Chemie*, **1**, 1040 ... 1893
157 Wischewiansky. Ph.D. Thesis, Berlin (*Ber.*, **26** (1893), 2877) ... 1893
158 Krug. Ph.D. Thesis, Giessen ... 1894
159 Perkin. *Chem. News*, **69**, 224 ... 1894
160 Scholvien. *Ber. deut. pharm. Gesell.*, **3**, 213; (*J. Soc. Chem. Ind.*, **13** (1894), 1099) ... 1894
161 Besson. *Compt. rend.*, **120**, 190 ... 1895
162 Nef. *Ann.*, **287**, 220 ... 1895
163 Besson. *Compt. rend.*, **122**, 140 ... 1896
164 Marckwald and Sedlaczek. *Ber.*, **29**, 2933 ... 1896
165 Schiff. *Ann.*, **291**, 367 ... 1896
166 Gartzen. Ph.D. Thesis, Erlangen ... 1898
167 Heyden. Ger. P. 109933 (*Chem. Zentr.*, **1900**, II, 460) ... 1898
168 Spindler. Ph.D. Thesis, Erlangen ... 1898
169 Barral and Morel. *Compt. rend.*, **128**, 1579 ... 1899
170 Barral and Morel. *Bull. soc. chim.*, [3] **21**, 725 ... 1899
171 Farbenfab. Bayer. Ger. P. 118537 (Friedlaender, *Fort. Teerfarbenfab.*, **6** (1904), 1166) ... 1899
172 Kuehn. *Ber.*, **33**, 2900 ... 1899
173 Farbenfab. Bayer. Ger. P. 121223 (*Chem. Zentr.*, **1901**, II, 69) ... 1900
174 Jaross. Ph.D. Thesis, Breslau ... 1901
175 Acree. *Ber.*, **36**, 3154 ... 1903
176 Grignard. *Compt. rend.*, **136**, 815 ... 1903
177 Sachs and Loevy. *Ber.*, **36**, 1588 ... 1903
178 Busch and Opfermann. *Ber.*, **37**, 2333 ... 1904
179 Baud. *Compt. rend.*, **140**, 1688 ... 1905
180 Haas. Ph.D. Thesis, Munich (not available) ... 1905
181 Krecsy. *Chem. Ztg.*, **29**, 310 ... 1905
182 Bartal. *Ann.*, **345**, 334 ... 1905
183 Hugouneng and Morel. *Compt. rend.*, **142**, 48 ... 1906
184 Willcox. *J. Am. Chem. Soc.*, **28**, 1031 ... 1906
185 Bartal. *Z. anorg. Chem.*, **55**, 152; (*Chem. Abs.*, **1** (1907), 2857) ... 1907

---

[1] All Ph.D. Theses (with two exceptions) are in the library of The Chemists' Club, New York City.

[1] See Reference 242.

186	Beckmann and Junker. *Z. anorg. Chem.*, **55**, 371; (*Chem. Abs.*, **2** (1908), 501)	1907
187	Lowry and Magson. *Proc. Chem. Soc.*, **23**, 260; (*Chem. Abs.*, **2** (1908), 802)	1907
188	Weigert. *Ann. Physik.*, [4] **24**, 55 and 243; (*Chem. Abs.*, **2** (1908), 360)	1907
189	Bartal. *Z. anorg. Chem.*, **56**, 49; (*Chem. Abs.*, **2** (1908), 399)	1908
190	Bodenstein and Dunant. *Z. physik. Chem.*, **61**, 437; (*Chem. Abs.*, **2** (1908), 1223)	1908
191	Boehringer. Ger. P. 236196 (*Chem. Zentr.*, **1911**, II, 318)	1908
192	Chauvenet. *Compt. rend.*, **147**, 1046	1908
193	Einhorn. Ger. P. 224160 (*Chem. Zentr.*, **1910**, II, 518)	1908
194	Hofmann. *Z. angew. Chem.*, **21**, 1986; (*Chem. Abs.*, **2** (1908), 3343, and **3** (1909), 1532)	1908
195	Lowry and Magson. *J. Chem. Soc.*, **93**, 119; (*Chem. Abs.*, **2** (1908), 1561)	1908
196	Badische A. & S. Fab. Ger. P. 231962 (*Chem. Zentr.*, **1911**, I, 937)	1909
197	Busch. *Ber.*, **42**, 4766; (*Chem. Abs.*, **4** (1910), 774)	1909
198	Einhorn. Ger. P. 224108 (*Chem. Zentr.*, **1910**, II, 517)	1909
199	Lutz. Ph.D. Thesis, Strassburg (*Ann.*, **370** (1909), 356)	1909
200	Meister, Lucius and Bruening. Ger. P. 224490 (*Z. angew. Chem.*, **23** (1910), 2014)	1909
201	Meister, Lucius and Bruening. Ger. P. 232739 (*Chem. Zentr.*, **1911**, I, 1093)	1909
202	Meister, Lucius and Bruening. Ger. P. 236375 (*Chem. Zentr.*, **1911**, II, 322)	1909
203	Meister, Lucius and Bruening. Ger. P. 236978 (*Chem. Zentr.*, **1911**, II, 406)	1909
204	Meister, Lucius and Bruening. Ger. P. 236982 (*Chem. Zentr.*, **1911**, II, 408)	1909
205	Meister, Lucius and Bruening. Ger. P. 238550 (*Chem. Zentr.*, **1911**, II, 1186)	1909
206	Sachs. *Ann.*, **365**, 64; (*Chem. Abs.*, **3** (1909), 1870)	1909
207	Coehn. *Jahrb. Radioakt.*, **7**, 577	1910
208	Coehn and Becker. *Ber.*, **43**, 130; (*Chem. Abs.*, **4** (1910), 985)	1910
209	Farbenfab. Mayer. Ger. P. 238981 (*Chem. Zentr.*, **1911**, II, 1288)	1910
210	Mueller. *Z. angew. Chem.*, **23**, 1489	1910
211	Straus and Bormann. *Ber.*, **43**, 729 and 732; (*Chem. Abs.*, **4** (1916), 1489)	1910
212	Aloy and Rabaut. *Bull. soc. chim.*, [4] **9**, 253; (*Chem. Abs.*, **5** (1911), 2096)	1911
213	Aloy and Rabaut. *J. pharm. chim.*, [7] **3**, 481; (*Chem. Abs.*, **5** (1911), 3557)	1911
214	Busch and Limpach. *Ber.*, **44**, 569; (*Chem. Abs.*, **5** (1911), 1777)	1911
215	Chapman and Gee. *J. Chem. Soc.*, **99**, 1726; (*Chem. Abs.*, **6** (1912), 315)	1911
216	Chauvenet. *Compt. rend.*, **152**, 87; (*Chem. Abs.*, **5** (1911), 1036)	1911
217	Chauvenet. *Compt. rend.*, **152**, 1250; (*Chem. Abs.*, **5** (1911), 2472)	1911
218	Delépine. *Compt. rend.*, **153**, 727	1911
219	Einhorn and Rothlauf. *Ann.*, **382**, 263; (*Chem. Abs.*, **5** (1911), 3459)	1911
220	Gerard. *Compt. rend.*, **153**, 404	1911
221	Haber and Just. *Ann. physik*, **36**, 308; (*Chem. Abs.*, **6** (1912), 8)	1911
222	Haber and Just. *Z. Elektrochem.*, **17**, 592; (*Chem. Abs.*, **6** (1912), 1081)	1911
223	Kuehn. *Ber.*, **33**, 2900	1911
224	Mueller. *Z. exper. Path.*, **9**, 103; (*Chem. Abs.*, **5** (1911), 3697)	1911
225	Sachs and Forster. *Ber.*, **44**, 1744; (*Chem. Abs.*, **5** (1911), 3254)	1911
226	Semibratov. *Centr. Bakt. Parasitenk.*, 1 *Abt.*, **63**, 479; (*Chem. Abs.*, **6** (1912), 2248)	1912
227	Barlot and Chauvenet. *Compt. rend.*, **157**, 1153; (*Chem. Abs.*, **8** (1914), 1926)	1913
228	Berthelot and Gaudechon. *Compt. rend.*, **156**, 1243; (*Chem. Abs.*, **7** (1913), 3073)	1913
229	Crowther and McCombie. *J. Chem. Soc.*, **103**, 27 and 56; (*Chem. Abs.*, **7** (1913), 1489)	1913
230	Crowther and McCombie. *Proc. Chem. Soc.*, **28**, 315 and 331; (*Chem. Abs.*, **7** (1913), 1489)	1913
231	Fischer and Freudenberger. *Ber.*, **46**, 1116; (*Chem. Abs.*, **7** (1913), 2561)	1913
232	Hochstetter. Aust. P. applic., 9887 (*Chem. Abs.*, **10** (1916), 1254)	1913
233	Hochstetter. Ger. P. 282134 (*Chem. Abs.*, **9** (1915), 2425)	1913
234	Hochstetter. Ger. P. 283896 (*Chem. Abs.*, **10** (1916), 93)	1913
235	Hochstetter. Ger. P. 284617 (*Chem. Abs.*, **10** (1916), 94)	1913
236	Meister, Lucius and Bruening. Ger. P. 286752 (*J. Soc. Chem. Ind.*, **35** (1916), 36)	1913
237	Rassow and Reuter. *J. prakt. Chem.*, **85**, 489; (*Chem. Abs.*, **7** (1913), 770)	1913
238	Riban. *Compt. rend.*, **157**, 1432; (*Chem. Abs.*, **8** (1914), 1926)	1913
239	Richards. The Scientific Work of Morris Loeb, p. 169	1913
240	Richards. The Scientific Work of Morris Loeb, p. 171	1913
241	Richards. The Scientific Work of Morris Loeb, p. 175	1913
242	Richards. The Scientific Work of Morris Loeb, p. 177	1913
243	Hochstetter. Ger. P. 292089 (*J. Soc. Chem. Ind.*, **35** (1916), 867)	1913
244	Staudinger, Goehring and Schoeller. *Ber.*, **47**, 40; (*Chem. Abs.*, **8** (1914), 1112)	1913
245	Hochstetter. Aust. P. 70733; (*Chem. Abs.*, **10** (1916), 1254)	1915
246	Kohn-Abrest. *Ann. falsif.*, **8**, 215; (*Chem. Abs.*, **10** (1916), 222)	1915
247	Lewis and Randall. *J. Am. Chem. Soc.*, **37**, 469; (*Chem. Abs.*, **9** (1915), 986)	1915
248	Plotnikov. *J. Russ. Phys. Chem. Soc.*, **48**, 457; (*Chem. Abs.*, **11** (1917), 764)	1916
249	Slovzov. *Russki Vratch*, **15**, 649; (*Chem. Abs.*, **11** (1917), 847)	1916
250	Whitehouse. U. S. P. 1231226, June 26 (*Chem. Abs.*, **11** (1917), 2396)	1917
251	Zunz. *Ambulance de l'ocean*, **1**, 257; (*Chem. Abs.*, **12** (1918), 1897)	1917
252	Garner. *Am. Gas Eng. J.*, **108**, 489 and 505; (*Chem. Abs.*, **12** (1918), 1827)	1918
253	Kleinstueck. *Ber.*, **51**, 108; (*Chem. Abs.*, **12** (1918), 1721)	1918
254	Razous. *L'industrie chimique*, **5**, 3; (*Chem. Abs.*, **12** (1918), 1108)	1918
255	Herty. *J. Ind. Eng. Chem.*, **11**, 9	1919

WASHINGTON LETTER

By Paul Wooton, Union Trust Building, Washington, D. C.

A determined effort is being made to secure the enactment of legislation which will permit of the continued development of domestic potash. A hearing has been conducted by Senator Henderson, the chairman of the Committee on Mines and Mining, in which the producers of potash established clearly that they will not be able to continue operations unless some assurance is given that foreign potash may not be imported without restrictions. The bill before the committee provides a licensing system for imports, which, it is believed, will allow domestic production to be absorbed at the least possible cost to the consumer. This is urged as an advantage over a protective tariff. If an import duty sufficiently high to protect the high-cost producers were enacted, it is admitted that the cost to the consumers would be prohibitive.

Senator Jones, of New Mexico, advocates the formation of a government corporation which will purchase all domestic potash and resell it at the average price. Such a provision was included in the bill, as originally drafted by the Bureau of Mines, but that portion of it failed to secure the approval of the Secretary of the Interior. It is understood that Secretary Lane thought the bill would be workable without a corporation, which necessarily would have to have a revolving fund of several million dollars.

Every producer of domestic potash was represented at the hearing. That they made a good case is admitted, even by the opponents of the bill. They sought to establish that their industries would be able to meet any foreign competition, if additional time were granted to further perfect their practice and to reduce their costs. Realizing how necessary it is to prove to Congress that it will be possible to compete, the producers threw open their cost accounts for public inspection. Some producers expect to be in a position to compete with the foreign product within a few months, but all insisted that the licensing plan should be assured for five years if the industry is to compete to the best advantage. The original draft of the bill named five years as the time for its duration, but the committee changed it to two years.

While an effort will be made to get the bill up at this session of Congress, the chance is admittedly small. The measure is certain to be vigorously opposed. There already is evidence that the farmers will clamor against it. Since the consumers of potash are so numerous, their voice will have no difficulty in being heard on Capitol Hill. It is very evident that the farmers and the other consumers will not agree to pay, even for five years, the price which will be necessary to keep the domestic industry going; and many are of the opinion that it never will be possible to produce potash in this country in competition with the German and Alsatian products. The opponents of the measure also include members of Congress who are making special efforts to reduce living costs. Another angle is that Germany must have a market for its potash, if she is to pay indemnities.

Producers of war minerals won a decided victory when they succeeded in attaching to the Dent Bill a provision providing for their relief. A rider to the Dent Bill, which provides for legalizing the War Department's informal contracts, was attached by Senator Henderson. The House conferees, however, decline to accept the Henderson provision without bringing it up before the Representatives. As a result, the matter was debated in the House. Sentiment appeared to be almost equally divided. After much discussion, the House refused to instruct the conferees. This left them free to safeguard the provision in any way that they saw fit. As finally agreed upon, the matter is left in great measure to the judgment of the Secretary of the Interior. It is regarded as certain that $8,000,000 will be returned to the producers of war minerals under the provision, but some estimate that a very much larger amount will be disbursed. The section, in its entirety, is as follows:

> SEC. 5. That the Secretary of the Interior be, and he is hereby, authorized to adjust, pay, or discharge any agreement, express or implied, upon a fair and equitable basis the amount or amounts of money heretofore invested or contracted to be invested and obligations incurred in good faith by any and all persons, firms, or corporations for producing or in good faith acquiring property for producing, within the United States, for the purpose of supplying the urgent needs of the nation during the war, any ores or mineral substances mentioned and enumerated in the act entitled "An act to provide further for the national security and defense by encouraging the production, conserving the supply, and controlling the distribution of those ores, metals, and minerals which have formerly been largely imported, or of which there is or may be an inadequate supply;" approved October 5, 1918, the production of which was requested or demanded by the War Industries Board, the War Trade Board, the Shipping Board, the Emergency Fleet Corporation, or the Department of the Interior and which has been performed in whole or in part by any such person, firm, or corporation prior to November 12, 1918; and that said Secretary ascertain, determine, adjust, liquidate, and, out of the moneys provided and appropriated by said act, pay to the parties justly entitled thereto the amounts of such losses and damages as he, the said Secretary, shall find and determine to have been sustained by reason of having made said investments for said purposes, and that in each case he shall make such determination, provision, settlement, advancement, or final payment, or by agreement with claimants take such other action as he shall find and determine to be just and equitable; that the decision and action of said Secretary in each case shall be conclusive and final; that all payments shall be made, and all expenses incurred by the said Secretary shall be paid from the funds appropriated by the said act of October 5, 1918, and that said funds and appropriations shall continue to be available for said purposes until such time as the said Secretary shall have fully exercised the authority hereby granted, and performed and completed the duties hereby provided and imposed: *Provided*, however, that said Secretary shall consider, approve, and dispose of only such claims as shall be made hereunder and filed with the Department of the Interior within three months from and after the approval of this act.
>
> That a report of all operations under this section, including receipts and disbursements, shall be made to Congress on or before the first Monday in December of each year.
>
> That nothing in this section shall be construed to confer jurisdiction upon any court to entertain a suit against the United States.

An appropriation of $100,000 has been granted by Congress to the Bureau of Mines for the investigation of lignite and peat. The Bureau is completing its plans for engaging in an intensive effort to prove that the better lignites of the country can be treated commercially. While attention is to be given its by-products, the main effort will be to obtain a solid fuel and a gaseous fuel.

Many chemists are writing the Bureau, urging work on this or that secondary product but it is being pointed out to them that the by-products will be developed rapidly, once that a commercial fuel can be obtained. The work is under the general supervision of O. P. Hood, the chief mechanical engineer of the Bureau, and under the immediate direction of S. M. Darling.

The Bureau of Mines authorizes the following statement with regard to Spanish pyrites:

> The embargo on the production of pyrite was removed on January 13, but no charters are reported since that time. Efforts are now being made to obtain charters, and it is expected that ore will commence coming in within the next two months, although it is not thought that shipments will be made rapidly until late in the spring. One cargo chartered late in December is now under way. There is a brisk demand for the material by the large consumers in the Northern markets, and some demand in the South.
>
> The high rates of 35 to 40 shillings per ton on Spanish pyrite, which prevailed during 1918, have been substantially reduced since the close of the war, and recently rates as low as 20 shillings per ton have been quoted. The pre-war rates ranged from 8 to 10 shillings, but it is not likely that these low rates will again prevail for some time to come.
>
> During 1918 the price of imported pyrite delivered at Atlantic ports varied widely, depending largely on ocean rates. The prices varied from 25 to 35 cents per unit of sulfur, with an average of perhaps 30 cents. A recent quotation at New York is $16^1/_2$ cents per unit, on the basis of a 10-shilling ocean freight.

With regard to chemical manganese, the Bureau of Mines says:

> Approximately 25,000 tons of manganese dioxide ore are consumed yearly in the United States in the manufacture of dry batteries and chemical work, which ore was not subject to the schedule established to fix the price of metallurgical ore. A large part of the battery ore was imported, considerable coming from Japan, but the demand was largely met by using lower grade ores, which were obtained from domestic sources and South America. The grade of the ore used during 1918 had about the following composition: 70 to 75 per cent manganese dioxide; 2 to 4 per cent iron; and less than 0.05 per cent copper, nickel, and cobalt.

As to manganese in general, this prediction is vouched:

> There is a strong probability that some of the larger and better-equipped manganese plants may attempt to operate in competition with foreign ores, which in turn will be materially affected by the new conditions resulting from the signing of the armistice.

Correspondence between employers of chemists and Charles L. Parsons, the secretary of the AMERICAN CHEMICAL SOCIETY, shows conclusively that the large corporations are going into research work on a greatly increased scale. This is opening new places for many chemists, but the demand is largely for those having the Ph.D. degree or its equivalent.

Application has been made to the Federal Trade Commission for the use of enemy patents as follows:

E. I. du Pont de Nemours & Company, Wilmington, Del., has filed additional applications for 48 dye, acid and compound patents; National Aniline & Chemical Co., Inc., New York City, has asked for the use of 142 similar patents; and Semet-Solvay Co., Solvay, N. Y., has applied for licenses to cover 25 patents covering ammonia manufacture.

The National Aniline & Chemical Co., Inc., New York City, has applied to use 35 dye, acid and compound patents which they represent are enemy-owned or controlled. The application is in addition to previous applications covering patents related to dye manufacture.

The Consolidated Color & Chemical Company, New York City, has applied for licenses to use 7 dye patents which they claim are enemy-owned or controlled.

INDUSTRIAL NOTES

The United Sulfur Company has been incorporated at Wilmington, Del., by M. L. Rogers, L. A. Irwin, and W. G. Singer with $1,000,000 capital, to separate sulfur from metallic sulfides, ores, etc.

The Jordan Coal-Tar Products Co., Inc., of New York City, began operation January 1. The vice president and general manager will be James A. Dowd, formerly manager of the coal-tar division of Ralph L. Fuller & Co., prior to which he was with the Bayway Chemical Company and the du Pont Company.

The American Tanning Materials Corporation has been incorporated under the laws of Delaware, with a capital of $250,000. Charles B. Bishop, S. H. Baynard, and A. M. Fox, of Wilmington, are the incorporators.

The quicksilver imported for consumption in the United States for the 6 months ending June 30, 1918, amounted to 261,879 lbs., or about 3,491 flasks, valued at $365,930. In the 11 months ending November 30, 1918, the exports amounted to 216,770 lbs., or about 2,890 flasks, valued at $313,272.

List of Applications Made to the Federal Trade Commission for Licenses under Enemy-Controlled Patents Pursuant to the "Trading with the Enemy" Act

Year	Patent No.	Patentee	Assignee	Patent	Applicant
1913	1,081,897	Paul Ehrlich and Alfred Bertheim, Frankfort-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Medicinal preparation	Phenarsenyl Distributing Company, 154 Nassau Street, New York City
1913	1,081,592	Paul Ehrlich and Alfred Bertheim, Frankfort-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Medicinal preparation	Phenarsenyl Distributing Company, 154 Nassau Street, New York City
1907	860,958	Wiland Astfalck, Tegel, near Berlin, Germany, a corporation		Hydraulic press	Heulings Lippincott and Alfred J. Major, receivers of Camden Iron Works, Camden, N. J.
1905	782,739	Emil Fischer, Berlin, Germany	Firm of E. Merck, Darmstadt, Germany, a copartnership	*C,C*-Dialkylbarbituric acid and process of making same	Takamine Laboratory, Inc., 120 Broadway, New York City
1904	757,109	Gillis Gullbransson, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Blue-red lake and process of making same	Ultro Chemical Corporation, 41 Union Square, New York City

Researches by the chemists of the Forest Products Laboratory at Madison, Wis., upon the production of ethyl or grain alcohol from wood waste, which before the war made possible a materially increased output, were continued as a means of conserving foodstuffs and of relieving tonnage for overseas transport. Similar researches to produce the same product from waste sulfite liquor in pulp-making have shown and demonstrated commercially that the yield of ethyl alcohol from this source can be increased by over 50 per cent. Field studies were made and aid given during the war to several large hardwood distillation plants upon the matter of temperature control as a means of increasing output. By use of proper methods the increased output amounts to 3 gals. of 82 per cent spirit per cord and the acetate of lime product was increased as much as 5 lbs. per cord of wood distilled. In addition to this, large quantities of fuel were conserved, due to the more efficient temperature regulations. This work supplemented much more extensive efforts conducted before the war. Extensive researches were carried out upon the preparation of acetic acid by the fusion of sawdust with sodium hydroxide. It was shown that 15 to 20 per cent of the dry weight of the wood can thus be converted into acetic acid. This work is at present awaiting commercial or large-scale application.

In Tokio and Osaka a new society was recently organized by scientists and manufacturers, under the presidency of Dr. Toyokichi Takamatsu, an eminent authority on chemical industries. The aim of the new organization is to undertake investigations into the possible effects of peace on chemical industries and devise means for their help. The society has also as one of its aims a movement for the establishment of protectionist tariff on dyes and some other chemicals as a relief of chemical lines.

Great strides have been made in chemical industry in Canada during the past two years, and development on an unprecedented scale within the next few months is looked for. Supplies of raw material and equipment are being secured much more easily than was the case before the signing of the armistice. One of the outstanding features of accomplishment by Canadian chemists has been the manufacture of aspirin. A firm formed in 1916 under the name of Chemical Products of Canada, Ltd., has produced aspirin successfully. Manufacture has been as high as 14,000 to 15,000 lbs. per month, of which 3,000 to 4,000 lbs. have been required for consumption in Canada. The balance is exported to England principally, but quantities are being shipped to South Africa and Japan. It is recognized that the principal competition which the Canadian industry has to meet is with the United States firms. Manufacture of sal ammoniac has been entered upon during the past few months, owing to the embargoes placed on this product by the United States and Great Britain. Realizing the importance of securing a supply of this material, the Chemical Products Company installed equipment and has entered upon its manufacture. Between 4,500 and 5,000 lbs. a day are now turned out, which is more than sufficient to supply the requirements of the market. Other products which are made by this company include phenacetin, potassium permanganate, glycerophosphate, oil of mustard, arsenic acid, and sodium acetate. Paramido phenol has been produced for about a year.

The largest potash reduction plant in the world is located at Antioch, Nebraska. It began to operate on September 17, 1918. Nebraska is now producing about 700 tons of potash a day. Next to the packing industry the potash industry is Nebraska's largest manufacturing institution.

The International Vegetable Oil Company, with general offices in Atlanta and mill properties in Georgia, North Carolina, and Texas, has given up its Massachusetts charter and incorporated under the laws of Georgia with a capital stock of $2,500-000.

Kali Company of America, potash, etc., has been incorporated under the laws of Delaware with a capital of $1,000,000. Incorporators: Stuart H. McIntosh, Joseph W. Henry, Thomas Robinson, all of New York.

The Sulfate of Ammonia Association of London proposes to form a trading company to be owned and controlled exclusively by manufacturers. The Association will indirectly develop both the home and the foreign markets. Work looking toward development of the home market has already been undertaken as revealed in the Association's report recently issued in which reference is made to the steps which have been taken since 1915 to secure the interest of home distributers. At a meeting of the Association held a week ago it was stated that no results on a commercial scale are to be expected from synthetic sulfate of ammonia for some time.

An interesting discussion of the chemical, paint, and allied industries of St. Louis is contained in an advance summary of a survey of the St. Louis industrial district, conducted by Edgar Gengenbach, industrial commissioner of the St. Louis Chamber of Commerce, in conjunction with Ernest P. Goodrich, consulting engineer of New York City.

The F. S. Royster Guano Company has purchased five acres adjoining its new fertilizer factory, Stickney Avenue, Toledo, Ohio, and will erect a $500,000 sulfuric acid plant.

The Omaha Potash & Refining Company, capitalized for $1,000,000 and headed by Everett Buckingham, Frank May, and other well-known Omaha and South Omaha men, are erecting a new $500,000 potash plant at Lakeside, Omaha. The company was organized during the past summer and secured leases on several thousand acres of water on the Webster ranch, twenty miles south of Lakeside. The lakes were thoroughly tested out and sufficient potash deposits found to care for a plant of a capacity of 100 tons of potash per day.

A company has been organized at Boise, Idaho, under the title of the National Potash Corporation with its principal place of business at Boise. The company owns many thousand acres of cement rock land at Huntington, Ore., McCammon and Lava, Idaho. The purpose of the company is to manufacture potash for the time being and cement later. Certain patents owned and controlled by the company will enable them, it is stated, to manufacture potash on a large scale from silicate rocks.

The Champion Chemical Company, of Asheville, N. C., manufacturing chemical supplies for cotton mills, has elected the following officers: President, W. Floyd Byram; vice president, Archibald Nichols; treasurer, S. M. Hanes; secretary, Charles Nichols.

An explosion in the plant of the American Aniline Products, Inc., Nyack, N. Y., on Friday, January 31, destroyed the building and set fire to other buildings in the neighborhood and shook the town of Nyack like an earthquake. The loss is estimated at about $200,000, partially covered by insurance. Four workmen were killed and eighteen injured. The first explosion was in the drying house and is supposed to have been caused by overheating of chemicals. There are about 16 buildings in the plant and the company employs over 300 men. The plant is said to have been appraised at $165,000 about one year ago. The company has offices at 80 Fifth Avenue, New York City.

Establishment of fertilizer standards by the Federal Government, with regulations covering the sale and shipment in interstate and foreign commerce, and designed to prevent deceptions in regard to fertilizers, is proposed in a bill introduced by Representative Asbury F. Lever, chairman of the House Committee on Agriculture. The bill as introduced gives the authority to the Secretary of Agriculture, and was prepared after conference between officials of the Department and Representative Lever.

The Metals and Chemicals Extraction Company has been incorporated at San Francisco, with a capital stock of $100,000, by E. G. Lewis, Granville Moore, Albert Hanford, C. E. Gilman, and R. P. Henshaw.

For the first time paraffin wax is being manufactured in California on a commercial scale from crude oil. The plant now in operation is that of the Ventura Consolidated Oil Fields Company, of which W. P. Hammon is president. Most of the oil produced in California is of a heavy type but the product flowing in the Ventura field has a specific gravity ranging from 30° to 34° Bé.

The Southeastern Dyestuff Co., Atlanta, Ga., has filed articles of incorporation with a capital of $25,000 to engage in the manufacture of dyestuffs and allied specialties. William A. Parsons is the principal incorporator.

Leading dry color producers have organized the Institute of Dry Color Manufacturers. P. S. Tilden, of E. I. du Pont de Nemours & Company, is president; Edward Kohnstamm, vice president; and Marcus M. Marks, treasurer.

The Suckow Chemical Co., Los Angeles, Cal., has been incorporated with a capital of $400,000 to engage in the manufacture of chemicals and allied specialties. John K. and O. Suckow, and George S. Greene, Los Angeles, are the incorporators.

Washington University, of St. Louis, is contemplating the creation of an industrial research department which will be closely linked with the chemistry department and school of engineering and will coöperate with the manufacturers of St. Louis in solving chemical and mechanical problems.

Work has been started on the erection of a large storage warehouse for the Pompeian Oil Company, at Highlandtown, Md. The structure is to cost not less than $50,000. The company is using large quantities of peanut oil in its operations.

Remodeling to cost approximately $20,000 will be undertaken by the Union Seed & Fertilizer Co., of Prichard, Ala., to fit the plant for extensive peanut crushing.

Fire destroyed recently the cooperage and storehouse of the Southern Cotton Oil Company at Bayonne, causing $100,000 loss. The building stood near the works of the Tidewater Oil Company and the Standard Oil Company, where thousands of barrels of oil are stored. The main building of the works was saved by a concrete fire wall separating it from the storehouse.

The Distillers' Securities Company will convert at once three of the great distilleries in Peoria, Ill., and one distillery at Perkin, Ill., into sugar manufacturing plants, to be devoted to a new process of manufacturing sugar from corn. The company will have six large plants remaining for the manufacture of alcohol for commercial and medicinal use, capable of producing 250,000 gallons a day.

A conference of State and local food and drug authorities from fifteen Middle Western States was held in St. Louis recently to consider the extension of food control legislation to the individual States as a substitute for the regulations of the National Food Administration. The meeting was held at the request of the United States Department of Agriculture. Dr. Carl L. Alsberg, chief of the Bureau of Chemistry of the Department of Agriculture, presided.

Consumers Graphite Company has been incorporated under the laws of Delaware with a capital of $500,000. Incorporators: Samuel W. Osgood, Albert C. Bell, James W. Luther, all of Chicago.

New uses have been found for the breweries made idle by recent legislation. Some who were unprepared are now actively seeking new lines of manufacture. One large plant is being converted into a food dehydrator; another is very successful with malted milk; sweet, pasteurized cider has attracted a third; and maltose syrup is the product of several others. Maltose syrup has proved very useful during the sugar shortage, and it seems certain to maintain its place upon its merits.

Elk Chemical & Color Company has been incorporated under Delaware laws to deal in clay and other minerals; capital, $500,000; incorporators, W. I. N. Lofland, Charles H. Jones, Dover; Andrew Urrman, Ridgeway, Pa.

PERSONAL NOTES

President William H. Nichols has appointed the following committee to prepare a report to the Advisory Committee, A. C. S., on an estimate of costs and an outline of policies of the proposed institute for drug research: Charles H. Herty, *Chairman;* John J. Abel, Johns Hopkins University Medical School; Reid Hunt, Harvard University Medical School; P. A. Levene, Rockefeller Institute; Raymond F. Bacon, Mellon Institute; F. R. Eldred, Indianapolis, Ind.; Treat B. Johnson, Yale University; F. O. Taylor, Chairman, Pharmaceutical Division, A. C. S.

Word has been received of the death of Sidney E. Lunak, chemist at the Forest Products Laboratory, Madison, Wis. Mr. Lunak received his technical education at the Armour Institute of Technology, Chicago, and was graduated from that institution as bachelor of science. He had been connected with the Forest Products Laboratory for more than eight years. He was the author of several papers on testing methods in sulfite work and sulfite cooking, having specialized to a great extent in the chemical engineering of sulfite pulp manufacture.

Mr. Arthur Lachman is now connected with the Great Western Electro-Chemical Co., San Francisco, Cal.

Mr. F. L. Shannon, formerly general superintendent for the Thomas Canning Co., Grand Rapids, Mich., is now quality man for P. J. Ritter Co., Philadelphia, Pa.

Mr. E. T. Casler, formerly chemist for the Phosphate Mining Co., Nichols, Florida, is now with the Air Nitrates Corporation as chemist.

Mr. D. D. Berolzheimer, librarian of the American Chemical Society, 1910 and 1911, librarian of The Chemists' Club, 1910 to 1915, and librarian of the Barrett Co., New York, since April 1915, has severed his connection with the latter firm and is now assistant technical editor with the Chemical Catalog Company, New York City.

Mr. I. D. Hager, formerly chief chemist of the Mound City paint and varnish division of the Certainteed Products Corporation, at St. Louis, is now paint specialist in the Sales Engineer's Department of the New Jersey Zinc Co., New York City.

Mr. J. V. Bassett, who has been a member of the Research Division of the Chemical Warfare Service, at Washington, has returned to his former position with the Hewitt Rubber Co., Buffalo, N. Y.

Dr. Harry Everett Barnard, of the State Laboratory of Hygiene, Indianapolis, has been made editor of the *American Food Journal.*

Major F. E. Breithut, Chemical Warfare Service, has been detailed by the War Department to the War Trade Board to act as chairman of the Chemical Group of the Price Section. Those who will be associated with Major Breithut are: Mr. F. W. Cassebeer, Capt. P. W. Carleton, Lt. Charles L. Fry, Lt. W. N. Jones, Dr. H. L. Lewenberg, Capt. W. Lee Lewis, Dr. W. B. Meldrum, and Capt. H. L. Trumbull.

Mr. John Helfrich has become associated with the Chemical Catalog Co., Inc., as manager of the Information Bureau.

Major A. C. Fieldner, Chemical Warfare Service, U. S. A., who was in charge of the gas mask research at the American University Experiment Station, Washington, D. C., has returned to the Pittsburgh Station of the Bureau of Mines, where he will have charge of the chemical research laboratory.

Mr. H. L. Olin, having been discharged from the Army at Edgewood Arsenal, where he had the rank of Captain, C. W. S., is now chemist in the research department of the Barrett Company at Edgewater, N. J.

Mr. B. E. Reuter, since October 1, 1917, chief of the Fats and Oils Division of the United States Food Administration, which work he is now closing, is opening his consulting engineering office in Baltimore, Md. In addition to being chief of the Fats and Oils Division, Mr. Reuter was chairman of the Inter-Departmental Fat and Grease Committee, a member of the Inter-Departmental Committee on Fats and Oils, and a member of the Inter-Departmental Glycerin Committee, also adviser on Fats and Oils, Soap, and Glycerin to all departments in Washington. At Mr. Hoover's request, Mr. Reuter will still act as consulting adviser to him during the readjustment or reconstruction period and will devote at least one day each week in Washington to this work.

Mr. George B. Bradshaw, formerly president of the American Synthetic Color Co., Stamford, Conn., is now superintendent of intermediates at the du Pont Dye Works at Deepwater Point, N. J.

William Klaber, Ph.D., formerly chemist for Castle Kid Co., Camden, N. J., is now consulting and research chemist with office and laboratory at 430 Walnut Street, Philadelphia, Pa.

Dr. R. E. Nelson, having received his discharge from the Army, December 10, 1918, where he served as 1st Lieutenant in the Research Division of the Chemical Warfare Service, at the American University Experiment Station, has accepted an assistant professorship in chemistry at Purdue University.

Mr. Frank M. Jones, formerly civilian chemist at the American University, Washington, D. C., Pyrotechnic Section of the Research Division, C. W. S., has accepted a position in the research department of the Brown Company (paper and pulp mills) at Berlin, N. H.

Lt. Charles F. Hawkins died at the home of his parents on December 27, 1918, of pneumonia following influenza. In August 1917, he accepted a position as professor of chemistry at Williams College, resigning in February 1918, to enlist with the Chemical Warfare Service. He was mustered out of the service December 21 and returned to his home December 23.

Mr. Theodore W. Fowle has resigned his position with the General Chemical Company, where he has been working on synthetic ammonia, to go into work with the American Committee for Relief in the Far East. He will probably be in sanitary work.

Mr. Carl Moe, formerly of the Bogalusa Paper Company where he had charge of the operations of the sulfate pulp mill, is now connected with the Stevens Point Pulp & Paper Company in the capacity of works and research chemist.

Mr. Frank L. Wright, formerly chemist with the Locomobile Company of America, is now located in Philadelphia as assistant metallurgist with the Standard Roller Bearing Division of the Marlin-Rockwell Corporation.

Mr. John F. McBride, who until last August was working in his private laboratory on some problems in organic synthesis, is now with the research department of the National Aniline and Chemical Company.

Mr. W. B. Meldrum, formerly head of the chemistry department at Haverford College and later in the Chemical Warfare Service on duty at the American University Experiment Station, having been transferred to it from the Infantry, received his discharge from the Army, January 6, and has accepted a temporary position as chemical expert with the Price Section of the War Industries Board.

Lt. Charles L. Burdick, of the Nitrate Division of the Ordnance Department, stationed at the experimental laboratories of Nitrate Plant No. 1, Sheffield, Ala., after receiving his discharge from service in the Army, entered the metallurgical research department of the Chile Exploration Co., New York City. On January 11 he sailed for Chile to work eight or nine months in the copper producing regions about Chuquicamata Province of Antofagasta, and in the vicinity of Braiden.

Mr. Frederic Bonnet, Jr., formerly chief chemist of the U. S. Ammonium Nitrate Plant, operated by the Atlas Powder Company at Perryville, Md., has been transferred to the forcite works of the Atlas Powder Company at Landing, N. J., where he is taking charge of the experimental laboratory for industrial development.

Mr. R. A. Barkhuff, formerly assistant chemist with the American Thread Co., Willimantic, Conn., is now assistant superintendent of the dry lime sulfur department of the Sherwin-Williams Company.

Mr. David E. Worrall has resigned as 1st Lieutenant, Chemical Warfare Service, U. S. A., to accept a position as instructor in chemistry at Harvard University for the remainder of the college year.

Major J. H. Mathews, Ordnance Dept., U. S. A., has been released from military service and has returned to the University of Wisconsin. While in the military service Major Mathews was in charge of the Gas and Flame Branch of the Trench Warfare Section, Engineering Division, Ordnance Department. Before taking up this work he spent several months in Europe studying gas warfare. Since his return to civil life he has been promoted to a full professorship at the University of Wisconsin, and has charge of the courses in physical chemistry at that institution.

Mr. George W. Morey, of the Geophysical Laboratory, Carnegie Institute, Washington, has been granted leave of absence for one year to take charge of the optical glass plant of the Spencer Lens Co., Hamburg, N. Y.

Mr. William E. Spandow has resigned from the United States Military Academy, at West Point, N. Y., to continue his studies toward a M.Sc. degree in chemistry at the University of Denver.

Mr. Louis S. Potsdamer has been discharged from the Army and has taken up civilian labors as chemical engineer with The Chemical Pigments Corporation.

Mr. Bruce O. Ranck, formerly chemist with the du Pont Engineering Company at the government smokeless powder plant, is now employed by E. I. du Pont de Nemours and Company in their research department on azo dyes.

Elias Yanovsky, formerly connected with the Bureau of Chemistry, U. S. Department of Agriculture, doing research work in chemistry of sugars and food, is now employed by the Norwalk Tire & Rubber Company as a research chemist.

Mr. Herbert J. Krase, formerly chief of the shell loading unit of the Chemical Warfare Service, Dispersoid Section, American University, Washington, D. C., is now chemical engineer for the Special Chemicals Co., Highland Park, Ill.

Mr. B. E. Long, formerly connected with sugar companies in Mexico, is now superintendent and chief chemist for the Cayey Sugar Co., Cayey, P. R.

Mr. R. H. Gerke, who served as 2nd Lieutenant in the Chemical Warfare Service, Dispersoid Section of the Research Division, has been honorably discharged from the Army and is now continuing graduate work at the University of Illinois.

Mr. Henry Wigglesworth, of the General Chemical Company, will take a leave of absence to serve for a time as a trade commissioner for the Bureau of Foreign and Domestic Commerce to study the dyestuff and textile conditions in France.

Mr. Oscar F. Boyd, recently returned from service where he was enlisted with the Gas Defense Division of the Chemical Warfare Service, is back in his former position as professor of chemistry at Wilmington College.

Col. G. A. Burrell, of the Chemical Warfare Service, has returned to private chemical engineering work at Pittsburgh, Pa. In coöperation with R. H. Brownlee he has installed at Pittsburgh complete equipment for the laboratory and plant testing of chemical processes and especially of petroleum, gasoline, and natural gas.

Mr. H. F. Staley, formerly professor of ceramic engineering at Iowa State College, and who had been engaged in war research at the Bureau of Standards since June 1918, joined the staff of the Bureau in December as metallurgical ceramist.

Dr. Edgar T. Wherry, of the Bureau of Chemistry, U. S. Department of Agriculture, has been appointed editor-in-chief of *The American Mineralogist.* Among the associate editors is Dr. W. T. Schaller, of the U. S. Geological Survey.

Edward Charles Pickering, professor of astronomy in Harvard University and director of the Harvard College Observatory, died on February 3 at the age of seventy-two years.

Lt.-Col. J. H. Hildebrand who has recently been Commandant of Hanlon Field, near Chaumont, France, which included the Experimental Field and the A. E. F. Gas Defense School of the Chemical Warfare Service, has returned after an absence of a year in France to his position of professor of chemistry in the University of California.

Mr. Edward Wallace Pierce, who has been chief chemist of the U. S. Conditioning and Testing Company for two years, is now vice president and technical director of the Zobel Color Works, New York City.

Mr. Mark Guthrie, for over fifteen years with the Behrens Drug Co., Waco, Tex., has resigned to accept a position with the National Aniline and Chemical Company, with headquarters in Kansas City, Mo.

Lt. George O. Richardson, who, before his enlistment in the U. S. Chemical Warfare Service where he was stationed in Washington, D. C., was chemist for the Roessler and Hasslacher Chemical Co., Perth Amboy, N. J., has been appointed technical assistant of the National Aniline and Chemical Co., Inc., at Shanghai, China.

Dr. Leo Forst, former head of the Cincinnati office of the U. S. Pure Food and Drug Laboratory, returned to his old position on January 15, from war work in Washington.

The death from influenza is announced of Edwin Henry Ingersoll, chemist in the Bureau of Animal Industry, U. S. Department of Agriculture.

Professor R. Nietzki, professor of chemistry at Bâle, known for his work on the chemistry of dyestuffs, has died at the age of seventy-one years.

Mr. John T. Ward, who has been with the National Carbon Co., Inc., as chemical engineer at the Cleveland works, has been transferred to the New York office of the company as assistant to the works manager.

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.

UNITED STATES TARIFF COMMISSION

Dyes and Other Coal-Tar Chemicals. Report to Congress recommending amendments to Title V of Act of September 8, 1916. 83 pp. Issued December 1918.

This report, issued as one among the publications of the United States Tariff Commission on industries affected by the tariff, is divided into six parts.

1—A statement to Congress recommending amendments to Title V of the Act of September 8, 1916. In this statement possible evasions of the intent of the law and difficulties in certain administrative features are explained.

2—A draft of a bill to amend Title V of the Act of September 8, 1916. This proposed bill is designed to prevent evasions which are possible under the Act of September 8, 1916.

3—Text of Title V of the Act of September 8, 1916.

4—Text of Title V of the Act of September 8, 1916, edited to show proposed amendments.

5—Detailed technical discussion of reasons for the proposed amendments.

6—Decisions of the Treasury Department, United States Board of General Appraisers, and the United States Court of Customs Appeals upon classifications under Title V of the Act of September 8, 1916.

UNITED STATES EMPLOYMENT SERVICE

The Bureau of Labor Statistics has prepared various pamphlets, describing occupations, some of which are of chemical interest as follows:

Boots and shoes, harness and saddlery, tanning
Cane-sugar refining, flour milling
Medicinal manufacturing
Metal working, building and general construction, railroad transportation, shipbuilding
Mines and mining

CONGRESSIONAL COMMITTEE REPORT

Lignite. The Mines and Mining Committee of the House of Representatives has reported on Senate Bill 3230, authorizing the Secretary of the Interior to make investigations, through the Bureau of Mines, of lignite coals and peat to determine their practicability of their utilization as fuel and in the production of commercial products. House Report 840. 10 pp. Submitted December 4.

UNITED STATES NATIONAL MUSEUM

Natural Gas: Its Production, Service and Conservation. S. S. Wyer. Bulletin 102, Part 7. The Mineral Industries of the United States. 66 pp.

PUBLIC HEALTH SERVICE

Treatment and Disposal of Creamery Wastes. E. B. Phelps. Public Health Reports, 34, 2169–74. Issued December 6. An experimental investigation of the treatment and disposal of creamery wastes was carried out during the years 1916–17 by the United States Public Health Service, coöperating with the Dairy Division, Bureau of Animal Industry, United States Department of Agriculture.

Resolutions Passed by National Commission of Milk Standards. Public Health Reports, 34, 69–71. Issued January 17.

GEOLOGICAL SURVEY

Phosphate Rock in 1917 with Notes on Phosphorus. R. W. Stone. Mineral Resources of the United States, 1917, Part II. 12 pp. Issued June 25, 1918.

The phosphate rock marketed in the United States in 1917 amounted to 2,584,287 long tons, valued at $7,771,084, an increase of 601,902 tons in quantity and of $1,874,091 in value over the production in 1916. The increase of 30 per cent in quantity is notable in view of the conditions brought about by the entry of the United States into the war. The quantity and value were greater than in 1915 or 1916 but less than in any other year since 1909.

In 1917 a general effort was made to increase the production of phosphate rock, owing to the conviction that the people of the United States must increase greatly their production of foodstuffs. Besides supplying food for ourselves we were more and more imperatively required to make large shipments to our allies, and at the close of the year it was apparent that even greater effort must be made to add to the supply of food required for shipment abroad. A great increase in the production of foodstuffs implies a greater use of fertilizer and therefore more energetic mining of phosphate rock.

The fertilizer materials imported into the United States in 1917 comprised many compounds containing phosphorus, nitrogen, and potash. Those containing phosphorus include bone ash, guano, basic slag, and crude phosphate rock. The potash fertilizers include various potash salts, kainite, manure salts, and double-manure salts. The nitrogen compounds are chiefly cyanamide, nitrates, and ammonium salts.

The quantity of calcium cyanamide, or lime nitrogen, used in the United States has increased from 5,000 tons in 1911 to 47,268 tons in 1917. It is a bluish black, odorless powder containing 20 to 22 per cent of nitrogen. The plants of the American Cyanamid Co., which manufactures it, are at Niagara Falls, Canada. It is used by more than 300 manufacturers of fertilizer in the United States, and is now a source of organic nitrogen in about one-fourth of the total ammoniated fertilizers consumed in the country.

FERTILIZERS IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES, 1917

FERTILIZER	Quantity Long Tons	Value Dollars
Apatite	.....	.....
Bone dust or animal carbon, and bone ash, fit only for fertilizing	10,521	308,497
Calcium cyanamide or lime nitrogen	47,268	2,472,936
Guano	7,067	160,923
Kainite	.....	.....
Manure salts, including double-manure salts	225	9,047
Phosphates, crude	92	1,169
Slag, basic, ground or unground	2	54
All other substances used only for manure	85,859	1,961,607
TOTAL	151,034	4,914,233

This table does not include all the imported material that is incorporated in fertilizers manufactured and sold in this country. To the materials indicated should be added the potash salts listed as such in the import tables of the Bureau of Foreign and Domestic Commerce—potassium chloride and potassium sulfate—which are largely used in manufactured fertilizers. Moreover, considerable import sodium nitrate (Chile saltpeter) is used in fertilizers. A large part of the sodium nitrate imported, however, is converted into nitric acid and nitrates for use in making gunpowder and other explosives, matches, and pyrotechnic material, in assaying and analytical operations, and in curing meats. The large importation of sodium nitrate is very significant. Sodium nitrate and potash salts are commodities for which the United States in past years has been entirely dependent on foreign countries. The production of potash salts, an infant industry in the United States, is described in another chapter of Mineral Resources.

Gold, Silver, Copper, and Lead in South Dakota and Wyoming in 1917. C. W. Henderson. Mines Report. Mineral Resources of the United States, 1917, Part I. 13 pp. Issued January 27, 1919.

Fluorspar and Cryolite in 1917. E. F. Burchard. Mineral Resources of the United States, 1917, Part II. 12 pp. Issued November 20, 1918.

Fluorspar mining made another high record in 1917 on account of the strong demand for this mineral for use as flux in basic open-hearth steel furnaces and in the chemical, ceramic, and other industries. Prices reached the highest levels ever recorded and naturally stimulated prospecting and new developments. The number of operators who shipped fluorspar increased from 22 in 1916 to 52 in 1917, and this number does not include several very small producers who sold their output to companies that also mine fluorspar.

The total quantity of domestic fluorspar reported to the Survey as sold (shipped from mines) in 1917 was 218,828 short tons, valued at $2,287,722, compared with 155,735 tons valued at $922,654, in 1916, an increase in quantity of 40.5 per cent and in value of nearly 148 per cent. The general average price per ton f. o. b. mines or shipping points for all grades of spar in 1917, according to these figures, was $10.45, compared with $5.92 in 1916, an increase of 76.5 per cent. These prices, however, are far below those that were paid for spar for prompt delivery, quotations at mines and furnaces ranging from $21.50 early in 1917 to $38 and $40 in 1918.

Mention was made in this report of Mineral Resources for 1916 of the need for fluorite, or fluorspar, suitable for optical purposes. During the last year hardly a week has passed in which one or more specimens of fluorspar have not been received by the Geological Survey for consideration as to their value for optical use. Of these, several have proved of sufficient promise to warrant careful testing at the Bureau of Standards, and a few have been found to be of value. The Bureau of Standards has issued the following statement concerning the properties and requirements of optical fluorite:

Optical properties and uses—Fluorite is very transparent to infra-red and ultraviolet rays. It has a low refractive power and a weak color dispersion. It is, therefore, useful in correcting the color and spherical aberration errors in lenses; especially for microscopes, small telescopes, etc.

Quality of material required—Fluorite suitable for optical instruments must be as clear as glass, that is, it must be free from cloudiness, inclusions, cracks (incipient cleavage marks), etc. Colorless material is most desired, but samples which are faintly tinged with yellow or green may be valuable. To assist in examining for cracks, inclusions, etc., the samples may be placed in a glass vessel and covered with glycerin or kerosene which reduces the reflection from the surface of the crystal.

Size of material—At present this bureau requires a small amount of material from which clear pieces 15 to 50 mm. ($^{1}/_{2}$ to 2 in.) in diameter can be cut. The price varies from $1 to $5 per lb., while a particularly fine specimen, fulfilling the above requirements, might have a value of $10 or more.

While fluorite is a common mineral, specimens of optical quality are uncommon. Those engaged in mining this material should, therefore, keep on the lookout for clear material, which, in smaller sizes than above specified, may be used by manufacturers of microscopes.

No cryolite is produced in the United States, the entire supply used in this country being imported from Greenland.

The quantity of cryolite reported to have been imported for consumption in the United States in 1917 was 4,383 long tons, valued at $218,500, as compared with 3,857 long tons, valued at $165,222, in 1916. The average price per ton declared in 1917 was apparently $49.85 as compared with $42.84 in 1916. Cryolite is imported free of duty.

BUREAU OF MINES

California Mining Statutes Annotated. J. W. Thompson. Bulletin 161. 312 pp. Paper, 20 cents. Issued August 1918. This bulletin includes all California mining laws.

Extinguishing and Preventing Oil and Gas Fires. C. P. Bowie. Bulletin 170. 50 pp. Paper, 20 cents. Issued October 1918.

The Inflammability of Aluminum Dust. A. Leighton. Paper 152. 15 pp. Paper, 5 cents. Issued January 1919.

Although these experiments do not show the exact conditions under which an ignition of the aluminum dust is obtained, they do show that it may ignite at temperatures even lower than those necessary for the ignition of 200-mesh standard Pittsburgh coal dust; also more heat is needed to ignite aluminum dust. The dust used in these tests was a commercial product labeled "aluminum bronze." A summary of the precautions to be observed in handling this material is included.

Method of Least Squares Applied to Estimating Errors in Coal Analysis. J. D. Davis and J. G. Fairchild. Technical Paper 171. 36 pp. Paper, 5 cents. Issued September 1918.

Notes on the Black-Sand Deposits of Southern Oregon and Northern California. R. R. Hornor. Technical Paper 196. 42 pp. Paper, 10 cents. Issued August 1918.

The results of the investigation may be summarized by the statement that in general the black-sand deposits are disappointing in both value and quantity; they rarely contain enough gold and platinum or occur in adequate quantity to be exploited at a profit.

There are, it is true, a few favored places where small areas of the black sand show some precious-metal content, and these may become the site of small operations. The deposits in many places contain appreciable amounts of magnetite, chromite, and ilmenite, but these minerals are generally too scattered and too poor to constitute an important source of iron ore, especially in competition with the known deposits of magnetite on the Pacific coast.

The chief difficulties in the profitable exploitation of these deposits are: (1) lack of uniformity in occurrence and metallic content; and (2) the high cost of mining and treating the materials.

BUREAU OF STANDARDS

Proceedings of the Second Annual Textile Conference. Held at the Bureau of Standards, Washington, May 21–22, 1917. Miscellaneous Publications, No. 19. 87 pp.

DEPARTMENT OF AGRICULTURE

Accuracy in Commercial Grading of Opened Eggs. M. K. Jenkins and N. Hendrickson. Department Bulletin 391. 27 pp. Paper, 15 cents. Contribution from the Bureau of Chemistry. Issued December 10, 1918.

Farm Practice in Growing Sugar Beets in Three Districts in Colorado, 1914–15. L. A. Moorehouse, R. S. Washburn, T. H. Summers and S. B. Nuckols. Department Bulletin 726. 60 pp. Paper, 10 cents. Issued December 14, 1918. This paper is a contribution from the Office of Farm Management and the Bureau of Plant Industry, and gives results of an investigation relative to the practice and costs of growing sugar beets in the district named.

Soils of Southern New Jersey, and Their Uses. J. A. Bonsteel. Department Bulletin 677. 78 pp. Paper, 40 cents. Issued October 24, 1918. Contribution from the Bureau of Soils.

The Beet-Sugar Industry in the United States. C. O. Townsend. Department Bulletin 721. 56 pp. Paper, 15 cents. Issued November 22, 1918. Contribution from the Bureau of Plant Industry. This paper is a general statement as to the condition of this industry at the present time.

Farm Practice in Growing Sugar Beets in the Billings Region of Montana. S. B. Nuckols and E. L. Currier. Department Bulletin 735. 40 pp. Paper, 10 cents. Issued November 15, 1918. This paper is a contribution from the Bureau of Plant Industry and gives data gathered from 305 farms in the Billings region of Montana, showing total hours of labor and other costs of production of beets in 1915.

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

Standard Specifications for Open Hearth Steel Girder and High Tee Rails. Adopted 1912. Industrial Standards, Series 3. 19 pp. Paper, 5 cents. Text as adopted by American Society for Testing Materials. Spanish-English editions prepared under supervision of Bureau of Standards. The series covers industrial standards for materials, which include standards prepared by the Government and by technical societies and other organizations.

Standard Specifications for Low-Carbon Steel Splice Bars. Industrial Standards, Series 4. 15 pp. Paper, 5 cents. Revised 1914.

COMMERCE REPORTS—DECEMBER 1918

Very considerable amounts of **candellila wax** are now available in Mexico. It is suggested for use in candles, varnish, shoe polish, electrical insulation, in pharmaceutical ointments, in leather greases and lubricants, and for sealing wax and wax paper. (P. 862)

The use of **"paper textiles,"** *i. e.*, textiles made from paper yarns, has increased greatly in all European countries. In England it has been used principally as a substitute for hemp, jute, etc., in bags and sacks used for numerous materials. In Germany and Austria it has been used in clothing, containing, *e. g.*, 40 per cent of paper yarn, 40 per cent of cotton, and 20 per cent of shoddy. The best and strongest yarns are made from "Kraft" paper. (Pp. 872–77)

A detailed account is given of the processes and patents for the manufacture of **paper yarn** in Europe. (Pp. 922–26)

The plan proposed by the British Board of Trade for government aid to the **dye industry** contemplates only such assistance as is necessary to the textile and other trades, in the production of new or unavailable dyes. Assistance is to be in the form of loans and grants for buildings and for research. None of these loans or grants will exceed 40 per cent of the total costs, or 50 per cent of the material assets of the firm. Other details of the plan are described. (Pp. 933–7)

The **lac cultivation** in India is described in detail. The lac is formed by the secretion of an insect from the tree branches. The output has been greatly increased during the last year. (Pp. 940–42)

In connection with the shortage of **metals** in Germany and Austria, it is predicted that much greater use will be made than formerly of aluminum, antimony, and zinc. New methods of producing hollow ware from aluminum are being developed. (Pp. 973–5)

The loss to Germany of Alsace and Lorraine depends chiefly upon the loss of **petroleum, potash,** and **iron ore.** Prior to the war, Alsace produced 42 per cent of the oil output of Germany. Loss of the Alsace potash deposits will effectually prevent a German monopoly. The German Lorraine iron mines produced before the war 19,000,000 tons of iron ore, far in excess of the entire British production. Lorraine and Luxemburg furnished 77 per cent of the total metallic iron output of Germany. (Pp. 993–5)

A survey of Latin-American markets shows a very great demand for **caustic soda** to be used chiefly in soap making. Considerable amounts of sodium carbonate and **silicate** are also required. (Pp. 1026–32)

In a summary of the census of imports of **chemicals** into the United States in 1914, it is stated that more than 20,000 chemical invoices had been segregated from 500,000 general invoices. The value of such a census to the American industries is emphasized. (P. 1055)

In Sweden it is proposed to make **alcohol** from white moss at a cost less than that from grain or potatoes. (P. 1107)

A description is given of numerous Chinese products, including **soy bean, camphor, cassia, castor oil, cottonseed oil, gall nuts, ramie fiber, linseed, licorice,** and **peanuts.** (Pp. 1110–18)

Efforts to locate suitable **glass sands** in Great Britain have shown that there is no difficulty in securing suitable sand for most glasses, including good crystal glass. A few small deposits of sand suitable for optical glass have been located, but they are not as uniform or reliable as French and German sands. (Pp. 113–5)

A summary of the work of the Bureau of Standards on **optical glass** describes the scope of the work which included the manufacture of the **clay pots** as well as much of the glass required for military optical instruments. (P. 1176)

In the development of the **kauri gum** industry of New Zealand methods have been devised for recovering the gum and oil from the low-grade dirt, by a system of flotation, using salt water. (P. 1177)

SPECIAL SUPPLEMENTS ISSUED IN DECEMBER

FRANCE—5*c*
GREECE—7*c*
ITALY—8*c*
NORWAY—10*a*
PORTUGAL—11*a*
BERMUDA—22*a*
CANADA—23*d*
COSTA RICA—24*a*
DUTCH WEST INDIES—27*a*
FRENCH WEST INDIES—28*c*
HAITI—30*a*
ECUADOR—43*a*
CHINA—52*b*
JAPAN—55*c*
BRITISH SOUTH AFRICA—66*b*

STATISTICS OF EXPORTS TO THE UNITED STATES

JAVA—P. 839
Rubber
Tin
Coconut oil
Hides
Sisal
Kapok
Cinchona bark
Quinine
Copra

FRANCE—Sup. 5*c*
Argols
Verdigris
Calcium tartrate
Paper stock
Glassware
Essential oils
Almond oil
Olive oil
Perfumes
Casein

GREECE—Sup. 7*c*
Gum mastic
Licorice
Olive oil
Fusel oil
Opium
Chrome ore
Emery
Magnesite
Resin

ITALY—Sup. 8*c*
Citrate of lime
Licorice
Essential oils
Olive oil
Pumice stone
Citric acid
Licorice
Mannite
Sumac
Tartar

DUTCH WEST INDIES—Sup. 27*a*
Aloes
Balsam copaiba
Chicle
Divi-divi
Hides
Mangrove bark
Sugar
Castor seed
Fustic

PORTUGAL—Sup. 11*a*
Antimony
Argols
Camphor
Ergot
Glycerin
Gum copal
Cork
Hides
Rubber
Manganese ore
Olive oil
Palm oil
Wood oil
Sulfur ore
Tungsten

CANADA—Sup. 23*d*
Aluminum
Antimony
Asbestos
Beeswax
Bones
Gums
Magnesite
Chrome ore
Copper ore
Glue stocks
Grease
Hides
Lead
Paper stock
Paper
Pigments
Graphite
Roofing felt
Rubber
Sugar
Sulfur ore
Tar
Wood pulp
Zinc
Zinc ore
Gold

COSTA RICA—Sup. 24*a*
Gold
Hides
Manganese ore
Rubber

HAITI—Sup. 30*a*
Beeswax
Castor beans
Castor oil
Copra
Cottonseed oil
Fustic
Hides
Logwood
Sisal

ECUADOR—Sup. 43*a*
Annatto
Cinchona bark
Hides
Indigo
Ivory nuts
Kapok
Gold
Rubber
Zinc
Mangrove bark

TIENTSIN, CHINA—Sup. 52*b*
Egg albumen
Hides
Licorice
Peanuts
Peanut oil
Castor oil

JAPAN—Sup. 55*c*
Antimony
Agar agar
Camphor
Menthol
Potassium carbonate
Potassium chlorate
Vegetable wax
Crucibles
Copra
Peanuts
Fish oil
Castor oil
Coconut oil
Cottonseed oil
Peanut oil
Rapeseed oil
Soy bean oil
Scheelite
Starch

COMMERCE REPORTS—JANUARY 1919

In a review of the **platinum** situation it is stated that the Choco fields in Colombia are only in their infancy, and that with modern mining methods production can be greatly increased. (P. 33)

Owing to the overstocked markets in the United States, the demand for **tungsten ore** from China has greatly decreased. However, owing to the low cost of production in China, a good future for this industry is predicted. (Pp. 37 and 423)

Detailed statistics are given of the exports of **carbolic acid, caustic soda,** and **soda ash** from the United States to various countries. (P. 90)

In order to utilize the oversupply of potatoes in Great Britain, it is proposed to manufacture **potato flour** upon a large scale. After the preliminary process of producing flakes by drying the potato pulp on hot rollers, the flour can be extracted in regular flour mills. (P. 102)

Extraction of **alcohol** from **peat** is proposed in Sweden. By heating peat with sulfuric acid under pressure "sugars" are obtained which are fermentable. (P. 107)

In a discussion of the **"staple fiber"** industry of Germany, it is shown that even with scarcity of chemicals, etc., considerable progress was made in the manufacture of a fabric similar to wool from the staple fiber which is simply **artificial silk** which has not been spun or twisted. There is no possibility, however, of its replacing cotton or wool to any great extent. (P. 122)

In a discussion of the shortage of **window glass** in England the use of a new American drawn glass process is suggested since it requires less skilled glass blowers. (P. 149)

Bauxite deposits of British Guiana are being conserved with a view to the ultimate production of aluminum. (P. 154)

In view of the shortage of **coal,** the large supplies of peat in Great Britain and Canada are used. The use of peat as **powdered fuel,** after drying to 25 per cent or less of moisture, is recommended for boilers, cement kilns, metallurgical furnaces, etc. It can be used to produce a good **producer gas,** which, however, contains about 10 per cent of carbon dioxide. By its use in gas manufacture a large amount of ammonia can be recovered. (P. 168)

Among the Chinese agricultural products of chemical interest are **rapeseed** and **rapeseed oil, rhubarb root, soy bean, sesame seed** and **oil, cane** and **beet sugar, vegetable tallow, "tree varnish,"** and **China wood oil.** (Pp. 177–84)

From present indications it is probable that the world's production of **molybdenum,** which has been greatly increased to meet war needs, will be more than sufficient for peace requirements. Further opening up of molybdenum deposits is therefore discouraged. (P. 206)

It is proposed to secure **salt** from sea water in Norway by using electrical power for evaporation. It is estimated that a kilowatt-year will yield 10 tons of salt beside the condensed brine, from which **potash** and **bromine** will be extracted. (P. 218)

A market decline is noted in the **price of chemicals** in the Japanese market as a result of restored American and English competition. (P. 279)

The operation of a new **electrolytic chlorine plant** at Pomilio, Italy, is described. The chlorine is compressed to liquid, or converted to hypochlorite; the **hydrogen** is compressed into cylinders for use in balloons; and the **caustic soda** is recovered in the usual way. (P. 340)

There are several important deposits of **tungsten ore** in Siberia. Most of it is wolframite, with some scheelite. The ore contains considerable manganese which is considered detrimental. (P. 362)

In connection with the deposits of **kauri gum** in New Zealand a large amount of "gum dirt" is recovered from which kauri gum oil may be obtained by distillation. (P. 376)

Among the plants investigated in Germany for the extraction of **rubber** are the "Sicilian artichoke," the "spindle tree," the "sow thistle," and the "wolf-milk tree." All of these contain some rubber, which however has never been extracted on a commercial scale. (P. 382)

It has been announced that in view of the great demand for **potash** in France, it is very unlikely that any potash will be shipped from Alsace to the United States before at least June 1919. (P. 385)

Total imports of **platinum** into the United States in the year ending June 1918 were 48,745 troy ounces, valued at $4,308,518. (P. 387)

Awards of loans have been made by the Brazilian government to four firms for the erection of **caustic soda** plants, three electrolytic and one Solvay. (P. 388)

There has been a great increase in the cultivation of **drugs** in Bengal, India, including cinchona, ipecacuanha, digitalis, and belladonna. A factory for handling the cinchona bark produces quinine, "cinchona febrifuge," quinidine, cinchonidine, and other alkaloids. (P. 428)

Mineral resources of Guatemala includes ores of silver, lead, zinc, iron, and chromium, limestone, coal, mica, marble, niter, salt and sulfur. (P. 492)

A review of the British **pottery** and **porcelain industry** including chemical and electrial porcelain shows that England has become practically independent and is now exporting these items in large amounts. (Sup. 191)

SPECIAL SUPPLEMENTS ISSUED IN JANUARY

NORWAY—10*b*
PORTUGAL—11*b*
SCOTLAND—19*k*
STOKE-ON-TRENT, ENGLAND—19*e*
DOMINICAN REPUBLIC—26*b*
PARAGUAY—45*a*
URUGUAY—47*a*
CEYLON—51*b*
CHINA—52*i*
STRAITS SETTLEMENTS—56*a*
PERSIA—57*a*
SIAM—58*a*
BRITISH SOUTH AFRICA—66*c*
TUNIS—79*a*
PHILIPPINES—80*b*

STATISTICS OF EXPORTS TO THE UNITED STATES

NORWAY—Sup. 10*b*
Cod-liver oil
Distilled spirits
Wood pulp

SCOTLAND—Sup. 19*k*
Asphalt
Glass
Iron and steel
Leather
Paints
Paper stock
Hides

DOMINICAN REPUBLIC—Sup. 26*b*
Hides
Molasses
Rosin
Sugar
Beeswax
Fustic
Logwood

URUGUAY—Sup. 47*a*
Dried blood
Bones
Glycerin
Ipecac
Guano
Rubber
Tallow
Oleo stearin
Tin ore
Flaxseed

CEYLON—Sup. 51*b*
Cinnamon
Citronella oil
Coconut oil
Croton seeds
Crude drugs
Papain
Graphite
Rubber

CHINA—Sup. 52*i*
Antimony
Soy beans
Bones
Camphor
Egg albumen
Gall nuts
Glue
Hides
Bean oil
Cottonseed oil
Rapeseed oil
Sesame oil
Soy bean oil
Tea oil
Wood oil
Tungsten ore
Sesame seed
Tallow
Tin
Turmeric

PERSIA—Sup. 57*a*
Gum tragacanth
Opium

STRAITS SETTLEMENTS (Singapore, etc.)—Sup. 56*a*
Betel nuts
Cassia
Copra
Cubebs
Cutch
Dragon's blood
Gambier
Gamboge
Gums
Gutta-percha
Gutta-jelutong
Gutta, siak
Hides
Mangrove bark
Coconut oil
Wood oil
Patchouli leaves
Rubber
Tin

SIAM—Sup. 58*a*
Gamboge
Gum benzoin
Gum damar
Hides
Sac
Sapphires
Tungsten ore

SOUTH AFRICA—Sup. 66*c*
Magnesite
Chrome ore
Corundum
Scheelite
Talc

NEW PUBLICATIONS

By Clara M. Guppy, Librarian Mellon Institute of Industrial Research, Pittsburgh

Alloys: Abridgment of United States, British, and German Patents on Alloys, Covering the Production of Platinum Substitutes Including Alloys Having Certain of the Properties of Platinum. Mock and Blum. 319 pp. Price, $25.00. Mock & Blum, 220 Broadway, New York.

Applied Chemistry: Reports of the Progress of Applied Chemistry. Volume 2, 1917. Society of Chemical Industry. 8vo. 538 pp. Price, 4s. 6d. to members, 6s. 6d. to non-members. Published for the Society of Chemical Industry by Messrs. Harrison & Sons, 45 St. Martin's Lane, London, W. C. 2.

Beverages: Home-Made Beverages and Vinegars, Temperance and Light Drinks; Theoretical Hints and Practical Methods with Over One Hundred and Seventy Formulas. J. P. Arnold. 12mo. 72 pp. Price, $0.75. Published by the author. Chicago.

Brassfounding. A Practical Treatise. J. H. Horner. 8vo. 190 pp. Price, 5s. Emmott & Co., London.

Butter Substitutes: List of United States, British, and German Patents Covering the Manufacture of Butter Substitutes, Hydrogenated Oils and Various Oils, and Milk Products. 8vo. 120 pp. Price, $25.00. Mock & Blum, 220 Broadway, New York.

Cast Iron: In the Light of Recent Research. W. H. Hatfield. 2nd Ed. Enlarged and Revised. 8vo. 309 pp. Price, 12s. 6d. Charles Griffin & Co., London.

Century of Science in America. E. S. Dana. 8vo. 420 pp. Yale University Press, New Haven.

Chemical German: An Introduction to Chemical German. E. V. Greenfield. 12mo. 384 pp. Price, $1.40. D. C. Heath & Co., New York.

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Carbonizing Methods: Ancient and Modern Carbonizing Methods. T. G. Selleck. *The American Drop Forger*, Vol. 5 (1919), No. 1, pp. 7–12.

Chemical Industry in America. W. H. Nichols. *The American Fertilizer*, Vol. 50 (1919), No. 1, pp. 60–72.

Chloramine Reactions of Proteins. J. F. Briggs. *Journal of the Society of Chemical Industry*, Vol. 37 (1918), No. 23, pp. 447*r*–448*r*.

Chrome Leather Problems for Research Laboratories. E. J. White. *Journal of the American Leather Chemists Association*, Vol. 14 (1919), No. 1, pp. 2–5.

Coal Tar as a Key Industry: What the Development of a Coal-Tar Industry Means in the Economy of a Company and Its Position as a Key Industry. Alfred Burton. *The Canadian Chemical Journal*, Vol. 3 (1919), No. 2, pp. 58–59.

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Concrete as a Chemical Engineering Material. Maximilian Toch. *The Canadian Chemical Journal*, Vol. 3 (1919), No. 2, pp. 54–55.

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Dyes: Trinitrotoluene Residues and Their Utilization. Isotrotyl, Liquid TNT, Chlorpicrin, and Sulfite Dyes. Maurice Copisarow. *The Chemical News*, Vol. 118 (1919), No. 3065, pp. 13–14.

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Ferromanganese in Blast Furnaces; Methods of Production as Shown by Investigation of Eighteen Furnaces by Bureau of Mines Experts. P. H. Royster. *The Iron Trade Review*, Vol. 64 (1919), No. 6, pp. 405–407.

Flotation Process. A. W. Allen. *Engineering and Mining Journal*, Vol. 107 (1919), No. 2, pp. 97–100.

Gasoline: Determination of Gasoline in Gas; Government Chemists Describe Improved Method of Testing Natural Gas for Its Gasoline Content. W. P. Dykema and R. O. Neal. *The Chemical Engineer*, Vol. 27 (1919), No. 1, pp. 5–7.

Grain Limits in Heat-Treated Alloy Steels; New Etching Process which Defines the Crystal, Boundaries, and Assists in Detecting Faulty Heat Treatment. R. S. Archer. *The Iron Age*, Vol. 103 (1919), No. 6, pp. 366–367.

Lead: Metallurgy of Lead. H. O. Hofman. *Engineering and Mining Journal*, Vol. 107 (1919), No. 2, pp. 88–90.

Metallurgy of Gold and Silver. A. W. Allen. *Engineering and Mining Journal*, Vol. 107 (1919), No. 2, pp. 92–96.

Nitrogen: The War and the Nitrogen Industry. W. D. Landis. *The Canadian Chemical Journal*, Vol. 3 (1919), No. 1, pp. 20–22.

Occlusion of Gases in Metals. A. W. Porter. *The Chemical Engineer*, Vol. 26 (1918), No. 13, pp. 499–500.

Ores: Uncommon Ores and Metals. H. C. Meyer. *Engineering and Mining Journal*, Vol. 107 (1919), No. 2, pp. 124–125.

Paint: Some Present-Day Aspects of the Paint and Varnish Industry with Special Reference to the War. A. de Waele. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 1, pp. 2*r*–4*r*.

Platinum Economy in the Industrial Chemical Laboratory. E. C. Mueser. *Chemical and Metallurgical Engineering*, Vol. 20 (1919), No. 2, p. 69.

Potash Content of Blast Furnace Charges. N. H. Gellert. *The Iron Age*, Vol. 103 (1919), No. 6, pp. 355–356.

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Pulverized Coal for Metallurgical Furnaces; Greater Efficiency Claimed for Furnaces of Correct Design. C. E. Longnecker. *The Iron Age*, Vol. 103 (1919), No. 6, pp. 351–352.

Refractory Materials: Mesure des Résistances a l'Ecrasement des Matériaux Réfractaires. Méthode du Capitaine V. Bodin. A. Bigot. *Chimie et Industrie*, Vol. 1 (1918), No. 7, pp. 724–726.

Rubber: Some Processes of Rubber Manufacturing; Preparation and Mixing of Various Compounds; The Reclamation of Rubber; Manufacture of Rubber Substitutes; Process of Manufacturing Automobile Tires. F. J. Maywald. *The Chemical Engineer*, Vol. 26 (1918), No. 13, pp. 497–498.

MARKET REPORT—FEBRUARY, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON FEBRUARY 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%	100 Lbs.	2.00	@	2.05
Alum, ammonia, lump	100 Lbs.		7 00	
Aluminum Sulfate, (iron free)	Lb.	4.50	@	4.75
Ammonium Carbonate, domestic	Lb.		nominal	
Ammonium Chloride, white	Lb.	19	@	20
Aqua Ammonia, 26°, drums	Lb.	7	@	9
Arsenic, white	Lb.	10	@	15
Barium Chloride	Ton	80.00	@	85.00
Barium Nitrate	Lb.	12	@	14
Barytes, prime white, foreign	Ton	30.00	@	35.00
Bleaching Powder, 35 per cent	Lb.	2	@	$3^{1}/_{4}$
Blue Vitriol	Lb.	$7^{3}/_{4}$	@	8
Borax, crystals, in bags	Lb.	$7^{1}/_{4}$	@	$10^{1}/_{4}$
Boric Acid, powdered crystals	Lb.	$7^{3}/_{4}$	@	$8^{3}/_{4}$
Brimstone, crude, domestic	Long Ton	28.00	@	35.00
Bromine, technical, bulk	Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused	Ton	18.00	@	22.00
Caustic Soda, 76 per cent	100 Lbs.	2.95	@	3.05
Chalk, light precipitated	Lb.	$4^{3}/_{4}$	@	5
China Clay, imported	Ton	20.00	@	30.00
Feldspar	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered	Ton		nominal	
Fuller's Earth, domestic	Ton	20.00	@	30.00
Glauber's Salt, in bbls	100 Lbs.	2.10	@	3.00
Green Vitriol, bulk	100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial, C. P.	Lb.	8	@	$8^{1}/_{4}$
Iodine, resublimed	Lb.	4.25	@	4.30
Lead Acetate, white crystals	Lb.	14	@	15
Lead Nitrate, C. P.	Lb.		85	
Litharge, American	Lb.	14	@	15
Lithium Carbonate	Lb.		1.50	
Magnesium Carbonate, U. S. P.	Lb.	25	@	30
Magnesite, "Calcined"	Ton	60.00	@	65.00
Nitric Acid, 40°	Lb.		$7^{3}/_{4}$	
Nitric Acid, 42°	Lb.		8	
Phosphoric Acid, 48/50%	Lb.	35	@	40
Phosphorus, yellow	Lb.	55	@	75
Plaster of Paris	Bbl.	2.00	@	2.50
Potassium Bichromate	Lb.	$37^{1}/_{2}$	@	38
Potassium Bromide, granular	Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 @ 85%	Lb.	16	@	17
Potassium Chlorate, crystals, spot	Lb.	40	@	41
Potassium Cyanide, bulk, 98–99 per cent	Lb.		nominal	
Potassium Hydroxide, 88 @ 92%	Lb.	60	@	70
Potassium Iodide, bulk	Lb.	3.75	@	4.00
Potassium Nitrate	Lb.	27	@	30
Potassium Permanganate, bulk, U. S. P.	Lb.	1.00	@	1.05
Quicksilver, flask	75 Lbs.	90.00	@	
Red Lead, American, dry	100 Lbs.	11.25	@	11.50
Salt Cake, glass makers'	Ton	17.50	@	22.00
Silver Nitrate	Oz.	$63^{1}/_{4}$	@	65
Soapstone, in bags	Ton	10.00	@	12.50
Soda Ash, 58%, in bags	100 Lbs.	1.50	@	1.55
Sodium Acetate, broken lump	Lb.	12	@	13
Sodium Bicarbonate, domestic	100 Lbs.	2.75	@	2.85
Sodium Bichromate	Lb.	$12^{1}/_{2}$	@	13
Sodium Chlorate	Lb.	18	@	19
Sodium Cyanide	Lb.	30	@	32
Sodium Fluoride, commercial	Lb.	14	@	15
Sodium Hyposulfite	100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot	100 Lbs.	$4.42^{1}/_{2}$	@	5.00
Sodium Silicate, liquid, 40° Bé.	Lb.	2	@	$2^{1}/_{2}$
Sodium Sulfide, 60%, fused in bbls	Lb.	$4^{3}/_{4}$	@	5
Sodium Bisulfite, powdered	Lb.	6	@	8
Strontium Nitrate	Lb.	25	@	30
Sulfur	100 Lbs.	2.25	@	4.60
Sulfuric Acid, chamber 66° Bé.	Ton		25.00	
Sulfuric Acid, oleum (fuming)	Ton		25.00	
Talc, American, white	Ton		15.00	
Terra Alba, American, No. 1	100 Lbs.		$1.17^{1}/_{2}$	
Tin Bichloride, 50°	Lb.	26	@	28
Tin Oxide	Lb.	70	@	80
White Lead, American, dry	Lb.	10	@	$10^{1}/_{2}$
Zinc Carbonate	Lb.	18	@	20
Zinc Chloride, commercial	Lb.	14	@	$14^{1}/_{2}$

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	52	@	53
Acetic Acid, 56 per cent, in bbls	100 Lbs.	7.00	@	7.50
Acetic Acid, glacial, $99^{1}/_{2}$%	100 Lbs.	14.50	@	15.00
Acetone, drums		$15^{1}/_{2}$	@	16
Alcohol, denatured, 180 proof	Gal.	45	@	47
Alcohol, sugar cane, 188 proof	Gal.	4.90	@	4.95
Alcohol, wood, 95 per cent, refined	Gal.	1.22	@	1.24
Amyl Acetate	Gal.	4.20	@	4.50
Aniline Oil, drums extra	Lb.	25	@	26
Benzoic Acid, ex-toluol	Lb.	2.00	@	2.25
Benzene, pure	Gal.	22	@	$22^{1}/_{2}$
Camphor, refined in bulk, bbls	Lb.	$1.24^{1}/_{2}$	@	1.25
Carbolic Acid, U. S. P., crystals, drums	Lb.	15	@	20
Carbon Bisulfide	Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals.	Lb.	$15^{1}/_{2}$	@	16
Chloroform	Lb.	63	@	70
Citric Acid, domestic, crystals	Lb.		1.25	
Creosote, beechwood	Lb.	2.00	@	2.10
Cresol, U. S. P.	Lb.	18	@	20
Dextrine, corn (carloads, bags)	Lb.	8	@	9
Dextrine, imported potato	Lb.		nominal	
Ether, U. S. P. 1900	Lb.	27	@	30
Formaldehyde, 40 per cent	Lb.	$22^{1}/_{2}$	@	23
Glycerin, dynamite, drums extra	Lb.	$15^{1}/_{2}$	@	16
Oxalic Acid, in casks	Lb.	36	@	38
Pyrogallic Acid, resublimed, bulk	Lb.	2.85	@	2.90
Salicylic Acid, U. S. P.	Lb.	55	@	60
Starch, corn (carloads, bags) pearl	100 Lbs.	6.00	@	7.00
Starch, potato, Japanese	Lb.	13	@	14
Starch, rice	Lb.	$12^{1}/_{2}$	@	13
Starch, sago flour	Lb.	$9^{3}/_{4}$	@	$10^{3}/_{4}$
Starch, wheat	Lb.		nominal	
Tannic Acid, commercial	Lb.	65	@	80
Tartaric Acid, crystals	Lb.	$84^{1}/_{2}$	@	85

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	63	@	65
Black Mineral Oil, 29 gravity	Gal.	24	@	25
Castor Oil, No. 3	Lb.	22	@	23
Ceresin, yellow	Lb.	16	@	17
Corn Oil, crude	100 Lbs.	16.75	@	17.7
Cottonseed Oil, crude, f. o. b. mill	Lb.	$17^{1}/_{2}$	@	—
Cottonseed Oil, p. s. y.	100 Lbs.	$21^{1}/_{2}$	@	22
Menhaden Oil, crude (southern)	Gal.	90	@	1.00
Neat's-foot Oil, 20°	Gal.	2.00	@	
Paraffin, crude, 118 to 120 m. p.	Lb.	$9^{3}/_{4}$	@	10
Paraffin Oil, high viscosity	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.	Bbl.	13.20	@	13.50
Rosin Oil, first run	Gal.	75	@	76
Shellac, T. N.	Lb.	52	@	53
Spermaceti, cake	Lb.	31	@	33
Sperm Oil, bleached winter, 38°	Gal.	2.08	@	2.10
Spindle Oil, No. 200	Gal.	38	@	40
Stearic Acid, double-pressed	Lb.	$22^{1}/_{2}$	@	$24^{1}/_{2}$
Tallow, acidless	Gal.	1.15	@	1.20
Tar Oil, distilled	Gal.	36	@	38
Turpentine, spirits of	Gal.	79	@	80

METALS

Aluminum, No. 1, ingots	Lb.	33	@	34
Antimony, ordinary	Lb.	$7^{3}/_{4}$	@	8
Bismuth, N. Y.	Lb.	3.50	@	3.65
Copper, electrolytic	Lb.	23	@	nominal
Copper, lake	Lb.	20	@	23
Lead, N. Y.	Lb.	5.75	@	6.00
Nickel, electrolytic	Lb.	55	@	56
Platinum, refined, soft	Oz.		nominal	
Silver	Oz.		$1.01^{1}/_{8}$	
Tin, Straits	Lb.		nominal	
Tungsten (WO_3)	Per Unit	15.00	@	20.00
Zinc, N. Y.	100 Lbs.	9.40	@	9.60

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	4.75	@	—
Blood, dried, f. o. b. New York	Unit	6.00	@	6.25
Bone, 3 and 50, ground, raw	Ton	37.00	@	37.50
Calcium Cyanamide	Unit of Ammonia		nominal	
Calcium Nitrate, Norwegian	100 Lbs.		—	
Castor Meal	Unit		—	
Fish Scrap, domestic, dried, f. o. b. works	Unit		nominal	
Phosphate, acid, 16 per cent	Ton	17.00	@	18.00
Phosphate Rock, f. o. b. mine:	Ton		nominal	
Florida land pebble, 68 per cent	Ton	5.00	@	6.00
Tennessee, 78–80 per cent	Ton		nominal	
Potassium "muriate," basis 80 per cent	Ton	270.00	@	280.00
Pyrites, furnace size, imported	Unit		nominal	
Tankage, high-grade, f. o. b. Chicago	Unit	5.00	@	5.50

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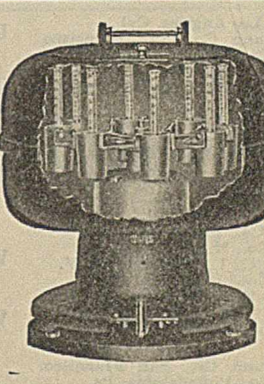

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Dorr Co., The, Denver, Col., and N. Y. C.
Industrial Filtration Corp., N. Y. C.

Tile (Tower)
General Ceramics Co., N. Y. C.
Guernsey Earthenware Co., The Cambridge, O.
Knight, M. A., East Akron, O.
U. S. Stoneware Co., The, Akron, O.

Tile—Tower Grillage (Acid Proof Stoneware)
Knight, M. A., East Akron, O.

Timers (Interval)
Victor Electric Corporation, Chicago, Ill

Time Valves
Tagliabue Mfg. Co., C. J., Brooklyn, N. Y.
Taylor Instrument Cos., Rochester, N. Y.

Tin
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Will Corporation, The, Rochester, N. Y.

Toluol
Merck & Co., N. Y. C.

Tongs
Denver Fire Clay Co., The, Denver, Colo.
Heil Chem. Co., Henry, St. Louis, Mo.
Hoskins Mfg. Co., Detroit, Mich.
Will Corporation, The, Rochester, N. Y.

Tower Packing or Filling (Acid Proof)
Knight, M. A., East Akron, O.

Transformers
General Electric Co., Schenectady, N. Y.

Transmission Lines
General Electric Co., Schenectady, N. Y.

Triangles
Braun-Knecht-Heimann Co., San Francisco.
Daigger & Co., A., Chicago, Ill.
Denver Fire Clay Co., The, Denver, Colo.
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.
Thermal Syndicate Ltd., The, N. Y. C.
Will Corporation, The Rochester, N. Y.

Triangles (Platinum)
Baker & Co., Inc., Newark, N. J.
Heil Chem. Co., Henry, St. Louis, Mo.
Will Corporation, The, Rochester, N. Y.

Trinitrotoluol Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Will Corporation, The, Rochester, N. Y.

Tubes—Alundum
Heil Chem. Co., Henry, St. Louis, Mo.
Norton Co., Worcester, Mass.
Will Corporation, The, Rochester, N. Y.

Tubes (Platinum)
Bishop & Co., J., Platinum Works, Malvern, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
Will Corporation, The, Rochester, N. Y.

Tubing (Glass)
Braun-Knecht-Heimann Co., San Francisco.
Daigger & Co., A., Chicago, Ill.
Denver Fire Clay Co., The, Denver, Colo.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Sargent & Co., E. H., Chicago, Ill.
Whitall Tatum Co., Philadelphia, Pa.
Will Corporation, The, Rochester, N. Y.

Tubing—India Rubber
Angel Co., Inc., H. Reeve, N. Y. C.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Will Corporation, The, Rochester, N. Y.

Ultra Violet Lamp & Laboratory Outfit
Engelhard, Charles, N. Y. C.
R. U. V. Co., Inc., The, N. Y. C.

Vacuum Drying Apparatus
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.
Jacoby, Henry E., N. Y. C.
Pfaudler Co., Rochester, N. Y.
Stokes Machine Co., F. J., Philadelphia, Pa.
Sowers Mfg. Co., Buffalo, N. Y.
Werner & Pfleiderer Co., Saginaw, Mich.

Vacuum Ovens—Direct Heat
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Devine Co., J. P., Buffalo, N. Y.

Vacuum Pans
Badger & Sons Co., E. B., Boston, Mass.
Birmingham Mch.&Fd'y Co.,Birmingham, Ala.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Detroit Heating & Lighting Co., Detroit, Mich.
Devine Co., J. P., Buffalo, N. Y.
Elyria Enameled Prod. Co., Elyria, O.
General Ceramics Co., N. Y. C.
Jacoby, Henry E., N. Y. C.
Lummus Co., The Walter E., Boston, Mass.
Pfaudler Co., Rochester, N. Y.
Sowers Mfg. Co., Buffalo, N. Y.
Sperry & Co., D. R., Batavia, Ill.
Stokes Machine Co., F. J., Philadelphia, Pa.
Swenson Evaporator Co., Chicago, Ill.
U. S. Stoneware Co., The, Akron, O.
Werner & Pfleiderer Co., Saginaw, Mich.
Zaremba Co., Buffalo, N. Y.

Vacuum Pumps
Abbé Engineering Co., N. Y. C.
Braun-Knecht-Heimann Co., San Francisco.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Crowell Engineering Co., Brooklyn, N. Y.
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.
Schutte & Koerting Co., Phila., Pa.
Will Corporation, The, Rochester, N. Y.

Vacuum Recorders
Scientific Materials Co., Pittsburgh, Pa.

Vacuum Stills
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Detroit Heating & Lighting Co., Detroit, Mich
Devine Co., J. P., Buffalo N. Y.
Egrot Co. Ltd., The, Paris, France.
Elyria Enameled Prod. Co., Elyria, O.
Jacoby, Henry E., N. Y. C.
Lummus Co., The Walter E., Boston, Mass.
Pfaudler Co., Rochester, N. Y.
Sowers Mfg. Co., Buffalo, N. Y.
Stevens Bros., N. Y. C.

Valves—Acid Proof
Duriron Castings Co., N. Y. C.

Valves—Acid Proof Stoneware
Knight, M. A., East Akron, O.

Valves, Ammonia
York Manufacturing Co., York, Pa.

Valves and Fittings—Lead
Schutte & Koerting Co., Phila., Pa.
United Lined Tube & Valve Co., Boston, Mass

Valves—Steam Jacketed
Devine Co., J. P., Buffalo, N. Y.

Varnish—Coil Impregnation
General Bakelite Co., N. Y. C.

Vats—Acid Proof
Knight, M. A., East Akron, O.

Vats (Rectangular)
Elyria Enameled Products Co., Elyria, O.
Pfaudler Co., Rochester, N. Y.
Sowers Mfg. Co., Buffalo, N. Y.

Viscosimeters
Bausch & Lomb Optical Co., Rochester, N. Y.
Brown Instrument Co., The, Phila., Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
Tagliabue Mfg. Co., C. J., Brooklyn, N. Y.
Taylor Instrument Cos., Rochester, N. Y.
Will Corporation, The, Rochester, N. Y.

Vitreosil
Heil Chem. Co., Henry, St. Louis, Mo.
Thermal Syndicate, Ltd., The, N. Y. C.
Will Corporation, The, Rochester, N.Y.

Voltmeters
Brown Instrument Co., Philadelphia, Pa.
General Electric Co., Schenectady, N. Y.

Volumetric Apparatus
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Scientific Materials Co., Pittsburgh, Pa.
Whitall Tatum Co., Philadelphia, Pa.
Will Corporation, The, Rochester, N. Y.

Water Bath (Laboratory)
Braun-Knecht-Heimann Co., San Francisco.
Daigger & Co., A., Chicago, Ill.
Denver Fire Clay Co., The, Denver, Colo.
Eimer & Amend, N. Y. C.
Electric Heating Apparatus Co., N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Company, Arthur H., Philadelphia, Pa.
Whitall Tatum Co., Philadelphia, Pa.
Will Corporation, The, Rochester, N. Y.

Water Softening Apparatus
Booth Apparatus Co., Syracuse, N. Y.
Scaife & Sons Co., Wm. B., Oakmont, Pa.

Water Sterilizing Equipment
Wallace & Tiernan Co., Inc., 137 Centre St., N. Y. C.
Wheeler Condenser & Eng. Co., Carteret, N. J.

Weighing Machinery—(Automatic)
Werner & Pfleiderer Co., Saginaw, Mich.

Welding Apparatus
General Electric Co., Schenectady, N. Y.
Oxygen Gas Co., The, Kansas City, Mo.

Wiring Devices
General Electric Co., Schenectady, N. Y.

Wood Distillation Equipment
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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.
Swenson Evaporator Co., Chicago, Ill.
Zaremba Co., Buffalo, N. Y.

Woulff Bottles—Acid Proof Stoneware
Knight, M. A., East Akron, Ohio.

X-Ray Apparatus
Victor Electric Corporation, Chicago, Ill.

Zinc, Dust
New Jersey Zinc Co., The, N. Y. C.

Zinc Oxides
New Jersey Zinc Co., The, N. Y. C.

Zinc—Salts of
Merck & Co., N. Y. C.

Zinc, Strip
New Jersey Zinc Co., The, N. Y. C.

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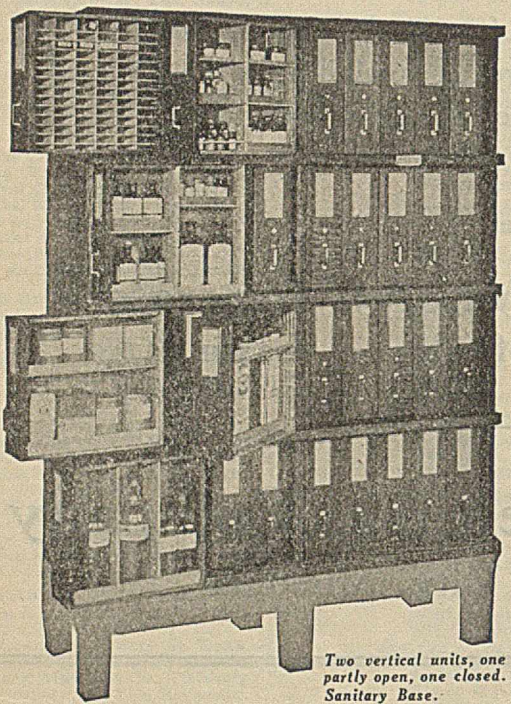

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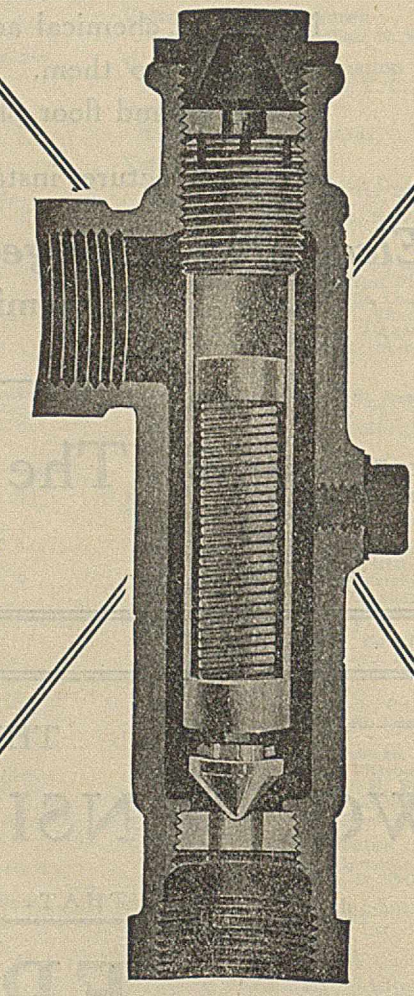

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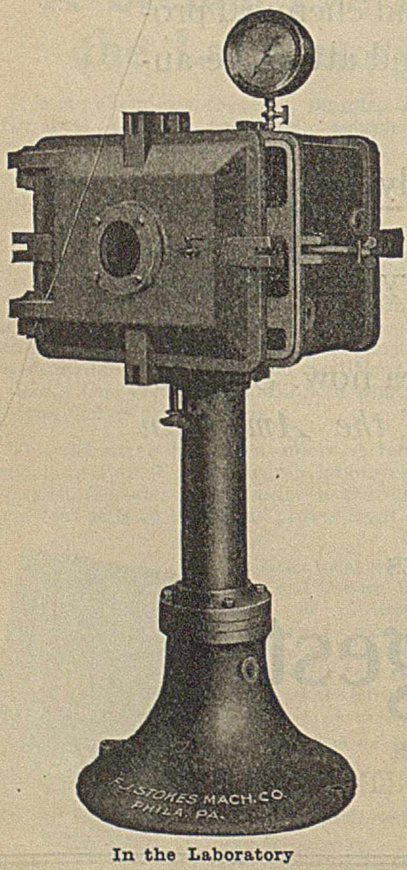

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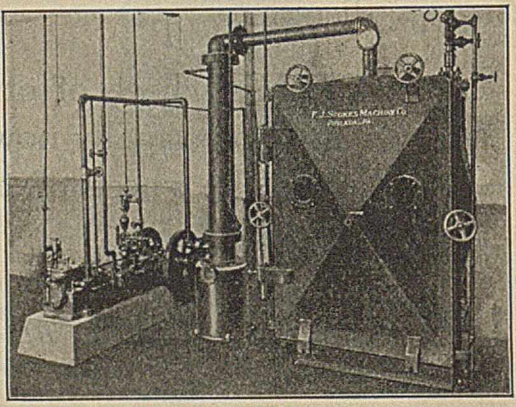

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This stock is in perfect condition, is all in maker's original cases, and is the remainder of a contract placed in 1916, since which time several advances have taken place in factory prices.

This ware was mostly packed before the adoption of the standard cases (see Supplement No. 30) which has made it inconvenient to utilize these cases in filling regular orders. Because of these facts and our desire to move this particular lot of ware promptly, we offer it at approximately

33 1-3% discount from net current prices as printed below

As our net current prices on Nonsol ware are extended at 50% discount from maker's list price (the manufacturer's discount to consumers), this special offer for this lot of ware is equivalent to 66⅔% discount from the manufacturer's list price.

The saving embodied in this offer is further emphasized by the fact that the manufacturers are now accepting orders for future delivery only at price prevailing at time of delivery, *i. e.*, no large orders are being taken by the manufacturers at the present time at their usual rate of 50% from their list.

We are especially desirous that this special offer shall not indicate in any way dissatisfaction on the part of our customers or ourselves with the quality of Nonsol Flasks and Beakers, and the offer is made only because of our desire to move a heavy stock not coinciding with our standard packing and is possible only because of the purchase having been made before the advances mentioned.

21852. **Beakers, Nonsol glass, Griffin low form, with pourout.**

Capacity, cc	180	600	1400
Net current price, each	.15	.28	.63
Special offer, each	.10	.19	.42

Stock available on Special Offer consists of:—

180 cc— 4 cases containing 360 each
20 cases containing 432 each
1 case containing 372
600 cc— 2 cases containing 144 each
1400 cc— 9 cases containing 48 each

21880. **Beakers, Nonsol glass, usual or Berzelius form, with pourout.**

Capacity, cc	30	60	90	180	250	500	700	1000
Net current price, each	.12	.12	.13	.15	.17	.25	.30	.45
Special offer, each	.08	.08	.09	.10	.11	.17	.20	.30

Stock available on Special Offer consists of:—

30 cc— 1 case containing 800
60 cc— 1 case containing 1200
1 case containing 996
90 cc— 1 case containing 1000
1 case containing 996
180 cc— 1 case containing 432
250 cc— 9 cases containing 300 each
500 cc— 2 cases containing 144 each
700 cc— 9 cases containing 120 each
1 case containing 128
2 cases containing 138 each
1000 cc— 1 case containing 96
1 case containing 68
3 cases containing 108 each
11 cases containing 72 each
1 case containing 60
1 case containing 104
1 case containing 111
1 case containing 105

21882. **Beakers, Nonsol glass, usual or Berzelius form, without pourout.**

Capacity, cc	30	60	90	120	180	250	300	350	500	700	1000	1200
Net current price, each	.12	.12	.13	.14	.15	.17	.18	.20	.25	.30	.45	.50
Special offer, each	.08	.08	.09	.09	.10	.11	.12	.13	.17	.20	.30	.33

Stock available on Special Offer consists of:—

30 cc—1 case containing 1008
60 cc—2 cases containing 900 each
90 cc—2 cases containing 900 each
1 case containing 204
120 cc—6 cases containing 480 each
1 case containing 520
1 case containing 600
1 case containing 564
180 cc—5 cases containing 432 each
250 cc—8 cases containing 300 each
1 case containing 408
1 case containing 396
300 cc— 5 cases containing 300 each
1 case containing 396
1 case containing 200
350 cc— 5 cases containing 240 each
1 case containing 132
6 cases containing 144
500 cc—18 cases containing 144 each
1 case containing 120
1 case containing 132
700 cc— 3 cases containing 72 each
1000 cc— 3 cases containing 72 each
1200 cc— 9 cases containing 36 each

28089. **Flasks, Nonsol glass, with heavy ring neck and flat bottom; 1000 cc. capacity.**

Net current price, each	.30
Special offer, each	.20

Stock available on Special Offer consists of:—

1000 cc—21 cases containing 72 each

28093. **Flasks, Nonsol glass, with round bottom and vial mouth.**

Capacity, cc	250	500	1000
Net current price, each	.15	.20	.28
Special offer, each	.10	.13	.19

Stock available on Special Offer consists of:—

250 cc—1 case containing 61
1 case containing 97
500 cc—5 cases containing 144 each
1 case containing 128
1000 cc—24 cases containing 72 each

28096. **Flask, Nonsol glass, with flat bottom and vial mouth.**

Capacity, cc	250	8000
Net current price, each	.15	1.75
Special offer, each	.10	1.17

Stock available on Special Offer consists of:—

250 cc—1 case containing 300
8000 cc—10 cases containing 12 each

28176. **Flasks, Erlenmeyer, of Nonsol glass.**

Capacity, cc	60	180
Net current price, each	.11	.14
Special offer, each	.07	.09

Stock available on Special Offer consists of:—

60 cc—1 case containing 900
180 cc—1 case containing 504
1 case containing 432
1 case containing 480

28205. **Flask, Distilling, of Nonsol glass, with side tube at center of neck; 120 cc. capacity.**

Net current price, each	.43
Special offer, each	.29

Stock available on Special Offer consists of:—

120 cc—3 cases containing 120 each
1 case containing 200
1 case containing 156

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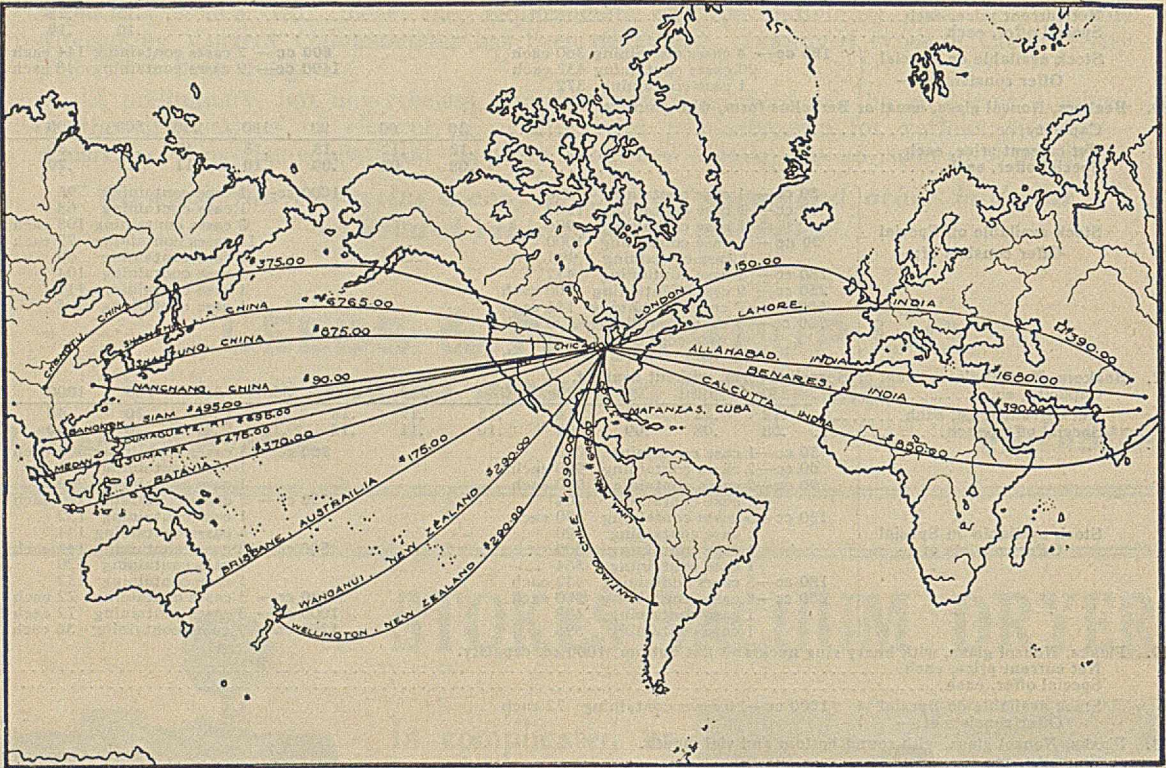
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