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EDITORIALS

WAYS AND MEANS COMMITTEE HEARINGS

The chemical industries developed during the war period will be safeguarded by the present Congress. That is our prediction based upon the hearings which have taken place before the Ways and Means Committee of the House of Representatives in Washington during the past two weeks. The final details of this protection may vary from the forms in which originally presented to the Congress, but it is evident that regardless of party politics Congress will stand united in its determination that these American industries shall not suffer from after-war German competition or from the invasion of this market by the industries of Japan, where, according to the testimony submitted, the cost of labor is from one-tenth to one-fifteenth of that paid in American establishments.

At the outset of the hearings full opportunity was given for the presentation of the claims of chemical glassware, chemical porcelain, and scientific instrument manufacturers. The hearings on potash held during the same week leave an impression of doubt as to the final outcome regarding this industry.

During the second week of the hearings the claims of the dyestuff industry were fully presented to the Committee. Representatives of the Army and Navy testified to the value of this industry in chemical warfare. Mr. Joseph H. Choate, Jr., representing the Chemical Foundation, Inc., presented a brilliant argument in support of the measures proposed. Important consumers, representing the great bulk of the consuming industry of the country, urged the importance of the industry as a means of economic independence, while dyestuff manufacturers presented, through the comprehensive brief of Dr. J. Merritt Matthews, representing the American Dyes Institute, a complete survey of the situation from the producers' standpoint. Opportunity was afforded to present to the Committee, with the official sanction of the War Trade Board, statistics showing the tremendous increase in the requests for import licenses for dyes from Switzerland, at a rate so far above the normal capacity of the Swiss factories as to suggest a contemplated leakage of German dyes or intermediates through a neutral country.

The discussion was based upon the Longworth bill, which embodies the recommendations of the U. S. Tariff Commission, and increases materially both the ad valorem and the specific duties on intermediates and on finished products. To this bill was proposed an amendment, put forward by the Chemical Foundation, Inc., providing for a license system which would permit the exclusion of dyes already produced in sufficient quantity in this country and the restricted importation of dyes not yet produced, pending the rounding out of the American industry.

It was evident that there was at the outset opposition to the license plan in the Committee, but as the hearings proceeded and opportunity was afforded to answer the objections raised by the various members of the Committee this opposition gradually diminished, and completely disappeared when, in the last few minutes of the hearings, Chairman Fordney clearly indicated his conversion to the necessity of a temporary license system supplementary to the protective duties.

The most dramatic feature of the hearings, and perhaps the most convincing argument, came from an entirely unexpected source. During the course of his extensive statement Mr. Choate introduced a translation of a report sent by Ambassador von Bernstorff to Berlin. This report was prepared by Dr. Hugo Schweitzer, the then head of the Bayer Company in this country, and one of the leading spirits in the German spy system in America. In January 1917, a copy of the report together with other papers was seized by agents of the Department of Justice in the office of Dr. Albert in New York City.

The importance of Dr. Schweitzer's report justifies its preservation in the chemical literature of the war period. Under date of New York, January 26, 1917, I. von Igel wrote to Ambassador von Bernstorff as follows:

> I am respectfully transmitting to your Excellency an expert opinion on the effect of the new duties on the dyestuffs handed over to me from an expert source [Dr. Hugo Schweitzer, Badische Anilin Fabrik (Baden Aniline Factory)]. As the matter is still in a fluid state and possibly still other changes in the legislation, of which I enclose a copy, will have to be reckoned with, I refrain from more detailed explanations until further notice. I suggest, however, that the expert judgment be passed on to Berlin.
>
> I. VON IGEL

The letter was addressed to "His Excellency, the Imperial Ambassador, Count von Bernstorff, Washington, D. C."

SCHWEITZER REPORT IN FULL

Following is the full text of the Schweitzer report:

The influence of the new customs tariff and its prospective effect on German importation and on the development of the American industry into an export industry, and on the chances of the American dyestuff industry in the world market must be considered from two points of view:

1—During a Long War

Should the war still continue for years, then, of course, the industry here would be very much furthered and would have a great boom. The United States does not lack raw materials for the manufacture of dyestuffs of any kind whatsoever. The only product necessary for manufacture that must be imported is saltpeter. The question of price does not play any part in this either, for as long as dyestuffs cannot be imported and must be produced here, the question whether the price of manufacture is higher or lower makes no difference. A longer war will bring the further danger that the plants can be amortized from the great earnings which can be made and that the factories after the peace can carry on competition with the German dyestuffs more easily.

The difficulties in manufacture, which are incomparably greater in the manufacture of intermediate products than in the manufacture of dyestuffs from imported intermediates, will be gradually overcome. The greatest lack is that of technically trained chemists. It seems that American industry is trying to emancipate itself in this respect by importing chemists from

Switzerland. One of the largest of the newly founded factories is said to have engaged, together with thirty chemists, Maurice Ceresole, who was lately professor of technical chemistry at the University of Zurich and formerly manager of the French branch of the Baden Aniline and Soda Factory, and had worked still earlier, together with myself, in the Badische Anilin und Soda Fabrik in Ludwigshafen, in order to help build up the American dyestuff industry here. I have not yet succeeded in finding out which factory has employed these chemists.

INQUIRY FOR AMERICAN GOODS

How difficult the production of intermediates is, is apparent from a letter which was sent to an American manufacturer by the French branch of the Badische Anilin und Soda Fabrik on September 13, 1915, over a year after the outbreak of the war, and which in the translation runs as follows:

> We are purchasers of beta-naphthol, beta-naphthylamine, diphenylamine, dimethylaniline.
>
> Will you please tell me whether you sell these products, and in case you do, please inform us of your conditions and the quantities you can offer us.
>
> At the same time we beg you to inform us of other raw materials of interest for the manufacture of dyestuffs which you may have to offer us, aside from those mentioned above.
>
> In case your answer should be negative, we should be obliged to you if you would kindly indicate to us the addresses of firms to whom we could address ourselves with prospect of success.

The content of this letter proves that the branch of the Badische Anilin und Soda Fabrik which has existed since the year 1873 and in which dyestuffs have been manufactured since that time, to be sure from intermediates which were delivered by the manufactory in Ludwigshafen, could not itself manufacture such simple intermediate products as beta-naphthol, beta-naphthylamine, diphenylamine, and dimethylaniline. This branch has besides the advantage that chemists stood at its disposal who had been trained in the German factory and had been sent by the same to France in order to produce as serviceable dyestuffs as those manufactured in Germany.

NEW INDUSTRY'S DRAWBACKS

The manufacture of the intermediates offers much greater difficulties for an industry still in the process of development for the reason that such an incredibly large variety of products is necessary. In a well developed industry like that of the Germans a technical use is found in the end for all these products. In a less well developed industry and in an industry which is only in the process of development, great hindrances stand in the way of the utilization of these derivatives. Many cannot be used at all and thus become troublesome waste products. The price of those derivatives which can be utilized is thereby increased to an incredible degree. In order to make the manufacture and utilization of these derivatives more graphic I subjoin the enclosed table[1] which shows how many derivatives of a single coal-tar raw product, namely naphthalene, are combined with a single basic substance, benzidine, in order to form dyestuffs. In a well developed industry all these products are manufactured, and ultimately find utilization. Those whose names appear in squares are used directly for the manufacture of colors; those which are enclosed in ovals, are at the present time not yet utilized, but are subjects of scientific investigation, and will ultimately find suitable utilization.

The manufacture of intermediates stands in Germany on such an incredibly high plane that the prices for the manufactured articles are very low. It would take American industry many years, even if it will ever be possible at all, before it could produce these intermediates as cheaply as German industry has done. In order to show these differences of price, the examples in the following table may be cited.

	It cost in 1908 in Germany per lb. in cents	Imported to America under the tariff at that time
Aniline oil	9.28	11.60
Paranitraniline	16.00	24.00
H acid	23.29	34.80
Alpha-naphthylamine	6.20	7.75
R salt	9.68	14.50
Amido G salt	17.60	26.75
Freun acid	11.60	17.25
Cleve acid	11.60	17.25
Gamma	29.36	44.00
Salicylic acid	12.06	26.01
Tolidine	26.40	33.00
Benzidine	24.20	30.26

These are figures which American industry will never attain. It can be assumed with certainty that the most of these products cannot be manufactured here at three to four times the price.

ADVANTAGE FOR GERMANY

The wonderfully developed technique of intermediates will, therefore, for many years to come, give German industry a preponderance over all other lands in which the derivative industry has first to be built up.

2—After the Peace

The question, what prospective effect the customs duties will have on German importation, on the development of American industry into an exporting industry and upon its chances in the world market can be answered by a single argument:

The new tariff divides the products used and manufactured in the dyestuff industry into three groups—raw products, half-products (intermediates), and dyes. While the raw products are imported free of duty, on the half-products and the dyes, in addition to an ad valorem duty, a specific duty of $2^{1}/_{2}$ cents per pound and 5 cents per pound is levied.

Happily, the following dyes are excluded from this specific duty:

> Except natural and synthetic alizarin, and dyes obtained from alizarin, anthracene, and carbazol; natural and synthetic indigo and all indigoids, whether or not obtained from indigo; and medicinals and flavors.

This exception may well become the sheet-anchor of the German industry. The dyestuffs which are excepted from this specific duty are the so-called vat dyes, and these vat dyes are a comparatively modern achievement of the German dye technique, and are in general regarded as the most genuine dyes.

The preëminent coloring qualities of these products have already brought it about, and will do it even more so in the future, that the older coal-tar dyes, which in many respects are inferior to these vat dyes, will be driven from the market. The manufacture of these vat dyes is very complicated and can be undertaken only in a very highly developed industry. It is wholly out of the question that a new industry like the American can take up the manufacture of these vat dyestuffs, and it may well take a very long time before the dyestuff industry outside of Germany can concern itself with the manufacture of these complicated products.

Here the very greatest exertions will not make it possible to cope with the competition of Germany. In our considerations it is of still further importance that these vat dyes are much dearer than the ordinary coal-tar dyestuffs, which is readily explicable in view of the difficulties of manufacture. But in spite of this higher price, the vat dyestuffs, on account of their superior tinctorial qualities, are finding a more and more widely extended sphere of application in all fields of the textile, leather, paper, etc., industries.

AD VALOREM TARIFF DISCUSSED

The history of American tariff legislation has shown that in general a protective tariff of 30 per cent ad valorem does not afford sufficient protection to create an American industry. If this was the case with the old coal-tar dyestuffs, of which only a few staple kinds were ever manufactured here, and these, for the most part, from intermediates which were im-

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[1] This table was not submitted by Mr. Choate. We venture the guess, however, that the table referred to is the one which appeared in THIS JOURNAL, 6 (1914), 1024.—[EDITOR.]

ported from Germany, a protective tariff of 30 per cent is, of course, absolutely insufficient for the complicated vat dyestuffs.

In recognition of this fact the new tariff provides the specific duties in order to provide a far greater protection for the American industry.

But the new tariff now specifies the following in regard to the specific duties:

> But if, at the expiration of five years from date of the passage of this Act, the President finds that there is not being manufactured or produced within the United States as much as 60 per centum in value of the domestic consumption of the articles mentioned in Groups II and III of Section 500, he shall by proclamation so declare, whereupon the special duties imposed by this section on such articles shall no longer be assessed, levied, or collected.

Here is where the German industry must apply the lever. It must, in any case, of these vat dyes, which must be regarded as the "highest quality" goods of the industry, dispose of in the American market more than 40 per cent of the total consumption in intermediates and dyestuffs, in order that the President will be in the position to abolish the specific duties. If this is actually made possible, and the President must abolish these specific duties, then the German industry will be in the same position as before the war, and has only to deal with the duty of 30 per cent ad valorem, which, as has already been elucidated above, was insufficient in the past to create an American industry.

EASY FOR GERMAN INDUSTRY

That it should be as easy as child's play for German industry to sell so much vat dyestuffs in the United States that the value of the same will amount to 60 per cent in value of the domestic consumption of the articles mentioned in Groups II and III of Section 500, is apparent from the following considerations:

1—The vat dyestuffs have in the past and will even more so in the future supplant the old coal-tar dyestuffs.

2—The money value of the vat dyestuffs is uncommonly higher than the money value of the old coal-tar dyestuffs.

3—The importation from Germany of these vat dyes amounts to-day already to 27.63 per cent of the money value of the total dyestuffs importation.

From the statements of the *Chemical Journal* [*Chemiker-Zeitung*] of the year 1914 we gather for the year 1913 the following figures for imports into the United States:

	Value	Per cent of the Whole
Indigo	$1,316,913	13.08
Alizarin	178,587	1.77
Anthracene dyestuffs	1,287,037	12.78
Aniline dyestuffs	7,288,471	72.40
Total	$10,071,008	100.03

In this connection, however, we must pay regard to the fact that Germany in the year 1913 imported to the United States intermediates to the value of $1,086,300. The foregoing percentage of 27.63 is somewhat lowered thereby. On the other hand, the production of the old aniline dyestuffs out of intermediates which have been imported from Germany would naturally decrease from the increased exportation of vat dyes, so that in our reckoning the value of the intermediates can, in fact, be entirely neglected.

The high price of vat dyes, which is, on the average, four or five times as much as that of the old aniline dyestuffs, is especially well calculated quickly to make possible the 14–15 per cent still lacking in the total value of the dyestuff consumption. From a recently published list it turns out that 511 dyes to the value of $7,500,000 have been imported into America, that is, the average import value of a dye amounts to $14,000. In this list four vat dyes are given, which altogether were worth $214,000, so that the average price of $14,000 for dyestuffs in the case of all dyestuffs rises to about $50,000 for the vat dyes, *i. e.*, amounts to about four times the average value.

When the time shall have come that the German industry will import more than 40 per cent of the vat dyes, and in America less than 60 per cent of the value of the domestic consumption will be manufactured, then great difficulties in the calculation of these figures will emerge, and it will depend on the party politics of the President at that time, whether he will make an honest effort to abolish the specific duty or not. How is this "value of the domestic consumption" to be reckoned? How will the customs prices be taken into consideration in connection with the freight rates, and with the expenses of insurance and of business? In the case of the domestic industry how will the expenditures for amortization, for general business expenses, trade-mark, and patent ownership be counted in the calculation?

From these arguments it is clear that the salvation of the German dyestuff industry is to be sought in the development of vat dyestuff chemistry. The tendency to develop this field to the highest degree possible existed already before the outbreak of the war. The new tariff brings then no change in this line. For the industry after the war also no change would arise in this regard, since in any case Germany will be compelled to manufacture and to export high-grade goods in the entire industrial field in contrast to articles demanded in large quantities, which can little by little be produced in all countries.

In the competition in the field of goods demanded in quantities German industry will in the end not fare much worse under the new tariff since, by the manufacture of intermediates forced upon American industry, the dyestuff manufacturer thereof will stand them at a much dearer price so that the old tariff rate of 30 per cent ad valorem will mean a still smaller protection for the American industry. This will not, of course, come completely to light until the specific duties have been abolished. But even if these specific duties are not abolished the higher prices of intermediates will tend more and more to eliminate the difference between the protection which the old percentage of 30 ad valorem and the protection which the new percentages of 30 plus specific duties afford.

An interesting document, strongly suggestive of many articles published in THIS JOURNAL, and characterized by the usual error of underestimation of the ability of Americans. Indigo and alizarin are already here. American vat dyes are standing on the threshold.

....

In a presidential address before the AMERICAN CHEMICAL SOCIETY at Seattle in September 1915, we said:

> Are the people of this country ready to coöperate with the chemists by authorizing the prompt enactment of such legislation? If so, there need be no fear that active capital will be longer withheld, and thus we can feel confident of a synthetic dyestuff industry commensurate with our needs.
>
> As I think of the possibility of such an industry, I recall the words of the Swiss professor, Gnehm, who, in 1900, after one of his lectures on coal-tar dyes, said to me: "The natural home of the dyestuff industry is in your country and some day it will flourish there."
>
> The creation of such a self-contained industry, however, has far deeper meaning for our national welfare than the supplying of needed dyestuffs, for such plants would constitute an easily convertible reserve for the manufacture of coal-tar explosives in times of war.
>
> Through its stimulative effect on research, on technique, and on supply of material the dyestuff industry has furthered the development of both the explosives and the medicinal industries. Its firm establishment here would foretell the complete development of each of this great trio of industries, which, as a whole, furnish the rational and economic utilization of that great mass of coal tar which now wastes itself in useless flames above the coke ovens throughout the land.
>
> Coöperation—it is a good word, and carries with it a wonderful power of accomplishment.

We have had coöperation. A flourishing industry is almost here. With the help of the present Congress the day of its full arrival will be assured.

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

THE FIRST GAS REGIMENT

By James C. Webster, 1st Lt., First Gas Regiment

Received April 25, 1919

The First Gas Regiment, Chemical Warfare Service, was organized at Camp American University, Washington, D. C., in September 1917 as the 30th Engineers, Gas and Flame, under the command of Major (later Colonel) Earl J. Atkisson of the Corps of Engineers. Two companies were quickly recruited and trained, and sailed for France on December 26, 1917. At this time little was known here of offensive gas warfare on the western front, and the technical training of the two companies had to be deferred until they reached France. The enlisted personnel of these and succeeding companies was of very high caliber, and consisted of chemists, engineers, and mechanics from all parts of the country.

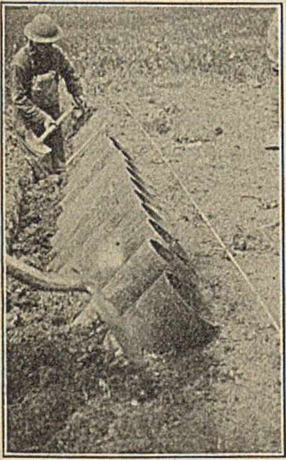

Fig. 1—Placing a Battery of Projectors in Position

While the first two companies were being trained with the Special Brigade, Royal Engineers (the British gas troops) at Helfaut, France, two more companies were being organized at Fort Myer, Va., and sailed on February 27, 1918. This gave us four companies, of 250 men each, trained for offensive work at the beginning of June 1918. A and B companies not only had seen service with the British, but had been working on the American front at this time, and, with the addition of companies C and D, we had gas troops operating during June and July in the Château-Thierry sector and on the Lorraine and Vosges fronts. The last two companies, E and F, which were also organized at Fort Myer, arrived in France in July.

The plan of a projector operation upon a stabilized front consisted, in brief, of a preliminary reconnaissance to determine the emplacements, number of guns, camouflage, the type and approximate time of the work, and the carry. The target was furnished by intelligence. To the emplacement, which was selected as close as possible to the enemy's line, were later brought the necessary guns, base plates, gas bombs, charge boxes, and tools for digging in. Twenty guns constitute a battery and the charges are fired simultaneously by means of an electric exploder. The gas bomb is projected into the enemy line a distance depending upon the weight of charge used, and explodes after reaching the ground. Ranges as high as 1700 meters were possible with the 4 ft. Livens projector. Frequently the 4 in. Stokes mortars were used in connection with the larger projector operations. Gas and thermite were fired from the mortar upon machine gun emplacements and concentrations of enemy troops. The following data may be of interest to show the amount of material which was transported for one of the larger "shows."

Frequently, the bombs instead of containing gas were filled with T. N. T. and their use produced a demoralizing effect upon the enemy troops as each bomb was equivalent in explosive force to an 8 in. shell.

Location of "show"	Merviller, near Baccarat
Company operating	C, 1st Gas Regt.
Time (zero)	Midnight, August 17, 1918
Number of guns	800
Weight of projectors (2 ft. 9 in.)	40 tons
Weight of gas bombs	24 tons
Weight of base plates	12 tons
Weight of charges, exploders, tools, etc.	4 tons
Total weight of material	80 tons
Weight of gas projected	12 tons
Kinds of gas used	Phosgene and Chlorpicrin

With the formation of the American First Army, the Regiment ceased to operate with independent French and American units. It became a part of the First Army and the battalions (two companies each) were assigned to army corps and the companies to divisions holding the line. With this organization, the Regiment operated throughout the St. Mihiel and Argonne-Meuse drives and was on the line at the time of the signing of the armistice.

On the liquid or moving front the Stokes mortar was used almost exclusively in connection with the advance of the infantry. The ammunition fired included smoke, for concealment and deception; gas, against machine guns and enemy strong points; and thermite, which was used for its demoralizing effect. Occasionally projectors were installed and fired upon short notice against enemy strong points, but where the front was changing rapidly the projectors could not be used.

The Regiment returned to the United States under the command of Maj. J. B. Carlock, of San Francisco, and was demobilized at Camp Kendrick, N. J., in February 1919. Individual decorations awarded to members of the Regiment totaled 61, including 1 D. S. M., 15 D. S. C., and 45 Croix de Guerre. The casualties suffered by the Regiment were approximately 50 per cent.

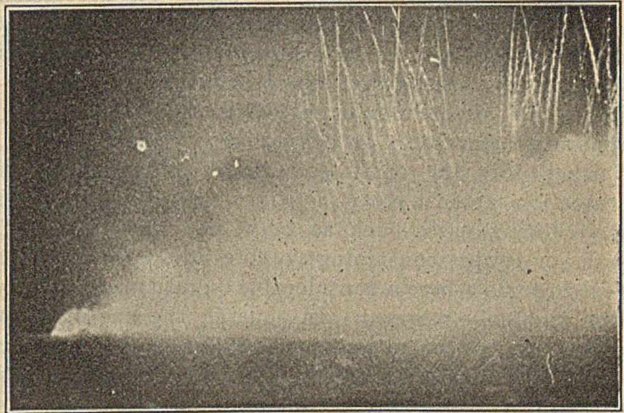

Fig. 2—Projectors Being Discharged

The following letter from Brig. Gen. Fries, Chief of the Chemical Warfare Service, A. E. F., was published to the Regiment as General Order No. 5:

> At this time, I desire personally, and on behalf of the Chemical Warfare Service as a whole, to express to you and the officers and men of the First Gas Regiment under you, our pride in and profound admiration of the work you have done. To take a new regiment and in a few short months teach it an entirely new method of warfare, known to few but the enemy, and so handle that work that the Chemical Warfare Service, as well as the Regiment, became favorably known throughout an army of nearly 2,000,000 men, is an achievement of which any body of men may well be proud.

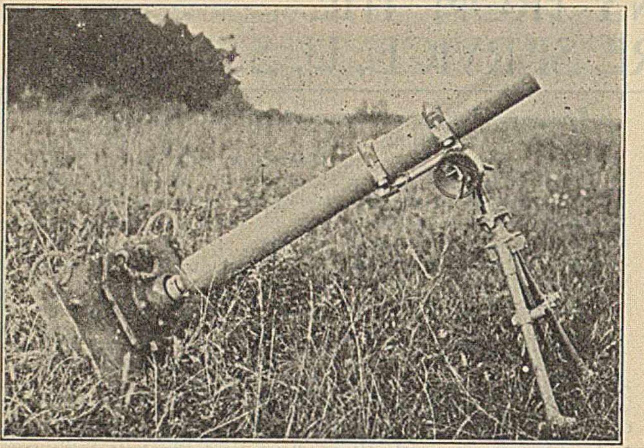

FIG. 3—4 IN. STOKES MORTAR IN POSITION

Not only is the First Gas Regiment well known, but its work has been so excellent that demands for more gas troops were constantly increasing in numbers and insistence. Everywhere the work has been spoken of as that of brave and able men, who feared no enemy and no hardships, and who stopped only when complete exhaustion overpowered them.

Whether the Chemical Warfare Service will be continued in peace remains to be seen. That your work will always be remembered and that it will be the guiding star for such work in any future war, should, unfortunately, our country ever again have to enter upon one, is absolutely certain.

At the time of the signing of the armistice other gas troops were being organized in the United States to supplement the six companies in France.

CLEVELAND, OHIO

PROTECTION AFFORDED BY ARMY GAS MASKS AGAINST VARIOUS INDUSTRIAL GASES[1]

By A. C. FIELDNER, M. C. TEAGUE AND J. H. YOE

Received May 26, 1919

In considering the use of gas masks for protection against various gases it must be emphasized that they should never be used in atmospheres containing less than 12 per cent oxygen by volume. In such atmospheres an air helmet or a self-contained breathing apparatus containing an oxygen supply must be used. Neither does the army gas mask afford complete protection against very high concentration of toxic or irritating gases such as may be found in closed tanks or towers containing volatile liquids or in small closed rooms where a considerable quantity of gas has been suddenly released. In general, the gas mask is limited to concentrations not exceeding 1 to 5 per cent, depending on the kind of gas, the absorbent used, and the size of the canister.

The chemical filling of the standard army canister, Type H, consists of 42 cu. in. of an intimate mixture of 60 per cent charcoal and 40 per cent "purple" soda lime (by volume). The size of granules is between 8 and 14 mesh. This mixture combines maximum protection as nearly as possible against both acid gases and those removed by physical absorption only. For special gases the filling may be all charcoal, all soda lime, or some other specific absorbent. When protection against irritating or toxic smokes is also required two cotton wadding pads are placed in the canister at $^1/_3$ and $^2/_3$ distance from the bottom, respectively.

In the following table of protection against various gases "standard army filling" shall refer to 42 cu. in. of the 60 to 40 per cent mixture of charcoal and soda lime.

These tests were made by the methods described in a previous paper[1] on "Methods of Testing Gas Masks and Absorbents."

AVERAGE RESULTS OF TESTS AGAINST VARIOUS GASES

Gas	Absorbent Filling	Concentration P. p. m. by Vol.	Kind of Test[1]	Life Min.
Aniline	Charcoal	300	Machine	1410
Ammonia	Standard	40,000	Machine	0
Ammonia	Standard	5,000	Machine	3
Ammonia	Standard	2,500	Machine	5
Ammonia	$NiCl_2.6H_2O$ on pumice	20,000	Machine	22
Ammonia	$CoCl_2.6H_2O$ on pumice	20,000	Machine	84
Ammonia	$CoCl_2.6H_2O$ on pumice	50,000	Machine	18
Ammonia	$CoCl_2.6H_2O$ on pumice	50,000	Man	192
Ammonia	$CuSO_4.5H_2O$ on pumice	50,000	Man	175
Ammonia	$CuSO_4.5H_2O$ on pumice	50,000	Machine	20
Ammonia	$CuSO_4.5H_2O$ on pumice	20,000	Machine	46
Arsenic trichloride	Standard	500	Machine	119
Arsenic trichloride	Standard	2,000	Machine	64
Benzol	Standard	40,000	Machine	3
Benzol	Standard	10,000	Machine	14
Benzol	Charcoal	10,000	Machine	57
Benzol	Charcoal	40,000	Machine	11
Benzyl bromide	Standard	100	Machine	470
Brombenzyl cyanide	Standard	28	Machine	+5100
Brombenzyl cyanide	Purple soda lime	28	Machine	0
Carbon bisulfide	Standard	10,000	Machine	17
Carbon bisulfide	Charcoal	10,000	Machine	68
Carbon bisulfide	Charcoal	30,000	Machine	20
Carbon bisulfide	Charcoal	50,000	Machine	8
Chloracetone	Standard	2,000	Machine	226
Chloracetone	Standard	8,000	Machine	41
Chloracetophenone	Standard	15	Machine	+1800
Chloracetophenone	Purple soda lime	15	Machine	0
Chloracetyl chloride	Standard	1,000	Machine	408
Chloracetyl chloride	Standard	10,000	Machine	29
Chloracetyl chloride	Purple soda lime	10,000	Machine	39
Chloracetyl chloride	Charcoal	10,000	Machine	21
Chlorine	Standard	5,000	Machine	47
Chlorine	Standard	10,000	Man	125
Chlorpicrin	Standard	17,500	Machine	7
Chlorpicrin	Standard	10,000	Machine	12
Chlorpicrin	Standard	4,000	Machine	30
Chlorpicrin	Standard	500	Machine	263
Chlorpicrin	Standard	4,000	Man	150
Cyanogen bromide	Standard	50,000	Machine	38
Cyanogen bromide	Standard	100	Machine	295
Cyanogen bromide	Standard	1,250	Man	+60
Cyanogen chloride	Standard	500	Machine	21
Cyanogen chloride	Standard	1,000	Machine	143
Cyanogen chloride	Charcoal	500	Machine	77
Cyanogen chloride	Charcoal	750	Machine	58
Cyanogen chloride	Charcoal	5,000	Machine	25
Cyanogen chloride	Purple soda lime	1,000	Machine	0
2,4 - Dichlorbenzyl bromide	Standard	40	Machine	+3600
Dichlordiethyl sulfide	Standard	100	Machine	1980
Dichlordiethyl sulfide	Soda lime	100	Machine	0
Dimethyl sulfate	Standard	700	Machine	262
Diphenylcyanarsine	Standard	15	Machine	150
Ethyl chloride	Charcoal	15,000	Machine	21
Ethyl chloride	Charcoal	10,000	Machine	33
Ethyl chloride	Charcoal	5,000	Machine	64
Formaldehyde	"J Type"	10,000	Man	40 (Not exhausted)
Hydrocyanic acid	Standard	250	Machine	217
Hydrocyanic acid	Standard	1,000	Machine	64
Hydrocyanic acid	Standard	2,500	Machine	30
Hydrocyanic acid	Standard	5,000	Machine	17
Hydrocyanic acid	Purple soda lime	5,000	Machine	31
Hydrocyanic acid	Green soda lime	5,000	Machine	67
Hydrogen chloride	Standard	5,000	Machine	74
Hydrogen chloride	Standard	50,000	Machine	9
Hydrogen sulfide	Standard	10,000	Machine	97
Hydrogen sulfide	Charcoal	10,000	Machine	37
Hydrogen sulfide	Purple soda lime	10,000	Machine	170
Methylchlorarsine	Standard	2,500	Machine	118
Methylchlorarsine	Standard	5,000	Machine	46
Methylchlorarsine	Standard	500	Man	+310
Methylchlorarsine	Charcoal	2,500	Machine	106
Methylchlorarsine	Purple soda lime	2,500	Machine	94
Nitrogen peroxide	Standard	1,500	Man	+70
Perchlormethylchloroformate	Standard	2,000	Machine	56
Perchlormethylchloroformate	Standard	3,000	Machine	39
Perchlormethylmercaptan	Standard	1,500	Machine	40
Perchlormethylmercaptan	Purple soda lime	......	Machine	3
Perchlormethylmercaptan	Charcoal	......	Machine	20

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

[1] A. C. Fieldner, G. G. Oberfell, M. C. Teague and J. N. Lawrence, THIS JOURNAL, **11** (1919), 519.

AVERAGE RESULTS OF TESTS AGAINST VARIOUS GASES (*Concluded*)

Gas	Absorbent Filling	Concentration P. p. m. by Vol.	Kind of Test[1]	Life Min.
Phenylamido phosgene	Standard	250	Machine	754
Phenylamido phosgene	Purple soda lime	250	Machine	6
Phosgene	Standard	5,000	Machine	47
Phosgene	Standard	5,000	Man	297
Phosgene	Charcoal	5,000	Man	160
Phosgene	Charcoal	10,000	Man	66
Phosgene	Purple soda lime	10,000	Man	15
Phosgene	Purple soda lime	5,000	Man	17
Silicon tetrachloride[2]	Standard	500	Man	+85
Sulfur dioxdie	Standard	2,500	Machine	60
Sulfur dioxide	Standard	5,000	Machine	32
Sulfur dioxide	Standard	50,000	Man	29
Sulfur dioxide	Charcoal	5,000	Machine	7
Sulfur dioxide	Purple soda lime	5,000	Machine	54
Sulfur dichloride	Charcoal	5,000	Machine	16
Sulfur monochloride	Standard	2,500	Machine	70
Sulfur monochloride	Charcoal	3,000	Machine	33
Thiophosgene	Standard	5,000	Machine	42
Thiophosgene	Purple soda lime	5,000	Machine	0
Tin tetrachloride	Standard	500	Man	+60
Titanium tetrachloride[2]	Standard	500	Man	+84
Xylyl bromide	Standard	250	Machine	470

[1] Machine test is at 32 l. per min. flow and corresponds to a man doing moderate work. Man test is made with the man at rest and approximates 8 l. per min.

[2] Attention is called to the fact that for protection against gases which fume on exposure to moist air, it is necessary that cotton pads be employed. The standard canister has two 3-layer pads placed $^1/_3$ and $^2/_3$ the distance from the bottom to the top.

From the above table it is seen that the standard army filling containing a mixture of charcoal and soda lime combines protection against almost all toxic gases; the chief conceptions among the common toxic gases are ammonia and carbon monoxide.

It is of course obvious that the standard mixture does not furnish the maximum protection against such gases as are absorbed by one component only, as for example, carbon tetrachloride or benzol which is absorbed by the charcoal only or sulfur dioxide which is taken up principally by the soda lime. Hence, when masks are required for specific gases or when high concentrations of a gas absorbable by one component only is to be encountered, it becomes advisable to fill the entire canister with either charcoal or soda lime.

The standard 60 to 40 per cent mixture filling is recommended for:

Chlorine
Phosgene
Tetrachlorides of tin, silicon and titanium[1]
Arsenic tin chloride[1]
Xylyl and benzyl bromides
Chlor- and brom-acetone
Chlorpicrin
Dimethyl sulfate
Perchlormethylchloroformate
Nitrogen peroxide

The all-charcoal filling is recommended for:

Gasoline vapor
Benzol
Carbon bisulfide
Carbon tetrachloride
Cyanogen bromide
Similar vapors which are not acted on by soda lime

The all-soda lime filling is recommended for:

Sulfur dioxide
Carbon dioxide
Hydrocyanic acid gas
Hydrogen sulfide
Hydrogen chloride
Other acid gases

When smoke particles, such as the hydrolysis products of stannic chloride, or solid particles, as arsenic trioxide, are encountered, the canister should contain at least two cotton wadding pads or other filter material.

Ammonia is not completely absorbed by the standard filling. For this purpose copper sulfate on pumice is recommended.

Carbon monoxide, natural gas, artificial illuminating gas, coke oven gas, blast furnace gas, and the difficultly condensable gases, such as oxygen, hydrogen, nitrogen, methane, etc., are not removed by the canister.

The standard canister containing filter pads gives good protection against smoke from wood, rags, tar, sulfur, and other combustibles. Tests have been made in which men wearing standard army masks remained in dense smoke from burning wood and wet straw for a period of 20 minutes without discomfort. Care, however, must be observed that such combustion smoke contains no appreciable quantities of carbon monoxide, for which the mask provides no protection, and which would not be detected by the wearer before being overcome. For this reason the standard army gas mask with charcoal and soda lime canister containing filter pads should be used with some caution by firemen in entering burning buildings; in exceptional cases, dangerous quantities of carbon monoxide may be present.

The army mask, however, has been used successfully in fighting forest fires. It can probably be used safely in similar smoke occurring in the open air, or for a very short period of time in buildings where the smoke is diluted by circulation of air.

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GAS FLOW METERS FOR SMALL RATES OF FLOW[1]

By A. F. BENTON

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INTRODUCTION

In the experimental work connected with the various phases of chemical warfare research, the measurement of the rate of flow of gas was a very important factor, and probably entered into more problems than any other single variable. Owing to the nature of the experiments, unusual difficulties were encountered in metering the gas. For example, the rates of flow were many times smaller than those ordinarily met with in industrial work, the gases to be handled were highly corrosive, and the urgency of the work was such that the meters had to be easy to construct, or readily available in quantity.

THE USUAL TYPES OF METER

Each of the customary methods of measuring gas flow possesses one or more features which render it unsuitable for work of this nature. The displacement type of meter, represented by the "dry" meter, or the comparatively accurate "wet" meter, could not conveniently be employed since these do not give instantaneous readings of *rate* of flow, but require the operator to observe the time interval during which a

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[1] Cotton filter pads are also required to remove the hydrated oxides.

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

definite volume is passed. Anemometers and float meters are delicate and insufficiently accurate, especially at small rates of flow. The method of measuring the change of temperature of the gas due to the continuous addition to it of a known quantity of heat has the disadvantage of not giving direct reading of flow without complicated apparatus.

Orifice meters seemed more promising. However, since glass is probably the most satisfactory material for use with corrosive gases, the construction according to specifications offers considerable difficulty. Small orifices made by punching a hole in the hot glass with a platinum wire of suitable diameter have been used almost exclusively by one unit of the Research Division, who have found them suitable for rates as small as 1 or 2 l. per min. Experience has shown, however, that it is very difficult to duplicate dimensions, so that the performance of the finished meters cannot be predicted with any great exactness. For smaller rates this difficulty renders them totally unsatisfactory. Both Pitot tubes and Venturi meters, while excellent in principle because of the comparatively small resistance they introduce into the line, are unsuited to the measurement of gas at rates of the order of 50 l. per min. or less, and the difficulty of constructing them of glass is very great.

RESISTANCE-TUBE METERS

Another principle, distinct from any of the above, which takes advantage of frictional resistance to flow, has occasionally been employed, particularly in water works, for the approximate measurement of fluids.[1]

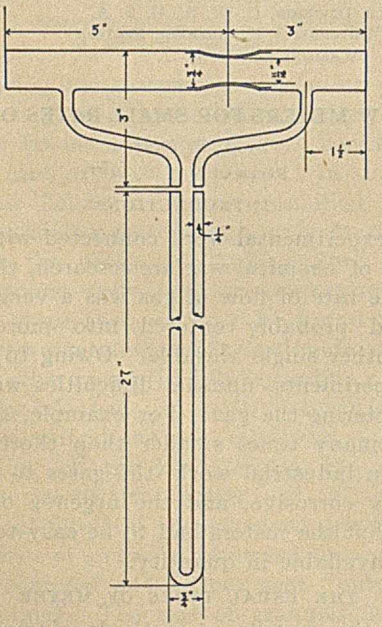

FIG. 1

The method consists simply in determining the pressure in the line at two widely separated points, the quantity passed being obtained from a previous calibration in which the volume has usually been measured by one of the methods described above, or by pumping into a receiver of known capacity. In spite of its obvious simplicity, this method has met with little favor in engineering practice, chiefly because of the uncertainty introduced by the continually changing surface of the pipe walls, and also for the reason that the points where the pressure was measured had ordinarily to be a mile or more apart to give a sufficiently large pressure drop. The principle is well adapted, however, to the measurement of low rates of flow. A meter for this purpose, in which the pressure difference is measured across a length of capillary tubing, has been described by Muster,[1] and more recently by Guye and Schneider.[2] Several years ago, a similar meter was developed in the Bureau of Mines Experiment Station at Pittsburgh, Pa., in connection with work on the chlorination of natural gas. These flow meters proved so simple and convenient, as regards both construction and operation, that they have been adopted almost universally throughout the Chemical Warfare Service.

To satisfy all the varied requirements, three general types of meter were evolved. Type A, shown in Fig. 1, can be used conveniently for rates of flow from 1 or 2 l. per min. up to 200 or more. In the constriction is placed a 1-hole rubber stopper, through which passes a short glass tube of suitable size, to serve as the resistance. The manometer, containing water or other convenient liquid, may be sealed to the head of the meter, or may be connected to it with good rubber tubing. Table I contains suitable specifications for the indicated rates of flow for air. These values are not to be relied upon, however, except as a guide in constructing meters; calibration[3] is essential for the best results. Dimensions for rates of flow of gases other than air will be considered later.

TABLE I[1]

LENGTH OF TUBE = 30 MM.

DIAMETER Mm.	RATE OF FLOW OF AIR (LITERS PER MINUTE) AT HEAD INDICATED		
	500 Mm. Water	250 Mm. Water	50 Mm. Water
6.2	120	84	37
5.4	90	64	28
4.7	70	50	22
3.9	50	35	16
3.5	40	28	12
3.2	32	23	10
2.8	24	17	7.5
2.3	16	11	5
1.8	10	7	3
1.5	6	4.5	2
0.9	2	1.3	0.5

[1] The values given are for tubes with sharp ends.

The Type B meter, shown in Fig. 2, is suitable for rates between 500 cc. and 5 l. per min. Because of the wide choice of dimensions for these low rates and the many factors affecting the selection of desirable sizes, no attempt will be made at this point to tabulate specifications. This question will be taken up later in the discussion of the experimental data given below. The Type C meter is particularly adapted to the measurement of exceedingly small rates of flow, although it will handle as much as 5 l. per min. quite satisfactorily. The construction is similar to that of Type B, with the exception that the capillary tube

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[1] The principle is illustrated by its frequent application to the determination of the viscosity of gases and liquids.

[1] Thesis, Geneva, **1907**.

[2] *Helv. Chim. Acta*, **1** (1918), 35.

[3] The method of calibration is described in the experimental part of the paper

is made a replaceable part, and is connected in with rubber tubing instead of being sealed to the rest of the meter. Since it is impracticable to duplicate dimensions for these small rates by actual measurement, this type allows of different tubes being connected in temporarily, until by means of a rough calibration the desired size is found. A flow meter of this type may be provided with a set of replaceable tubes of suitable dimensions so that any particular rate, over a considerable range, may be quickly and easily obtained.

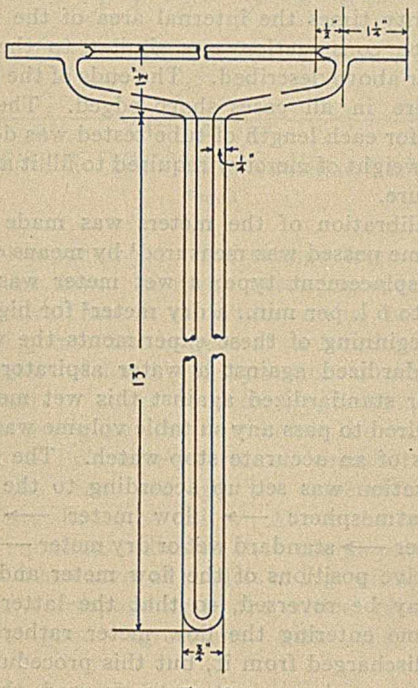

FIG. 2

Various modifications and conveniences may be added to any of these types of meter, as circumstances may require or permit. For example, the refilling of the manometer is greatly facilitated by means of a third tube, sealed at its lower end to the bend of the U-tube, and closed at its upper end with a rubber tube carrying a short length of glass rod. To prevent the liquid "sucking over," a bulb larger than the total volume of liquid in the manometer may advantageously be blown in the upper portion of the low-pressure arm. If desired, the manometer may be made to read on one side only by employing at the lower end of the high-pressure arm a bulb of such size that the level of liquid in it is not materially altered by changes in the height of the column in the other arm. This modification is of no advantage, however, if the liquid has a considerable volatility. A much more dependable method of reading the pressure drop is obtained by the use of a sliding scale, which may be made to move up and down between the arms of the manometer. In this way errors of observation are reduced to a minimum since, if the zero point of the scale is adjusted opposite the lower level, the pressure drop may be read off the scale directly. If it be desired to reduce to a minimum the head lost in metering the gas, or if only very small heads are available, some more sensitive type of gauge than the U-manometer may be employed, such as an inclined gauge or a differential manometer.[1] Such an instrument will give satisfactory results, however, only when the pressure in the gas line is almost entirely free from fluctuations. In those numerous cases in which the function of the meter is to pass a known, constant rate of flow, the automatic device[2] of Oberfell and Mase for maintaining a constant head is said to give excellent results.

THEORETICAL DISCUSSION

The theory of the flow of gas through tubes of small diameter has a very important bearing on their use as flow meters. The development of the theory for gases is due originally to O. E. Meyer,[3] whose formula may be expressed as follows:

$$p_1v_1 = p_2v_2 = \frac{\pi r^4 t(p_1^2 - p_2^2)}{16\eta l} \ldots\ldots (1)$$

where p_1 and p_2 represent the pressures at the inlet and outlet ends of the tube, respectively, v_1 and v_2 are the corresponding volumes, t is the time, η is the coefficient of viscosity, and r is the radius, and l the length of the tube. If, however, we consider that the volume is measured under the mean pressure, *i. e.*, $\frac{1}{2}(p_1 + p_2)$, this equation reduces to the well-known formula of Poiseuille for the flow of liquids:

$$v = \frac{\pi r^4 t(p_1 - p_2)}{8\eta l} = \frac{\pi r^4 t h}{8\eta l} \ldots\ldots\ldots\ldots (2)$$

when h is the pressure difference, or head. Obviously the volume is not actually measured under the mean pressure, but if the head is small in comparison with the pressures at the ends of the tube, only a small error will result from substituting the measured volume in Equation 2. For example, if p_1 is atmospheric pressure and h is 20 cm. of water, the error is roughly 1 per cent. In what follows, therefore, Poiseuille's formula will be taken to be sufficiently exact for the purpose.

These equations are obtained on the supposition that the motion of the gas is streamline, that is, that the lines of flow in the tube are parallel to its axis. When this is the case the resistance to flow is due simply to molecular friction, *i. e.*, viscosity, as the above equations indicate. Above a certain rate of flow, which depends on the diameter, the motion loses its streamline character and breaks up into turbulent, or eddy, flow. When this occurs, motion is transferred from one layer of gas to another by actual cross currents and eddies much more than by molecular friction, so that here the resistance depends chiefly on the density of the gas. Osbourne Reynolds[4] studied this so-called "critical" phenomenon, and found for the case of water that the change in the character of the flow occurs when $\frac{dS\rho}{\eta}$ = 1900 to 2000, where d represents diameter, S linear velocity of flow, and ρ the density of the water. In 1908, W. Ruckes[5] found that gases exhibit the same phenomenon, and that, for glass tubes, it occurs at about the same value of

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[1] See, *e. g.*, L. S. Marks, "Mechanical Engineers' Handbook," p. 284.

[2] THIS JOURNAL, **11** (1919), 294.

[3] *Pogg. Ann.*, **127** (1866), 253.

[4] *Phil. Trans.*, **174** (1883), 935.

[5] *Ann. Physik*, [4] **25** (1908), 983.

$\frac{dS\rho}{\eta}$ as given by Reynolds' criterion.[1] For the turbid flow above this critical region, Lees[2] has obtained an empirical expression, which may be put in the following form:

$$\frac{h}{l} = \frac{\rho R^2}{r^5}\left[0.00018 + 0.0182\left(\frac{\eta r}{\rho R}\right)^{0.35}\right],$$

where R is v/t, the rate of flow.

When applied to flow meters, these results show that when the flow is streamline, the head is proportional to the first power of the rate of flow, whereas above the critical region, it varies as R^n, where n lies usually between 1.86 and 2. If a meter is constructed of such dimensions that the available range of rates is entirely above or entirely below the critical region, the head will vary with the rate in a regular manner, and smooth curves will be obtained when these are plotted as variables. If, however, the critical region lies within the range through which the meter is to be used, the curves plotted in this way will show a sudden change in direction where the motion becomes turbulent. Under these circumstances an inconveniently large number of "points" would have to be determined on the meter to make the calibration at all certain.

The theoretical development outlined above takes no account of a distributing influence which is almost always present when these tubes are used as flow meters. This is due to the fact that some static pressure is converted into kinetic pressure as the gas enters the capillary. This will be evident if a tube be considered to become shorter and shorter, until finally only the ends remain, and the middle has shrunk to nothing. According to the formulas given above, the resistance h should now be zero. Actually this is not the case, since it is the resistance offered by an orifice of the same diameter as the tube. This so-called "end effect" has frequently been considered[3] in determining gas viscosity by the capillary tube method, but investigators have generally found it convenient to employ such long tubes that the effect was negligible. For flow meter purposes, however, it is essential to have data giving the relation between dimensions and capacity in this intermediate range, if the construction of meters is not to be simply a "cut-and-try" process.

EXPERIMENTAL METHOD

The majority of the resistance-tube flow meters, with their calibration data, that have been used in the Chemical Warfare Service, do not supply the necessary material, since the dimensions of the tubes were seldom determined by any but the roughest methods. However, 40 meters were made and calibrated especially for this purpose, covering the range most frequently required. Five diameters of resistance tube were tested (from 0.7 to 4 mm.) and 8 lengths of each were employed (from 1 to 100 cm.). The construction was as follows: Glass tubes of each desired diameter and about a meter long were examined for irregularities of bore by observing the length of a short thread of clean mercury at different positions along the whole length of each tube. The tubes finally selected were those found free from any abrupt change, and which showed the least gradual variation in bore from end to end. Each of these was then made up into a flow meter by connecting a T tube to each end with rubber tubing, and attaching a water manometer to the vertical branches of these T's. Care was taken to have the cross sectional area of these end vessels at least twenty times the internal area of the resistance tube. The construction was similar to the Type C flow meter above described. The ends of the resistance tubes were in all cases sharp edged. The average diameter for each length of tube tested was determined from the weight of mercury required to fill it at a known temperature.

The calibration of the meters was made with air. The volume passed was measured[1] by means of a meter of the displacement type; a wet meter was used for rates up to 6 l. per min., a dry meter[2] for higher rates. At the beginning of these experiments the wet meter was standardized against a water aspirator, and the dry meter standardized against this wet meter. The time required to pass any suitable volume was obtained by means of an accurate stop-watch. The apparatus for calibration was set up according to the following scheme: atmosphere ⟶ flow meter ⟶ mercury manometer ⟶ standard wet or dry meter ⟶ suction. The relative positions of the flow meter and standard meter may be reversed, so that the latter indicates the volume entering the flow meter rather than the volume discharged from it, but this procedure has the disadvantage, when a wet meter is used, that the air entering the flow meter is practically saturated with water vapor, which may condense in the capillary, thus altering its resistance. For this reason the arrangement shown was adopted, and the mercury manometer was added to render it possible to calculate the observed volumes to any other conditions of temperature and pressure, or to convert them to weight if desired. In the results which are given below, the volumes have been calculated by this means to 25° C. and 760 mm. pressure, the conditions adopted as standard. For each meter the rate of flow was obtained at four different heads, between 50 and 500 mm. of water, the value at each head being the average of 3 or 4 trials. The rate of flow is plotted against the head, preferably on logarithmic paper, and the head corresponding to the rate desired is then read off the resulting curve directly.

RESULTS

Space does not permit of presenting all the results in this form. In Fig. 3, however, the logarithmic curves are shown for one tube, which is typical of the rest. It will be noted that many of the curves show a sharp

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[1] For metal (iron, copper, brass) capillaries, Ruckes found $dS\rho/\eta$ = 400 to 500.

[2] *Proc. Roy. Soc.* (*London*), [A] **91** (1914), 46.

[3] See especially M. Brillouin, "Lecons sur la Viscosité des Liquids et des Gas," **2**, 37; W. J. Fisher, *Phys. Rev.*, **32** (1911), 216; I. M. Rapp, *Ibid.*, [2] **2** (1913), 363.

[1] Very small rates are most conveniently measured by drawing the gas through the flow meter with some sort of aspirator, *e. g.*, a gas burette, in which the volume may be read off directly.

[2] No hesitation need be felt in using a dry meter for this purpose. Although it is quite true that its limit of accuracy may be several per cent, plus or minus, its *precision* has been found entirely satisfactory.

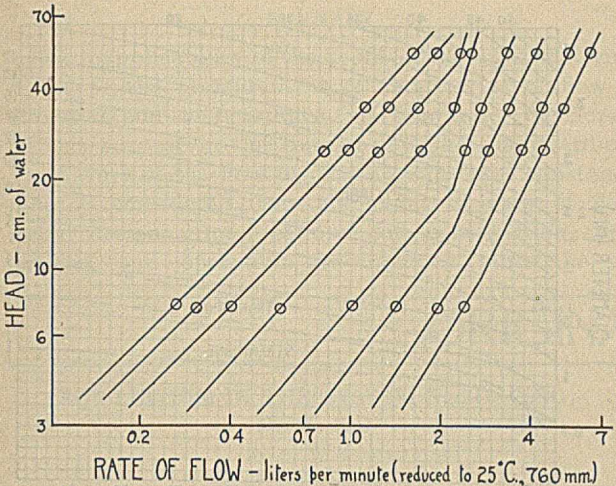

Fig. 3

break, corresponding to the change from streamline to turbulent flow. In many cases the exact position of this critical rate is uncertain, owing to the small number of points, but in general its location is at least approximately defined. If attention is confined for the moment to tubes of such length that the end effects are negligible, the flow below the critical rate, according to Poiseuille's formula, should be proportional to the head, and here the slope of these logarithmic plots should be unity. Above the critical rate the Lees equation indicates that the slope should be nearer 2. The curves at the left in Fig. 3 illustrate this. The break, corresponding to the critical rate, is found to be in good agreement with the Reynolds criterion.

From a practical standpoint, however, interest attaches chiefly to shorter tubes. Here every gradation down to orifices will be encountered. With sharp ends such as were here used, there will always be some initial disturbance of the air, which will tend to die out or to increase according as the flow is below or above the critical rate, respectively. In other words, for some distance from the inlet end the flow will always be turbulent. Now it is evident that if this distance be a large part of the whole length of the tube, the motion will never be entirely streamline, and the shorter the length the more turbulent the flow will be. Consequently it is to be expected that as the length is made shorter and shorter, the break in the curves, corresponding to the critical rate, will become less and less pronounced. Fig. 3 shows this to be the case.

In order to make the results of the greatest practical value, they have been replotted in the form shown in Figs. 4, 5 and 6, in which, for the sake of brevity, three standard heads have been chosen, 500, 250, and 50 mm. of water, 500 being about the maximum desirable head, and 50, the minimum which can usually be read with sufficient accuracy, while 250 is a convenient head for most purposes. In the figures, each curve represents a certain rate of flow of air at the head indicated, and the coördinates give the corresponding lengths and diameters of resistance tubes which must be used to obtain this rate.[1] The regions between the broken-line curves, marked "transition," show the corresponding pairs of lengths and diameters which must not be used, if the critical region is to be avoided near the head indicated. When a meter is desired for a single flow rate, it is only necessary to make certain that the calibration curve will contain no break near this point. On the other hand, where several different rates are required, corresponding to the whole available range of heads, it is very desirable to exclude the critical region entirely from the range of the meter. This may be accomplished by selecting only such dimensions as lie within the region marked "turbid" at a head of 50 mm. (Fig. 4), or in the streamline region at 500 mm. (Fig. 6). In the former case a shorter tube is to be preferred; in the latter, it is well to use a fairly long length in order to have the diameter as large as possible. The choice of dimensions will of course be largely influenced by considerations of space, liability to breakage, etc. Wherever it is not practicable to eliminate the critical region in the manner above described, the difficulty may be readily overcome by using a tube whose length is less than, roughly, twenty to thirty times its diameter.

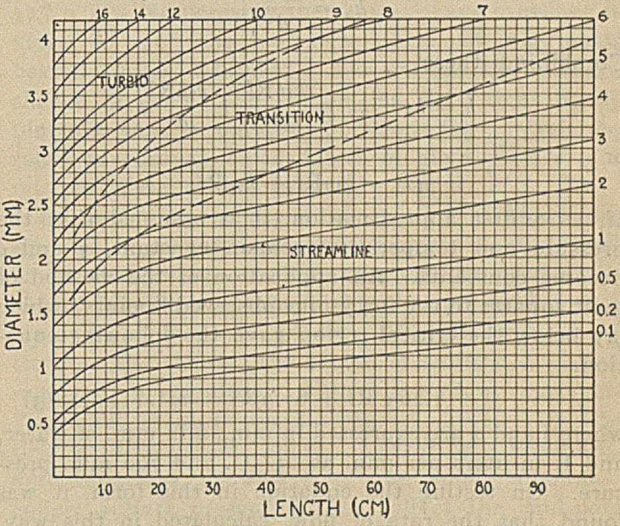

Fig. 4—Curves Showing Rate of Flow, in Liters per Minute, at a Head of 50 Mm. of Water, for Different Lengths and Diameters of Resistance Tubes

The method of plotting used in Figs. 4, 5 and 6 introduces considerable uncertainty in the very small rates of flow. These rates, however, below the critical region, are capable of the simplest mathematical expression. Here Poiseuille's formula should represent the flow through the main part of the tube, while the orifice law should account for the end effects. If that part of the head which measures the resistance of the ends be designated by h_o, that part which measures the resistance within the tube by h_l, and the total head by h, as before, then Poiseuille's formula may be written

$$h_l = \frac{k_1 \eta R l}{d^4},$$

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[1] If a standard meter is not available and an accuracy of 5 to 10 per cent is sufficient, these curves may be used to take the place of calibration. Wherever possible, however, each meter should be calibrated directly.

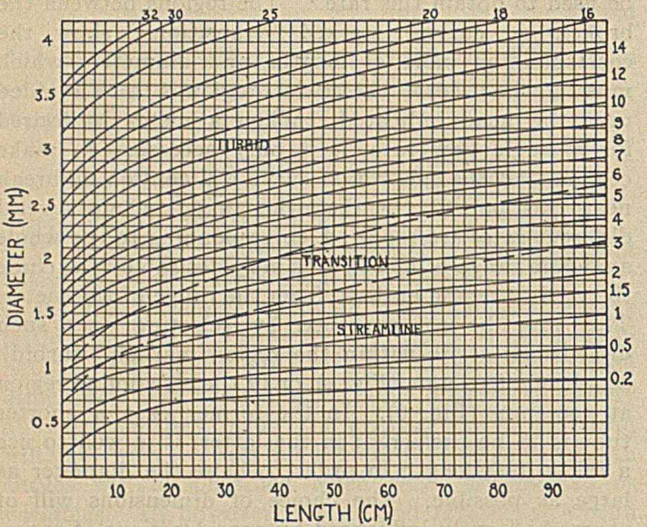

Fig. 5—Curves Showing Rate of Flow, in Liters per Minute, at a Head of 250 Mm. of Water, for Different Lengths and Diameters of Resistance Tubes

where d is the diameter. Similarly the orifice formula may be put in the form:[1]

$$h_o = \frac{k_2 \rho R^2}{d^4}.$$

Combining these

$$h = h_l + h_o = \frac{k_1 \eta R l}{d^4} + \frac{k_2 \rho R^2}{d^4},$$

or

$$hd^4 = k_1 \eta R l + k_2 \rho R^2.$$

If, as a first approximation, it is assumed that the pressure and temperature remain constant, η and ρ become constants. An application of the method of least squares to the forty-nine observed "points" which lay below the critical region gave the following equation:

$$1.263\ Rl + 67.9 R^2 = hd^4 \ldots\ldots\ldots (3)$$

where l and d are expressed in mm., h in mm. of water, and R in liters per min. at 25° C. and 760 mm. pressure. On testing the equation in this form, it was found that the rate of flow, calculated in this way, agreed with the observed rate within 2 per cent on the average. Hence the equation is adequate for the purpose of supplying suitable dimensions for a given rate of flow, for air at atmospheric pressure and room temperature.

OTHER GASES THAN AIR

Specifications for flow meters have been experimentally determined only for air, or for mixtures of other gases with air in such low concentration that the viscosity and density of the air remained substantially unaltered. However, with the help of the equation given above, it is possible to choose suitable dimensions for use with other gases, with considerable confidence. It will be observed that resistance tubes act in two quite different ways, according as the flow is below or above the critical region. Below this point the tube will usually be of such length that the end effect can be disregarded in choosing specifications.

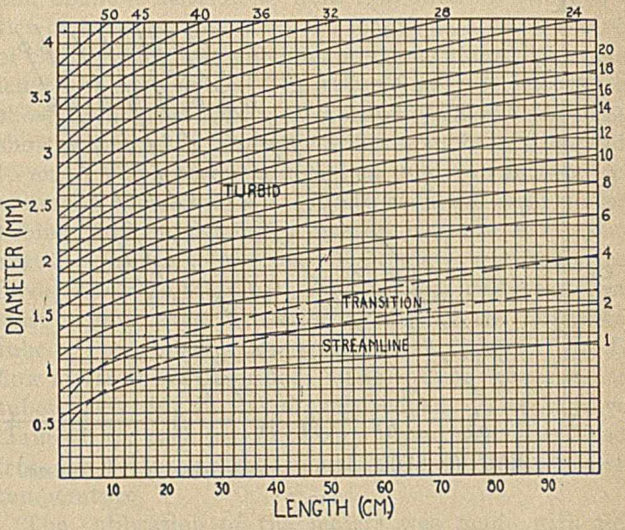

Fig. 6—Curves Showing Rate of Flow, in Liters per Minute, at a Head of 500 Mm. of Water, for Different Lengths and Diameters of Resistance Tubes

In this case Poiseuille's law indicates that the volume passing through the meter is inversely proportional to the viscosity of the gas, while the weight (or the actual volume, calculated to standard temperature and pressure) is proportional directly to the density and inversely to the viscosity. Above the critical region, on the other hand, viscosity contributes very little to the resistance. Here whether the tube be long or short, the volume varies inversely and the weight directly as approximately the square root of the density. Hence if other gases than air, or even liquids, are to be measured, it is only necessary to calculate, by means of these relations, the rate of flow of air which corresponds to the desired rate of gas, and then select the necessary dimensions from Figs. 4, 5 and 6, or from Equation 3.

INFLUENCE OF TEMPERATURE AND PRESSURE

The relations considered in the preceding section show also the effect on the flow of changes in temperature and pressure.[1] Since the viscosity of gases is independent of the pressure, it is evident that ordinary changes in barometric pressure will have only a very slight influence on the flow below the critical region. In this range, however, the influence of temperature is very marked. In the neighborhood of room temperature, a rise of 10° C. will decrease the volume about 3 per cent and the weight nearly 7 per cent. Obviously no great accuracy will be obtained in these long tubes where the flow of gas is below the critical region, unless the temperature be maintained fairly constant. If, however, the flow be above the critical region or if the tube be sufficiently short, the rate depends principally on the density, but the relative change in rate is only half the relative change in density. Thus in the vicinity of room conditions, a decrease in pressure of 15 mm. of mercury, or an increase in temperature of about 6° C. would be required to increase the volume or decrease the weight by 1 per cent.

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[1] Since the pressure differences employed are small in comparison with the actual pressures. See R. J. Durley, *Trans. A. S. M. E.*, **27** (1906), 193.

[1] The effect of temperature and pressure on the dimensions of the capillary and on the density of the manometer liquid is negligible in comparison with the other influences mentioned.

SUMMARY

The inapplicability of the usual forms of gas-metering device to the measurement of small rates of flow is discussed, and the resistance-tube flow meter, developed for this purpose in the Bureau of Mines, is described. The nature of the flow of gas through these resistance tubes is considered from the point of view of flow meter design. Specifications for construction, calibration, and operation are included, and the influence of temperature and pressure changes discussed.

This work was carried out under the direction of the Bureau of Mines. The writer wishes further to express his deep appreciation of the valuable suggestions of Dr. E. Buckingham, of the U. S. Bureau of Standards.

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ORIGINAL PAPERS

EQUILIBRIUM IN THE SYSTEM Na_2SO_4–$CuSO_4$–H_2SO_4–H_2O[1]

By H. W. Foote

Received October 28, 1918

In considering proposals for the utilization of niter cake, Johnston[2] has stated that "the best mode of using a solution of niter cake for any particular purpose could be ascertained from the appropriate solubility data; this involves the investigation * * * * of four-component systems such as Na_2SO_4–H_2SO_4–$FeSO_4$–H_2O." It is hoped that the present investigation may serve as an aid in that direction.

The problem has been limited to determining the solubility relations, at two temperatures, of the following systems:

(1) Na_2SO_4–H_2SO_4–H_2O
(2) $CuSO_4$–H_2SO_4–H_2O
(3) Na_2SO_4–$CuSO_4$–H_2O
(4) Na_2SO_4–$CuSO_4$–H_2SO_4–H_2O

A knowledge of (1), (2), and (3) is obviously necessary in considering (4). Stated in a different way, the problem has consisted in determining the changes which take place when sulfuric acid, in increasing amounts, is added to the system Na_2SO_4–$CuSO_4$–H_2O. Systems containing more than approximately 60 per cent of sulfuric acid in solution were not investigated.

In general, only the solubility of univariant systems was determined and in plotting the results the points which represent them are connected by straight lines to show the composition of the corresponding divariant systems. Actually, these curves are usually somewhat concave. At a given temperature, the univariant systems of three components have two solid phases in equilibrium with a solution of fixed composition and vapor pressure. With four components, there are three solid phases at such points.

METHOD

To determine the univariant points in the three-component systems, a series of crystallization experiments at the given temperature showed approximately the conditions necessary. The solution which deposited one compound near the point where another formed was then treated with an excess of the latter, or in some cases with both, and the solubility of the mixture determined. In all cases, a second result was obtained by adding further quantities of one or both solids and again shaking, the constancy of the results showing that the univariant point had been reached. When the univariant points in the ternary systems had been fixed, it was usually a simple matter to obtain the corresponding points in the quaternary system by merely adding an excess of the third solid necessary. Here also a duplicate result was obtained after adding further quantities of the solids in equilibrium.

Solubilities were determined at 12° and 25°. For 12° a low temperature thermostat[1] gave excellent service. At 25° the ordinary form of thermostat, heated by gas, was used. The various mixtures were shaken in glass-stoppered bottles, kept tight by dipping the tops in paraffin. Solutions for analysis were removed through small filters of glass wool directly into weighed specimen tubes.

In analyzing solutions containing all four components, copper was determined either electrolytically or, as the amount was always small, by precipitating as sulfide, roasting, and weighing copper oxide. After removing copper, sodium was determined in the filtrate as the sulfate, the excess of sulfuric acid being removed by ignition with ammonium carbonate. Free sulfuric acid was determined directly by titrating with standard sodium hydroxide. Preliminary determinations showed that the small amount of copper sulfate present did not affect the end-point. In a few cases, total sulfate was determined (by precipitating as barium sulfate) instead of weighing sodium sulfate, but the method was abandoned as less accurate than the other. Where only three components were present, the method of analysis could be correspondingly simplified.

(1) SYSTEM, Na_2SO_4–H_2SO_4–H_2O

This system has been investigated previously by D'Ans[2] at 25° and by Pascal[3] through a considerable range of temperature, though the latter expresses his results only in the form of a diagram which contains some obvious inaccuracies. D'Ans gives the solubility conditions for the following salts: $Na_2SO_4.10H_2O$, Na_2SO_4, $Na_3H(SO_4)_2.H_2O$, $Na_3H(SO_4)_2$, $NaHSO_4.H_2O$, $NaHSO_4$.

The salt $Na_3H(SO_4)_2.H_2O$ forms spontaneously from solutions only very rarely and D'Ans speaks of ob-

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[1] This investigation was undertaken at the request of the Division of Chemistry and Chemical Technology of the National Research Council.

[2] This Journal, **10** (1918), 468.

[1] *Z. physik Chem.*, **33** (1900), 749.

[2] *Ber.*, **39** (1906), 1534; *Z. anorg. Chem.*, **49** (1906), 356; **61** (1909), 91.

[3] *Compt. rend.*, **164** (1917), 628.

taining it only by chance, though when it has formed, it can doubtless be obtained afterward by inoculating. In all our experience we have never observed this form. Its solubility relations, as shown by D'Ans, are very nearly those of the anhydrous form, so it affects the diagram but slightly and it is not considered here. It seems unlikely that this form would be met in practice. Our solubility results agree closely with those of D'Ans at 25°. One difference as to the solid phases in strongly acid solution is mentioned later.

The following results were obtained. Percentages here and in all tables following represent the parts in 100 parts of solution. The letters in the last column refer to the corresponding points in the diagrams which are described later.

TEMPERATURE = 12°

SOLID PHASES	Per cent H_2SO_4	Per cent Na_2SO_4	Corresponding Point in Diagram
$Na_2SO_4.10H_2O$	None	9.53	A
		9.44	
$Na_2SO_4.10H_2O$ and $Na_3H(SO_4)_2$	16.51	32.96	Q
	16.52	32.90	
$Na_3H(SO_4)_2$ and $NaHSO_4.H_2O$	27.96	25.38	H
	27.96	25.45	
$NaH(SO_4)_2.H_2O$ (Divariant)[1]	58.79	4.33	G

TEMPERATURE = 25°

SOLID PHASES	Per cent H_2SO_4	Per cent Na_2SO_4	Corresponding Point in Diagram
$Na_2SO_4.10H_2O$	None	21.90[1]	A
$Na_2SO_4.10H_2O$ and Na_2SO_4	8.62	33.46	J
	8.62	33.50	
Na_2SO_4 and $Na_3H(SO_4)_2$	16.25	35.20	I
	16.29	35.53	
$Na_3H(SO_4)_2$ and $NaHSO_4.H_2O$	30.59	27.13	H
	30.57	26.91	
$NaHSO_4.H_2O$ (Divariant)[2]	56.25	6.54	G

[1] Loewel, *Ann. chim. phys.*, [3] **49** (1857), 50.

[2] This was as far toward the sulfuric end of the diagram as we considered it necessary to go. D'Ans found a univariant point with the solids $NaHSO_4.H_2O$ and $NaHSO_4$ at about the same concentration at 25°, but at neither 12° nor 25° did we get any indication of the second salt at the concentrations given. The means we had of judging as to the solid present here was that a series of crystallizations carried out in this region all showed the very characteristic crystalline form of the hydrated salt. The solutions contained so much free sulfuric acid that the crystals could not be freed from it properly and analysis could not decide which salt was present. A salt very different in appearance, which was probably $NaHSO_4$, was obtained in more concentrated solutions but its identity was not determined.

The solubility relations are somewhat simpler at 12° than at 25°, for at the former temperature the anhydrous salt is no longer stable under any conditions, as D'Ans showed originally, and the decahydrate exists in equilibrium with the salt $Na_3H(SO_4)_2$ at the univariant point.

(2) SYSTEM, $CuSO_4$–H_2SO_4–H_2O

In this system no acid salt forms, but the presence of sulfuric acid dehydrates the pentahydrate in stages, yielding the trihydrate, monohydrate, and ultimately the anhydrous salt in strong sulfuric acid. A discussion of this behavior will be found in a previous article[1] from which the solubility results at 25° have been taken. Bell and Taber[2] have also determined the solubility of this system at 25°. Following are the results:

TEMPERATURE = 12°

SOLID PHASES	Per cent H_2SO_4	Per cent $CuSO_4$	Corresponding Point in Diagram
$CuSO_4.5H_2O$	None	16.19	D
		16.11	
$CuSO_4.5H_2O$ and $CuSO_4.3H_2O$	51.63	1.67	E
	51.38	1.61	
$CuSO_4.3H_2O$ and $CuSO_4.H_2O$	61.56	0.87	F
	61.52	0.75	

TEMPERATURE = 25°

SOLID PHASES	Per cent H_2SO_4	Per cent $CuSO_4$	Corresponding Point in Diagram
$CuSO_4.5H_2O$	None	18.47	D
$CuSO_4.5H_2O$ and $CuSO_4.3H_2O$	49.20	2.83	E
$CuSO_4.3H_2O$ and $CuSO_4.H_2O$	55.72	2.13	F

(3) SYSTEM, Na_2SO_4–$CuSO_4$–H_2O

This system has been investigated in some detail by Koppel[1] and his data are given below for 25°. A transition temperature in this system exists at 16.7°, below which only the single salts crystallize, while above it the double salt $Na_2SO_4.CuSO_4.2H_2O$ forms. At 12°, therefore, there is but one univariant system and the two solids present consist of the single salts. At 25° there are two such systems. In one the solid phases consist of double salt and $CuSO_4.5H_2O$, and in the other, double salt and $Na_2SO_4.10H_2O$.

TEMPERATURE = 12°

SOLID PHASES	Per cent Na_2SO_4	Per cent $CuSO_4$	Corresponding Point in Diagram
$Na_2SO_4.10H_2O$	9.53	None	A
	9.54		
$Na_2SO_4.10H_2O$ and $CuSO_4.5H_2O$	10.43	14.69	R
	10.44	14.51	
$CuSO_4.5H_2O$	None	16.19	D
		16.11	

TEMPERATURE = 25°

SOLID PHASES	Per cent Na_2SO_4	Per cent $CuSO_4$	Corresponding Point in Diagram
$Na_2SO_4.10H_2O$	21.90	None	A
$Na_2SO_4.10H_2O$ and $Na_2SO_4.CuSO_4.2H_2O$	21.20	6.28	B
$CuSO_4.5H_2O$ and $Na_2SO_4.CuSO_4.2H_2O$	10.95	16.85	C
$CuSO_4.5H_2O$	None	18.47[1]	D

[1] *J. Am. Chem. Soc.*, **37** (1915), 288.

(4) SYSTEM, Na_2SO_4–$CuSO_4$–H_2SO_4–H_2O

The general method of obtaining the univariant points in the four-component system has already been mentioned. In most cases there was no special difficulty when once the univariant points in the ternary systems were found. For each univariant point in the latter, there was a corresponding point in the quaternary system, in which the solution was saturated with one more solid phase. For instance, starting with the ternary univariant system containing the solid phases $CuSO_4.5H_2O$ and $CuSO_4.3H_2O$, a univariant point in the quaternary system could be reached by adding sodium sulfate. As this salt, however, would be converted into the double salt $Na_2SO_4.CuSO_4.2H_2O$ before equilibrium was established, the latter was actually used in the solubility determinations. This double salt was the only one found and exists under a very wide range of conditions. It forms one of the phases in every univariant system containing the four components.

The relations in the system at 12° are unusual in one respect. As already mentioned, the two salts in water do not form a double salt at this temperature, but crystallize separately. With more than 7.4 per cent of sulfuric acid, the double salt forms, and at this concentration of acid there is a univariant system with the three solid phases, $CuSO_4.5H_2O$, $Na_2SO_4.10H_2O$, and double salt. The presence of the sulfuric acid causes the double salt to be stable below its transition temperature. The case is comparable with the simpler one of sodium sulfate, in which the anhydrous form may exist in contact with sulfuric acid solutions below its transition temperature into the decahydrate, but I am not aware of any similar case which has been observed with four components.

The solubility data for the univariant systems are given in the following table. The one divariant system included at each temperature shows the limiting value obtained on the curve at the sulfuric acid end.

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[1] *J. Am. Chem. Soc.*, **37** (1915), 288.

[2] *J. Phys. Chem.*, **12** (1908), 171.

[1] *Z. phys. Chem.*, **42** (1902), 1.

Solid Phases	Per cent H_2SO_4	Per cent Na_2SO_4	Per cent $CuSO_4$	Corresponding Point in Diagram
Temperature = 12°				
$Na_2SO_4.10H_2O$, $Na_3H(SO_4)_2$, D.S[1].	16.50	32.92	0.18	S
	16.54	32.89	0.13	
$Na_3H(SO_4)_2$, $NaHSO_4.H_2O$, D.S.	27.97	25.47	0.08	M
	27.86	25.36	0.14	
$NaHSO_4.H_2O$, D.S. (Divariant)	58.20	4.65	0.77	N
	50.41	2.53	1.60	P
$CuSO_4.5H_2O$, $CuSO_4.3H_2O$, D.S.	50.54	2.51	1.59	
$CuSO_4.3H_2O$, $CuSO_4.H_2O$, D.S.	59.96	2.59	0.73	V
	59.86	2.80	0.73	
$Na_2SO_4.10H_2O$, $CuSO_4.5H_2O$, D.S.	7.40	13.62	8.65	T
	7.42	13.69	8.82	
Temperature = 25°				
$Na_2SO_4.10H_2O$, Na_2SO_4, D.S[1].	8.58	33.18	0.44	K
	8.59	33.43	0.44	
Na_2SO_4, $Na_3H(SO_4)_2$, D.S.	16.21	35.57	0.18	L
	16.18	36.16	0.19	
$Na_3H(SO_4)_2$, $NaHSO_4.H_2O$, D.S.	30.41	26.98	0.16	M
	30.52	27.02	0.20	
$NaHSO_4.H_2O$, D.S. (Divariant)	55.58	6.62	0.69	N
	55.46	6.54	0.87	
$CuSO_4.5H_2O$, $CuSO_4.3H_2O$, D.S.	47.04	2.98	2.75	P
	47.11	2.81	2.97	
$CuSO_4.3H_2O$, $CuSO_4.H_2O$, D.S.	54.15	2.38	2.24	V
	53.80	2.63	2.10	

[1] Double salt.

Equilibrium in the system $CuSO_4.5H_2O$–$Na_2SO_4.10H_2O$, D. S. given in the above table at 12° was reached very slowly and it is possible for the two single salts to remain in contact with a solution containing considerably more than 7.4 per cent of sulfuric acid and show no sign of transforming into double salt even after a considerable time. The other systems offered no difficulty in reaching equilibrium.

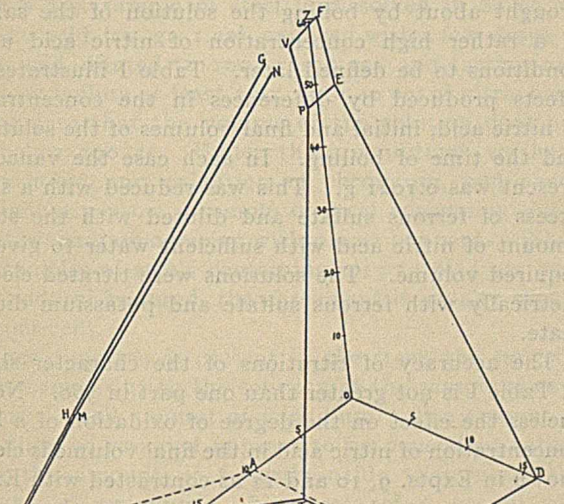

Fig. 1—Temperature = 12°

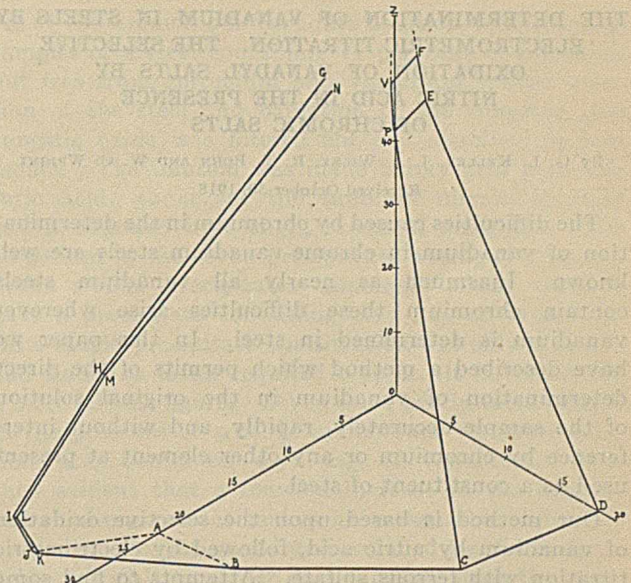

Fig. 2—Temperature = 25°

The relations of the different systems appear much clearer when the results which have been given are plotted. This has been done in Figs. 1 and 2. The percentages of sodium sulfate, copper sulfate, and sulfuric acid are plotted respectively on the three axes, OA, OD and OZ, which make an angle of 120° with each other. For clearness, the scale for sulfuric acid is one-half that for the two salts. Points where the same solids are present at both temperatures are lettered alike. AQHG at 12° (Fig. 1) and AJIHG at 25° (Fig. 2) represent the solubility of sodium sulfate in sulfuric acid solutions; DEF gives that of copper sulfate at both temperatures, and DRA at 12° and ABCD at 25° give the solubility of sodium and copper sulfates (or their double sulfate) in water in the presence of each other. The four-component systems are, of course, limited by these three-component curves, the points inside, at the intersection of three curves, representing univariant systems with three solid phases; the lines, divariant systems with two solids; and the fields, trivariant, with one solid. The fields, and their corresponding solid phases, are as follows:

	12° (Fig. 1)	25° (Fig. 2)
$Na_2SO_4.CuSO_4.2H_2O$	N M S T P V[1]	N M L K B C P V[1]
$Na_2SO_4.10H_2O$	A Q S T R	A J K B
Na_2SO_4	Absent	J I L K
$Na_3H(SO_4)_2$	Q H M S	I H M L
$NaHSO_4.H_2O$	G H M N[1]	G H M N[1]
$CuSO_4.5H_2O$	D E P T R	D E P C
$CuSO_4.3H_2O$	E F V P	E F V P

[1] Field incomplete at sulfuric acid end.

The diagram shows the wide range of conditions under which the double salt forms and the extremely limited range of stability of the acid sulfates of sodium in the presence of dissolved copper sulfate, which converts them into the double salt.

The very slight solubility of copper sulfate on the sodium sulfate-sulfuric acid side of the diagram is of course shown quantitatively in the solubility tables. Some of the difficulties which have been met in using niter cake to replace sulfuric acid for pickling copper alloys are probably due to this slight solubility, which causes the double salt to precipitate. The slight solubility also points to an obvious way of preventing copper sulfate from accumulating in solution or of removing it from solution.

Sodium sulfate forms double salts with all the vitriols, which resemble each other markedly in general solubility relations and in the fact that they are formed from their components above the transition temperature and break down below, this being the reverse of the common behavior of double salts. The transition temperatures also all lie near each other. On account of these similarities, it is probable that the system which has been investigated is typical of systems containing other vitriols in place of copper sulfate.

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THE DETERMINATION OF VANADIUM IN STEELS BY ELECTROMETRIC TITRATION. THE SELECTIVE OXIDATION OF VANADYL SALTS BY NITRIC ACID IN THE PRESENCE OF CHROMIC SALTS

By G. L. Kelley, J. A. Wiley, R. T. Bohn and W. C. Wright

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The difficulties caused by chromium in the determination of vanadium in chrome-vanadium steels are well known. Inasmuch as nearly all vanadium steels contain chromium these difficulties arise wherever vanadium is determined in steel. In this paper we have described a method which permits of the direct determination of vanadium in the original solution of the sample accurately, rapidly, and without interference by chromium or any other element at present used as a constituent of steel.

Our method is based upon the selective oxidation of vanadium by nitric acid, followed by electrometric titration with ferrous sulfate. Attempts to find some reagent which, when added to a mixture of chromate and vanadate, would reduce one completely without reducing the other, or which would exercise a similar selective oxidizing action upon a mixture of chromic and vanadyl salts led us to test many substances. Among reducing agents tried without success, mention may be made of arsenious, phosphorous, hypophosphorous, nitrous, formic, and lactic acids, and mercurous salts. As oxidizing agents we tried manganese dioxide, lead dioxide, sodium bismuthate, potassium iodate, and potassium chlorate. Some of these, particularly manganese dioxide and potassium iodate used as oxidizing agents, and nitrous acid used as a reducing agent, lacked only a little of being satisfactory. The only substance which regularly gave satisfactory results, even in a limited way, was nitric acid. The conditions under which we found it possible to use nitric acid are described below.

It should be confessed that our success in the use of nitric acid here was suggested by a study of our failure to secure complete oxidation as described in an earlier paper by one of us.[1] There the largest oxidation found amounted to 97.7 per cent. Our failure in that case was due to the fact that those concentrations of nitric acid which would have given us complete oxidation gave a solution which could not be titrated on the apparatus then in use. On the apparatus used in these experiments (which has been described elsewhere)[2] we are able to titrate solutions containing much larger amounts of nitric acid. This is probably because the galvanometer now in use is much more sensitive than the one used in the earlier work, but it is not certain that this accounts for the degree of improvement noted. Even now, however, it is somewhat more difficult to determine the end-point sharply in nitric than in sulfuric acid solution. In the earlier paper referred to above, we also observed that the titration of vanadium was favored by low concentrations of vanadic acid and ferric and chromic salts, and a low temperature. Fortunately it is possible to observe these conditions conveniently and still deal with all percentages of vanadium found in commercial steels.

TABLE I—EFFECT OF CONCENTRATION OF NITRIC ACID, TIME OF BOILING, AND INITIAL AND FINAL VOLUMES

Expt. No.	Conc. HNO₃ Cc.	H_2SO_4 Sp. gr. 1.58 Cc.	Time Boiled Min.	Initial Volume Cc.	Final Volume Cc.	V Oxidized Per cent
1	5	..	30	130	100	92.5
2	15	..	30	130	100	96.6
3	25	..	30	130	100	98.1
4	35	..	30	130	100	99.1
5	35	..	60	130	100	99.3
6	45	..	30	130	100	99.5
7	45	..	60	130	100	99.7
8	60	..	30	130	100	99.6
9	60	..	60	130	100	99.7
10	50	..	60	130	75	99.9
11	50	..	60	130	50	100.0
12	30	25	60	130	100	99.7
13	45	25	60	130	100	99.7
14	60	25	60	130	100	99.7
15	30	25	60	200	100	98.7
16	30	25	60	300	200	98.7
17	30	25	60	400	300	97.4
18	45	25	60	200	100	99.4
19	45	25	60	300	200	99.4
20	45	25	60	400	300	98.1
21	60	25	60	200	100	99.9
22	60	25	60	300	200	99.7
23	60	25	60	400	300	98.8
24	35	25	5	130	100	98.3
25	35	25	10	130	100	98.7
26	35	25	30	130	100	99.3
27	35	25	60	130	100	99.5
28	35	25	120	130	100	99.8
29	35	25	240	130	100	99.8
30	35	25	360	130	100	99.8

Selective oxidation of vanadium in the presence of chromium and other constituents of alloy steels was brought about by boiling the solution of the sample in a rather high concentration of nitric acid under conditions to be defined later. Table I illustrates the effects produced by differences in the concentration of nitric acid, initial and final volumes of the solutions, and the time of boiling. In each case the vanadium present was 0.1021 g. This was reduced with a slight excess of ferrous sulfate and diluted with the stated amount of nitric acid with sufficient water to give the required volume. The solutions were titrated electrometrically with ferrous sulfate and potassium dichromate.

The accuracy of titrations of the character shown in Table I is not greater than one part in 300. Nevertheless the effect on the degree of oxidation of a large concentration of nitric acid in the final volume is clearly shown in Expts. 9, 10 and 11 as contrasted with Expts. 1, 2, 3, 17, 20 and 23. Unfortunately for the method a concentration of nitric acid greater than 45 cc. in a final volume of 100 cc. may result in the oxidation of chromium. Expts. 15 and 18 are somewhat low because it is not until the latter part of the period of boiling that the concentration of nitric acid reaches its most effective oxidizing value. Boiling for a period less than 1 hr. gives distinctly lower results as shown by Expts. 4, 24, 25 and 26.

TABLE II—THE EFFECT OF IRON AND SULFURIC ACID UPON THE OXIDATION OF VANADIUM

Expt. No.	H_2SO_4 Cc.	HNO_3 Cc.	Fe Grams	V Gram	Time Min.	Initial Volume Cc.	Final Volume Cc.	V Oxidized Per cent
31	..	40	1	0.0500	120	200	40	100.0
32	25	40	1	0.0500	30	150	100	98.1
33	25	40	1	0.0500	60	150	100	99.1
34	50	40	1	0.0500	60	150	100	98.7
35	25	40	2	0.0025	60	150	100	101.0
36	25	40	2	0.0050	60	150	100	100.0
37	..	40	1	0.0200	60	150	100	99.5

When large amounts of vanadium, iron, and sulfuric acid are present, the oxidation of the vanadium appears to be inhibited. Expt. 31 in Table II shows

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[1] *J. Am. Chem. Soc.*, **38** (1916), 349.

[2] This Journal, **9** (1917), 780.

complete oxidation of the vanadium in the presence of 1 g. of iron when sulfuric acid is absent and the final volume is small. Expts. 32, 33 and 34 show a low oxidation of vanadium as compared with oxidation in Table I by similar concentrations of nitric acid in the absence of sulfuric acid and in the presence of only small amounts of iron. On the other hand, Expts. 35 and 36 show that very small amounts of vanadium may be completely oxidized in the presence of considerable amounts of both sulfuric acid and iron. The oxidation of chromium by nitric acid is variable. It occurs only in concentrations of nitric acid of almost constant boiling strength, and even then, only after boiling for a considerable length of time. Boiling 1-g. samples of steel containing 1.5 per cent of chromium with from 40 to 70 cc. of concentrated nitric acid from a volume of 200 cc. to volumes of 20, 40 and 60 cc. gave solutions which when titrated contained oxidized chromium.

As a result of a large number of experiments, part of which are shown in Tables I and II, we have observed that the degree of oxidation of the vanadium varies widely with the conditions of the oxidation. All practical purposes, however, are adequately served by assuming that the vanadium is 99 per cent oxidized when a 1-g. sample of steel is dissolved in 80 cc. of sulfuric acid (sp. gr. 1.20), oxidized with a few drops of nitric acid diluted to 100 or 125 cc., and further oxidized by boiling at least 1 hr. with 40 cc. of nitric acid, taking care that the volume of the solution does not fall below 100 cc. Under these conditions we have never noted any oxidation of chromium, and check determinations on a sample of steel containing 2 per cent of vanadium agreeing within 0.02 per cent. When 2-g. samples of steels containing 0.15 to 0.25 per cent of vanadium are used, the agreement is usually within 0.01 per cent.

When tungsten is present in the steel, the tungstic oxide formed during the solution of the sample always retains a small amount of vanadium. The amount of vanadium so retained appears to be dependent rather upon the amount of tungstic oxide than upon the amount of vanadium. An excess of a uranyl salt precipitated with ammonia carries down completely small amounts of vanadium which may be present. To test this point we have prepared a solution of uranium nitrate containing about 4 g. of the salt in 1 l. To different amounts of this solution we added a few drops of sulfuric acid, 20 cc. of ammonium vanadate solution containing 21.0 mg. of vanadium, carbon dioxide-free ammonia in excess, and boiled for a few minutes. The precipitate was then filtered out, washed, and dissolved in dilute sulfuric acid. The vanadium in this solution was oxidized with silver nitrate and ammonium persulfate and determined electrometrically. The precipitation of vanadium was complete when 30 cc. of the uranium solution were used. When various quantities of tungstic oxide were present in the original mixture of uranium nitrate, sulfuric acid, and ammonium vanadate, ammonia served to dissolve the tungstic oxide and at the same time to completely precipitate both the uranium and the vanadium. We added 20 cc. of the ammonium vanadate solution to seven 1-g. samples of a steel containing 11 per cent of tungsten, but free from chromium and vanadium. After solution of the steel and oxidation of the tungsten, the tungstic oxide was filtered out and dissolved in ammonia. The solution was made barely acid with sulfuric acid, 30 cc. of the uranium nitrate solution added, followed by a slight excess of ammonia. The vanadium in the seven precipitates averaged 0.14 mg. Seven similar precipitates combined in one solution gave a precipitate containing 0.77 mg. of vanadium. On a single precipitate the titration was only 0.14 cc., and since the latter required 0.77 cc., it is considered a more reliable figure. Seven other precipitates formed in the presence of 5 cc. of ammonium vanadate solution also contained 0.77 mg. of vanadium. It is thus evident that a fourfold increase in the amount of vanadium present makes no measurable difference in the amount of vanadium occluded by the tungstic oxide. With this 11 per cent tungsten steel, the vanadium occluded amounts to 0.01 mg. per per cent of tungsten. Under similar conditions, but with tungsten varying from 5 to 30 per cent, the occluded vanadium was found to be in about the same proportion. We carried out similar experiments with steels containing chromium. When the vanadium was oxidized with nitric acid, the vanadium found in the tungstic oxide was in the proportion of 0.01 mg. per per cent of tungsten, but when ammonium persulfate was used to oxidize the solution, the apparent vanadium corresponded to 0.012 mg. per per cent of tungsten. This is undoubtedly due to traces of chromium which could not be washed out of the precipitate. This quantity of chromium, corresponding to 0.09 mg. or 0.009 per cent in a 1-g. sample of ordinary high-speed steel, is so small as to be entirely negligible. Under the conditions of our experiments the amount of vanadium occluded was so regular that we have adopted the practice of adding to the vanadium found by titration 0.001 per cent for each per cent of tungsten present. Thus for a steel containing 15 per cent of tungsten we would add 0.015 to the value otherwise found. No correction is made for chromium.

METHOD FOR THE DETERMINATION OF VANADIUM IN STEEL

When the amount of vanadium is less than 0.5 per cent, dissolve a 2-g. sample in 100 cc. of sulfuric acid (sp. gr. 1.20). With higher percentages of vanadium use a 1-g. sample and dissolve in 80 cc. of sulfuric acid of sp. gr. 1.20. When solution is complete add nitric acid, drop by drop, to the amount of 2 cc. Boil until the oxides of nitrogen are removed and until the tungstic oxide is yellow if there is any present. Dilute the solutions with hot water to a volume of 100 to 125 cc. and add 40 cc. of concentrated nitric acid. Boil this solution during 1 hr. or more at such a rate that the volume does not fall below 100 cc. Cool, dilute to 300 cc., and titrate electrometrically at 20° C. or lower with ferrous sulfate and dichromate solution. For this purpose a solution of dichromate may be prepared by dissolving 0.9609 g. of potassium dichromate in a liter of water. The ferrous sulfate solution may be made by dissolving 8 g. of ferrous ammonium sulfate and 50 cc. of sulfuric acid in 1 l. of water which is then diluted until it is of the same strength as the dichromate solution. These solutions need frequent renewal. The dichromate solution, which is the standard, must be kept in well-stoppered bottles and should be freshly prepared at least once a week. One cubic centimeter of this dichromate solution is equivalent to 0.1 per cent of vanadium in a 1-g. sample.

The titration of the nitric acid solution of the oxidized vanadium corresponds to 99 per cent of the vanadium present. Accordingly this may be calculated by dividing by 0.99 or approximated by adding 1 per cent of the amount found by titration. The vanadium retained by the tungsten is not ordinarily determined in most of the published methods. As indicated above, this corresponds in the case of 1-g. samples to 0.001 per cent of vanadium for each per cent of tungsten present. This may be calculated and added, or in the case of most tungsten vanadium steels, it may be closely enough approximated by adding 0.014 per cent since these usually contain 13 to 15 per cent of tungsten.

THE DETERMINATION OF CHROMIUM IN CHROME-VANADIUM STEELS

Dissolve 1 g. of samples containing less than 5 per cent of chromium in 70 cc. of sulfuric acid (sp. gr. 1.20). Use smaller samples when the percentage of chromium is higher. In chromium and chromium vanadium steels it is often necessary to evaporate until salts separate to decompose carbides. Dilute the solution cautiously to a volume of 75 cc. This evaporation does not appear to be necessary, nor is it desirable, in the case of tungsten steels. After dissolving the separated salts, or after solution of the tungsten steel, 2 cc. of nitric acid are added cautiously. The solution is then boiled about 5 min. It is next diluted with hot water to a volume of 250 to 300 cc. and heated to boiling. To the boiling solution are added 10 cc. of silver nitrate solution (2.5 g. per l.) and 20 cc. of ammonium persulfate solution (100 g. per l.). For higher percentages of chromium larger amounts of persulfate should be used. The amount to use can be determined by observing the color of the solution which should become permanently colored with permanganic acid after 2 or 3 min. The solution should be allowed to boil at least 8 min. after the last addition of persulfate to permit of the complete decomposition of the latter. While still boiling, add 5 cc. of dilute hydrochloric acid (1 : 3) and continue boiling at least 5 min. After cooling to 20° C. the solution is ready to titrate.

A solution of potassium dichromate is prepared by dissolving 2.829 g. of the salt in enough water to make a liter. The iron solution is prepared by dissolving 23 g. of ferrous ammonium sulfate and 100 cc. of sulfuric acid in enough water to make a liter. The iron solution is then diluted to correspond to the dichromate solution. One cubic centimeter of this solution is equivalent to 0.1 per cent of chromium in a 1-g. sample. The dichromate solution should be renewed at least once a week and the ferrous sulfate solution should be compared with the former daily.

Both chromium and vanadium are titrated, and the end-point observed is the vanadium end-point which has been described by Conant and one of us.[1] Take the number of cubic centimeters of the dichromate solution used in titrating the vanadium, after correction for the fact that the vanadium is only 99 per cent oxidized, but without including that portion which is in the tungstic oxide, and multiply by 0.339. This factor expresses the relation between the dichromate solution used for titrating vanadium and that used for titrating chromium. The number of cubic centimeters so found are to be subtracted from the total titration of chromium and vanadium. This gives the amount used in titrating chromium alone.

To illustrate the results obtained by the application of the methods described above to the analysis of synthetic steels we give the following:

Two grams of bar iron, dissolved as required in the vanadium determination, were treated at the time of solution with chromate solution corresponding to 1.25 per cent chromium and vanadate solution corresponding to 0.272 per cent vanadium. In three such solutions we found 0.27(3), 0.27(1), and 0.27(9) per cent vanadium. To 1 g. of a tungsten steel which was especially prepared under circumstances which would insure the presence of less than 0.01 per cent of chromium or vanadium, we added, at the time of solution, chromate solution corresponding to 4.23(7) per cent chromium and vanadate corresponding to 2.20(8) per cent vanadium. Of course, both the vanadate and chromate were completely reduced in the process of solution. Vanadium determined in three such solutions was found to be 2.19(9), 2.20(2), and 2.19(9). Chromium was determined as 4.23(7), 4.22(0), and 4.21(7).

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A SIMPLIFIED WET COMBUSTION METHOD FOR THE DETERMINATION OF CARBON IN SOILS

By D. D. Waynick

Received October 23, 1918

The determination of total carbon through oxidation with a mixture of chromic and sulfuric acids is a method given in nearly all treatises on quantitative analysis. As applied to the determination of total carbon in soils and soil extracts, the method has been modified by different investigators, both from the standpoint of increased accuracy in the determination itself and the simplification of the apparatus. Of the modifications recently proposed, that of Gortner[2] provides for the weighing of the carbon dioxide evolved after absorption in potassium hydroxide, while both Ames and Gaither,[3] and, more recently, Schollenberger,[4] have used barium hydroxide as an absorbent, titrating with a standard acid. The first of these modifications is objectionable in that the time

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[1] *J. Am. Chem. Soc.*, **38** (1916), 343.

[2] *Soil Science*, **2** (1916), 401.

[3] This Journal, **7** (1915), 561.

[4] *Ibid.*, **8** (1916), 1126.

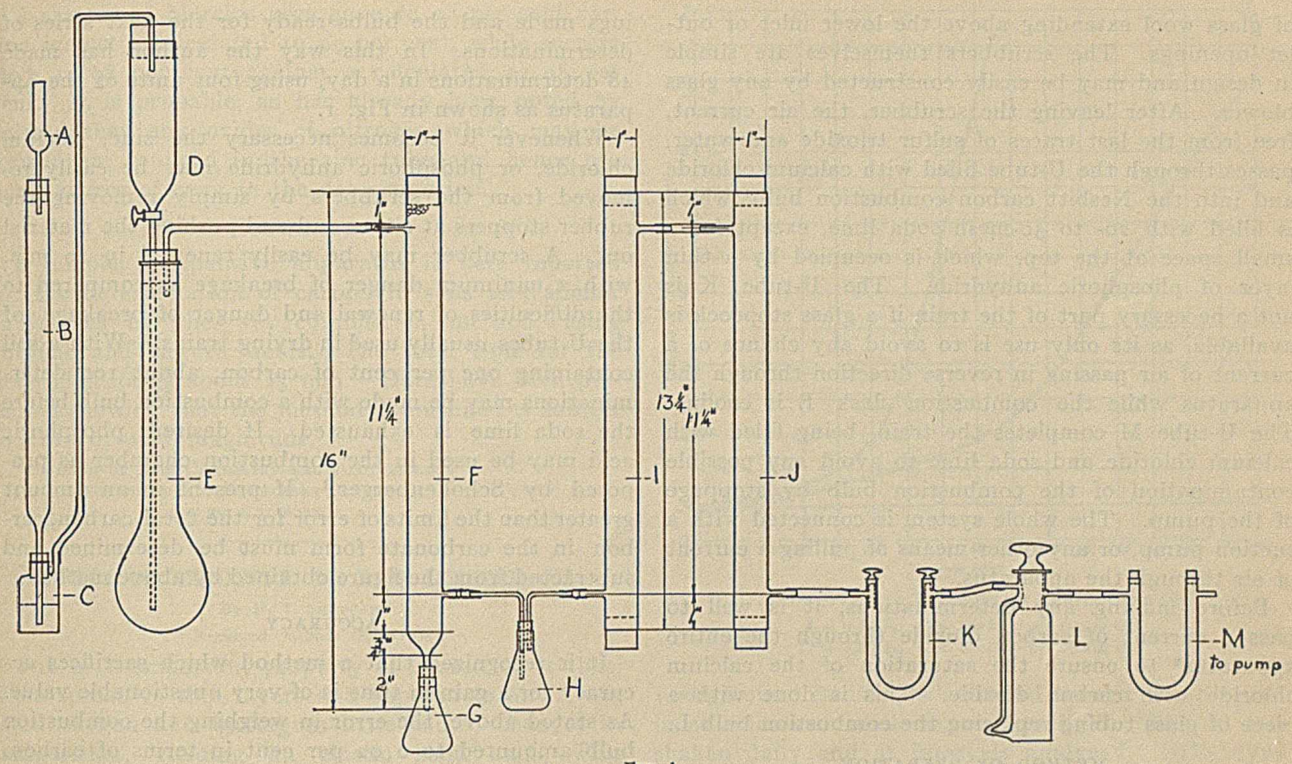

Fig. 1

required is about $2^{1}/_{2}$ hrs., while the chief objection to the two latter methods lies in the use of barium hydroxide as an absorbent, the inherent difficulties in its protection from the carbon dioxide of the air and in the titration of the excess barium hydroxide. The work in hand requiring the determination of total carbon in a large number of soil samples, the author undertook to modify the apparatus usually used in the wet combustion method to the end that the carbon dioxide evolved might be absorbed in soda lime and thus determined gravimetrically and that the time might be so reduced that the determination could be rapidly as well as accurately made. It is believed that both of these objectives have been attained and that the method outlined below will serve as a practical working scheme for the determination of total carbon in soils or similar substances.

REAGENTS

The reagents used are essentially those given by Ames and Gaither,[1] except that the chromic acid solution contained 3.3 g. in 5 cc. of water. This amount of chromic acid, together with 50 cc. of sulfuric acid, were used for each combustion. It was found necessary to boil the chromic acid solution after the addition of a little sulfuric acid to expel any carbon dioxide which might be present.

APPARATUS

The form of apparatus finally adopted is essentially different from any proposed heretofore and for that reason will be taken up somewhat at length. The essential details are given in Fig. 1, although the apparatus may be arranged on the table in any manner which circumstances demand. As set up in this laboratory, 4 units occupy less than 6 ft. of table space. The air enters the apparatus through A, which is simply a tube filled with calcium chloride. It next passes through a column of 30-mesh soda lime in B and a small volume of concentrated potassium hydroxide in C. This potassium hydroxide solution is the only liquid in the train and is in place simply as a means of keeping check on the rate of flow of air through the apparatus. The dropping funnel D holds the sulfuric acid before its introduction into the combustion flask E, which is a 300 cc. long-necked Kjeldahl flask. The rate of flow of air through the apparatus is regulated entirely by the stopcock shown as part of the dropping funnel. The first of a series of three scrubbers shown at F is filled with glass beads wet with sulfuric acid. This scrubber takes the place of a condenser usually employed as a part of the purifying train and under operating conditions removes most of the sulfur trioxide fumes which come over from the combustion flask E. The dilute sulfuric acid condensed in F is caught in a 100 cc. Erlenmeyer flask, G, with a second flask, H, of the same size serving to prevent any acid from getting into the scrubber shown at I, which is filled with 30-mesh zinc amalgamated with mercury. The trap H may be partially filled with a concentrated solution of silver sulfate if the scrubber I does not remove all the chlorine as well as sulfur trioxide fumes. It has been found necessary to renew the zinc after about 300 determinations and, if coarser pieces are used, it will be necessary to make the renewal at more frequent intervals. The upper half of J is filled with calcium chloride and the lower half with phosphoric anhydride, the two being separated by a layer of glass wool. The various materials in the three scrubbers are supported by layers

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[1] This Journal, 7 (1915), 561.

of glass wool extending above the lower inlet or outlet openings. The scrubbers themselves are simple in design and may be easily constructed by any glass blower. After leaving the scrubber, the air current, free from the last traces of sulfur trioxide and water, passes through the U-tube filled with calcium chloride and into the Nesbitt carbon combustion bulb[1] which is filled with 20- to 30-mesh soda lime, except for a small space at the top, which is occupied by a thin layer of phosphoric anhydride. The U-tube K is not a necessary part of the train if a glass stopcock is available, as its only use is to avoid any chance of a current of air passing in reverse direction through the apparatus while the combustion flask E is cooling. The U-tube M completes the train, being filled with calcium chloride and soda lime to avoid any possible contamination of the combustion bulb by stoppage of the pump. The whole system is connected with a suction pump, or any other means of pulling a current of air through the apparatus.

Before making any determinations, it is well to pass a current of carbon dioxide through the entire apparatus[2] to ensure the saturation of the calcium chloride with carbon dioxide. This is done with a piece of glass tubing replacing the combustion bulb L.

METHOD OF OPERATION

From 5 to 15 g. of soil are introduced into the combustion flask E, together with 5 cc. of the chromic acid solution. Fifty cc. of sulfuric acid are then run into the flask rapidly and the amount of air passing through the apparatus regulated by observing the rate of passage of the bubbles of air through the potassium hydroxide solution contained in C. A gas flame of a height which will ensure a boiling temperature of the mixture in the combustion flask within a time period of 5 min. is started as soon as all the acid has been run into the flask. Heating is continued for about 20 min., after which the combustion flask E is allowed to cool, aspiration being continued for 5 min. longer, however. The only operation remaining is to close and weigh the absorption bulb L. Aspiration should proceed throughout the entire time period at a rate which will ensure about 5 liters of air being drawn through the apparatus, but not so rapidly that the sufur trioxide fumes will be carried over in excessive amounts.

In weighing the absorption bulbs, it is well to use a second bulb filled, like the first one, with soda lime, as a counter balance. This procedure renders insignificant errors in weighing, due to differences in the amount of moisture condensed on the surfaces of the bulbs. Under normal working conditions, it has been found possible to weigh with an average error of 0.0010 g. or, in terms of carbon, about 0.02 per cent. It is well to have two complete sets of bulbs so that it will not be necessary to make the weighings while the apparatus is idle. With two sets, it is possible to allow 20 min. after the determination is completed for the bulbs to cool and still have the weighings made and the bulbs ready for the next series of determinations. In this way the author has made 48 determinations in a day, using four units of the apparatus as shown in Fig. 1.

Whenever it becomes necessary the zinc, calcium chloride, or phosphoric anhydride may be easily removed from the scrubbers by simply removing the rubber stoppers at either end and pushing the material out. A scrubber may be easily renewed in 10 min. with a minimum danger of breakage as compared to the difficulties of renewal and danger of breakage of the U-tubes usually used in drying trains. With a soil containing one per cent of carbon, about 100 determinations may be made with a combustion bulb before the soda lime is exhausted. If desired, phosphoric acid may be used in the combustion chamber as proposed by Schollenberger.[1] If present in an amount greater than the limits of error for the total carbon, carbon in the carbonate form must be determined and subtracted from the figure obtained by above method.

ACCURACY

It is recognized that a method which sacrifices accuracy for a gain in time is of very questionable value. As stated above, the error in weighing the combustion bulb amounted to 0.02 per cent in terms of carbon. That the determination itself is subject to practically the same error is shown by the data given in Table I. Ten determinations are recorded, all made upon a sample of soil thoroughly mixed and ground. The maximum variation between any two determinations is 0.023 per cent, while the average variation is less than 0.010 per cent. The absolute accuracy of the determination for carbon on this particular sample was checked by P. L. Hibbard, using a modification of the method proposed by Ames and Gaither, his data agreeing with that in Table I, within the limits of error already given.

TABLE I

No.	Carbon Per cent	No.	Carbon Per cent
1	1.358	6	1.372
2	1.377	7	1.354
3	1.358	8	1.361
4	1.351	9	1.351
5	1.374	10	1.372

A series of ten determinations made in duplicate on two soils is given in Table II. These determinations are selected at random from 200 determinations run in duplicate in a study of field variability made upon these soils.

TABLE II

	DAVIS SOIL Per cent Carbon			OAKLEY SOIL Per cent Carbon	
No.	I	II	No.	I	II
1	1.168	1.167	6	0.624	0.641
2	0.883	0.910	7	0.179	0.178
3	1.186	1.210	8	0.355	0.382
4	1.125	1.120	9	0.279	0.311
5	1.025	1.044	10	0.420	0.442

It will be noted that the greatest difference between the duplicate determinations amounts to 0.027 and 0.032 per cent, respectively. These differences are somewhat greater than the error in weighing the combustion bulbs, but is regarded as an error due to sampling rather than in the method of making the determination.

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[1] Made by Scientific Materials Co. Full directions for filling the bulb are furnished with the apparatus.

[2] *J. Am. Chem. Soc.*, **39** (1917), 2057.

[1] THIS JOURNAL, **8** (1916), 1126.

A sample of Merck's urea gave 20.28 per cent carbon against a calculated 19.99 per cent, while sucrose gave 41.98 per cent against a calculated 42.08 per cent. It is probable, as has already been noted by Salter,[1] that any oxides of nitrogen which may be formed are reduced in the zinc tube and hence are not a source of error in the determination.

SUMMARY

A simple, inexpensive apparatus is here reported for the determination of carbon in soils and similar substances by the wet combustion method, using chromic and sulfuric acids. The total time for the determination is about 25 min. Data have been presented showing that the method as outlined is subject to errors of small magnitude.

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[1] This Journal, 8 (1916), 637.

EFFECT OF EXPOSURE ON RAW LINSEED OIL

By E. J. Sheppard

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The most important property of linseed oil is that, when spread in thin layers and exposed to air, it absorbs oxygen and undergoes little-known changes in composition, yielding an elastic solid skin. This phenomenon is termed "drying" and on it depends the extensive industrial use of linseed oil in the manufacture of paint, varnish, linoleum, etc.

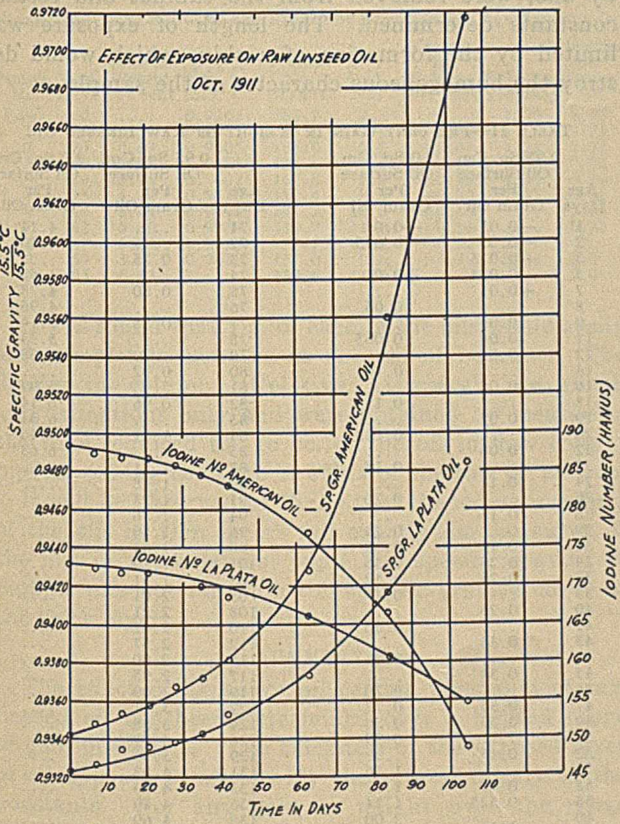

Fig. 1

The changes which take place in linseed oil when exposed to air have been studied by a number of investigators. Ballantyne[1] allowed linseed oil to stand in an uncorked bottle exposed to light. The oil was shaken daily and at intervals analyzed. Ballantyne found that under these conditions the iodine number decreased, while the specific gravity and acid number increased without a change in volume.

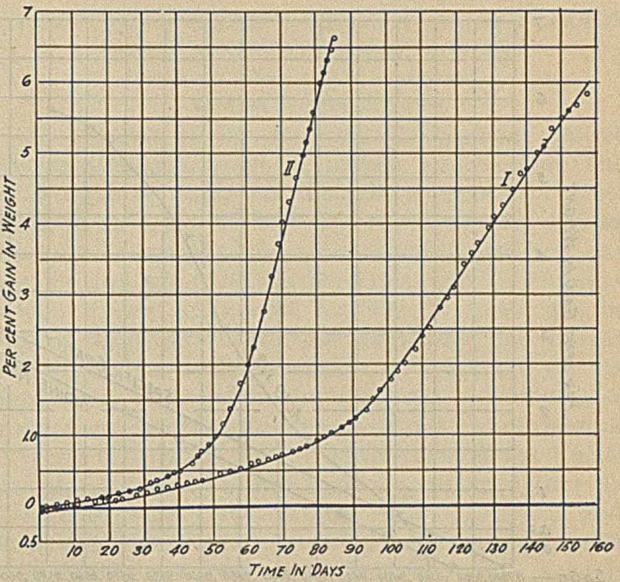

Fig. 2—Effect of Exposure on Raw Linseed Oil
I = 0.95 Sq. Cm. Surface per Gram Oil
II = 2.00 Sq. Cm. Surface per Gram Oil

Sherman and Falk[2] studied the same question similarly and found a lower iodine number and higher specific gravity and a small increase in acidity. These authors found a 3.43 per cent increase in specific gravity calculated on the original weight, while elementary analysis showed that the oil had taken up 3.16 per cent oxygen. They concluded that the greater increase in specific gravity was probably due to a slight contraction in volume.

Sabin[3] exposed raw linseed oil in thin films for 8 mo. and found a specific gravity of 1.098 and a gain in weight of not more than 2 per cent. Assuming a specific gravity of 0.932 for the original oil, Friend[4] calculated a contraction in volume of 13.4 per cent for Sabin's film.

Thompson[5] exposed two varieties of raw linseed oil in thin films for 212 days and found

	Sp. Gr.	Gain in Wt. Per cent	Decrease in Vol. Per cent
North American Oil....	1.16	8.25	13.0
South American Oil.....	1.15	7.70	12.4

Friend[6] oxidized raw Calcutta oil by passing air through the oil and by spreading in thin films on glass. He found that as the oil gained in weight the density increased, while the volume increased to a maximum and then slowly decreased.

Except for the determinations of Sabin, of Thompson, and of Friend, there are no data known to the writer

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[1] *J. Soc. Chem. Ind.*, **10** (1891), 29.

[2] *J. Am. Chem. Soc.*, **25** (1903), 711; **27** (1905), 605.

[3] This Journal, **3** (1911), 84.

[4] *J. Chem. Soc.*, **111** (1917), 162.

[5] *Trans. Am. Inst. of Chem. Eng.*, **8** (1915), 251.

[6] *Loc. cit.*

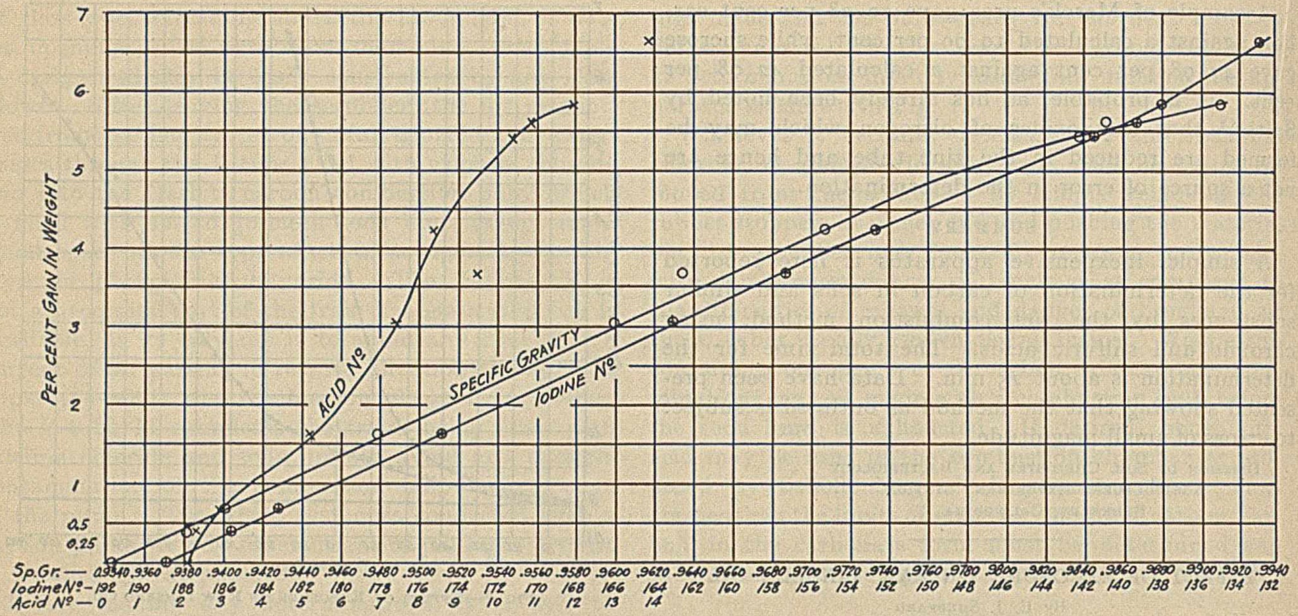

FIG. 3—CHANGES IN CONSTANTS WITH GAIN IN WEIGHT OF RAW LINSEED OIL

showing the variation of the constants with gain in weight of raw linseed oil on exposure to atmospheric oxidation. In 1911 the writer exposed two samples of raw linseed oil in shallow glass dishes of approximately 12.5 cm. diameter in a dust-proof glass top cabinet which permitted circulation of air. In order to prevent the formation of a skin, the oils were thoroughly stirred at least twice a day. At intervals the oil in each dish was thoroughly mixed and the specific gravity and iodine number determined, with the results as shown in Table I and Fig. 1.

TABLE I—EFFECT OF EXPOSURE ON RAW LINSEED OIL

	NORTH AMERICAN		LA PLATA	
Age Days	Sp. Gr. 15.5° C. / 15.5° C.	Iodine No. (Hanus)	Sp. Gr. 15.5° C. / 15.5° C.	Iodine No. (Hanus)
0	0.9342	188.4	0.9323	173.0
7	0.9348	187.3	0.9327	172.4
14	0.9355	186.8	0.9335	171.9
21	0.9357	186.8	0.9336	171.8
28	0.9368	185.6	0.9338	171.5
35	0.9372	184.6	0.9343	170.0
42	0.9382	183.2	0.9353	168.6
63	0.9428	177.0	0.9374	166.4
84	0.9561	166.4	0.9417	160.6
105	0.9717	149.0	0.9485	154.9

By withdrawing portions of the oils for determination of the constants, the volumes of the oils were gradually reduced, thus increasing the oil surface per gram of oil; or, in other words, decreasing the thickness of the oil layer. Now, since it is well known that, other things being equal, thin layers dry more rapidly than thick layers, these experiments suggested two questions: First, given layers of different thicknesses, are the changes in the constants the same for the same change in weight? Second, what is the quantitative effect of thickness of layer upon the rate of change in the constants?

In order to determine the variation of the constants for determined gains in weight, some pure, raw North American linseed oil was exposed in 10 shallow round glass dishes, eight of 9.2 cm. diameter and two of 9.7 cm. diameter, and the dishes kept in a glass top cabinet protected from dust but permitting circulation of air. About 70 g. of oil, accurately weighed, were placed in the eight smaller dishes, and about 36.9 g. in the two larger dishes. Each dish held throughout the test a glass stirring rod. Twice daily each sample was thoroughly stirred and at intervals the gain in weight noted. At longer intervals, the samples, one by one, were removed from the cabinet and certain constants determined. The length of exposure was limited by the formation of a skin, which would destroy the homogeneous character of the sample.

TABLE II—PER CENT GAIN IN WEIGHT OF RAW LINSEED OIL

Age Days	0.95 Sq. Cm. Oil Surface Per Gram Oil	2.0 Sq. Cm. Oil Surface Per Gram Oil	Age Days	0.95 Sq. Cm. Oil Surface Per Gram Oil	2.0 Sq. Cm. Oil Surface Per Gram Oil
1	—0.05	—0.04	71	....	4.14
2	—0.05	—0.015	72	....	4.30
3	—0.035	....	73	0.75	....
5	—0.025	+0.01	74	....	4.65
7	+0.01	....	75	0.80	4.78
8	....	0.05	76	....	4.96
9	0.03	....	77	0.88	5.14
11	0.04	0.065	78	....	5.33
12	0.04	....	79	....	5.58
14	....	0.10	80	0.92	....
16	0.06	....	81	....	5.99
18	....	0.115	82	0.96	6.14
19	0.07	....	83	....	6.31
20	....	0.135	84	1.01	6.46
22	0.08	....	85	....	6.63
23	....	0.18	87	1.11	....
24	0.11	....	89	1.18	....
26	....	0.20	91	1.23	....
28	0.15	....	94	1.36	....
29	....	0.24	96	1.50	....
31	0.19	0.32	98	1.64	....
34	0.23	0.36	101	1.79	....
37	0.25	0.42	103	1.91	....
39	....	0.47	105	2.01	....
40	0.28	....	108	2.21	....
41	....	0.50	110	2.42	....
43	0.33	....	112	2.57	....
44	....	0.61	115	2.80	....
45	0.34	....	117	2.95	....
46	....	0.70	119	3.09	....
47	0.35	0.77	122	3.41	....
49	0.39	0.86	124	3.58	....
51	....	0.99	126	3.72	....
52	0.45	....	129	3.93	....
53	....	1.16	131	4.08	....
55	0.48	1.37	133	4.23	....
58	0.525	1.74	136	4.49	....
60	....	2.00	138	4.69	....
61	0.60	....	140	4.76	....
62	....	2.25	143	5.00	....
63	0.625	....	145	5.09	....
65	....	2.76	147	5.33	....
66	0.655	....	150	5.49	....
67	....	3.25	152	5.60	....
68	0.69	....	154	5.68	....
69	....	3.71	157	5.84	....
70	0.71	4.02			

Table II and Fig. 2 give the time-gain in weight results. It is worthy of note that all samples showed a loss in weight during the first few days, although a well-settled oil was used. The longer the exposure the paler the oils became; Samples 6, 7 and 8, however, show practically no difference. The amount of oil placed in the large dishes made a layer about one-half as thick as the oil placed in the small dishes. In Fig. 2 the effect of thickness is clearly brought out showing that the thin layer gained in weight about twice as rapidly as the thick layer.

Without regard to the thickness of the layers, the evolution of pungent volatile products became distinctly noticeable when the oils had gained about one per cent in weight.

In Table III are assembled the analytical results shown in Fig. 3. Samples 7 and 8 skinned very slightly when 152 days old; this skin was stirred up with the oil and Sample 7 removed, while Sample 8 was continued 5 days longer, when it skinned again. It is remarkable to note, however, that Sample 10 did not skin, although it had gained about 1 per cent more in weight. There is a change in the specific gravity curve at the point of skinning of Samples 7 and 8 but no noticeable effect is produced in the iodine number curve. The acid numbers are rather irregular. Calculations of the per cent change in volume have been made but yield results not so decisive as those reported by Friend.

TABLE III—DATA SHOWING THE EFFECT OF EXPOSURE ON RAW LINSEED OIL

Sample No.	Age Days	Gain in Weight Per cent	Sp. Gr. $\frac{15.5° C.}{15.5° C.}$	Iodine No. (Hanus)	Acid No.	Change in Volume Per cent	Relative Viscosity	Oil Surface per Gram Oil
Raw	0	....	0.9345	188.7	2.2	....	1.00	0.95
1	49	0.38	0.9383	185.2	2.4	—0.02	1.15	0.95
2	70	0.69	0.9403	183.0	3.0	+0.07	1.25	0.95
3	98	1.63	0.9481	174.6	5.3	+0.17	2.00	0.95
4	119	3.05	0.9602	162.8	7.5	+0.29	4.30	0.95
5	135	4.22	0.9710	152.4	8.5	+0.30	7.35	0.95
6	148	5.41	0.9840	141.2	10.5	+0.10	....	0.95
7	152	5.60	0.9854	139.2	11.0	+0.14	....	0.95
8	157	5.84	0.9913	137.7	12.1	—0.22	....	....
9	69	3.67	0.9638	157.0	9.6	+0.52	6.00	2.0
10	85	6.63	....	132.6	14.0	....	....	2.0

It was found that 1 g. of each of the oils would easily and completely dissolve in 100 cc. of benzene. The figures in column "Relative Viscosity" are rough approximations only and were obtained by measuring the time required for 10 cc. of the oil to flow from a pipette, taking the time of efflux of the raw oil as 1.00.

It will be observed in Fig. 3 that the iodine numbers of the oils in thin layers fall exactly on the curve of the oils in thick layers; while the specific gravity of Sample 9 is not far from the specific gravity curve of the thick layers.

SUMMARY

The effect of exposure on certain constants of raw linseed oil has been determined over a limited range of gain in weight. The thickness of the exposed layer of oil appears to affect only the rate of change in the constants. For any gain in weight over the range covered by these experiments, the changes occurring in the constants appear to be independent of the rate of gain in weight.

NATIONAL LEAD COMPANY
ST. LOUIS, MISSOURI

CARBON TETRACHLORIDE, CHLOROFORM AND CARBON HEXACHLORIDE FROM NATURAL GAS[1]

By G. W. JONES AND V. C. ALLISON

Received December 21, 1918

As a result of the war, the Government desired the maximum amount of carbon tetrachloride and chloroform to carry on the gas program. A great many of the gases used in modern warfare are derived from these sources. In view of the above fact, and also because after the war a great amount of chlorine, which is now being used for war purposes, will be turned back toward peaceful enterprises, the Bureau of Mines has undertaken an investigation on the production of useful products by the chlorination of natural gas and thus utilize part of this excess chlorine. The gas from many fields of natural gas in the United States which yield a pure methane gas, free from the higher saturated hydrocarbons, ethane, propane, etc., is especially desirable for making chlorinated products. The natural gas from several of these fields, notably those in Texas and Louisiana, in locations too far removed from industrial centers and large cities to warrant the expense of piping, could be successfully made into chlorinated products.

In this report only a preliminary survey of work done on a small scale is given and more elaborate results of the investigation will be published as the work develops.

A large amount of experimental work has been done along these lines during the last 25 years but so far nothing of practical value, that the authors are aware of, has been accomplished.[2] The general tendency has been to use a large excess of either chlorine or natural gas to prevent explosion. If a large excess of either gas is used the products desired are hard to separate from the excess of inert gas, since the deposition of the chloroform and carbon tetrachloride depends upon the partial pressure of these products in the gaseous state at the given temperature at which they are separated and the reaction cannot be controlled to produce the products desired. That the chlorination may work successfully there is required a catalyzer which will cause the reaction to proceed smoothly without explosions or deposition of carbon, and which will accomplish the substitution of the chlorine in the methane and ethane molecule according to the reaction $CH_4 + 4Cl_2 = CCl_4 + 4HCl$ instead of the production of carbon and hydrochloric acid in accordance with the reaction $CH_4 + 2Cl_2 = C + 4HCl$. A great many catalyzers will cause chlorine and methane to react, when the temperature is high enough. In fact, no catalyzer is needed at all, but the reaction takes place violently and, being exothermic in character, explosively, and gives very little, if any, products other than carbon and hydrochloric acid. It is desirable to make the chlorination complete at one operation, hence if the desired product is carbon tetrachloride, four volumes of chlorine are caused to react with one volume of methane (natural gas), or in other words, the gases are caused to react in the ratios necessary to

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[1] Published by permission of the Director of the Bureau of Mines.

[2] Phillips, Baskerville, and others.

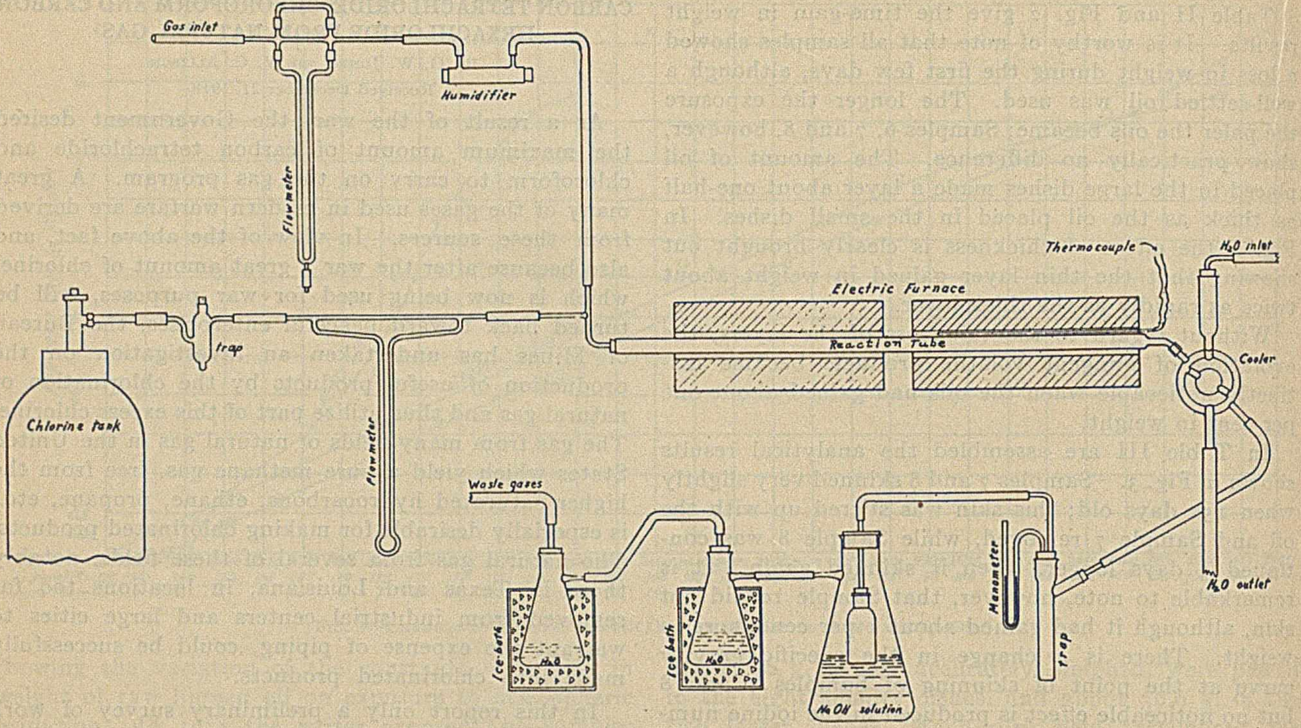

FIG. 1—APPARATUS FOR CHLORINATING NATURAL GAS

produce the most highly chlorinated products without any waste of chlorine.

Of the saturated hydrocarbons, methane is very much more inert toward chlorine than those of higher molecular weights. The authors found that at certain temperatures the chlorine reacted readily with the ethane while there was very little reaction with the methane. In fact, the chlorine reacted with the ethane to form carbon hexachloride before any chloroform or carbon tetrachloride was formed.

By using certain catalyzers, such as war-gas charcoal, steamed anthracite coal, and bachite, the reaction took place smoothly without explosions or deposition of carbon even when the chlorine ratio was four or more to one of gas. When other catalyzers such as cokes impregnated with different metals and metallic oxides were used and four volumes of chlorine to one of gas were caused to react, a small amount of chlorine came through without reacting.

The best catalyzers for complete chlorination were those which had a high absorption coefficient for chlorine. The increased concentration of the chlorine causes an increase in the reaction velocity and the chlorination goes to completion.

War-gas charcoal was loaned to the Bureau by the American University Experiment Station and is the same as that used for filling canisters in gas masks. This is a high-grade charcoal and far superior to other charcoals tried. Nearly all others were practically useless as a catalyzer and were no better than inert material such as broken porcelain and silica.

Bachite is a patented material made by the National Carbon Company. This has also been used for war-gas purposes.

The steam treated anthracite coal was made by reducing a commercial coal to a 4 to 10 mesh size. The coal thus prepared was next placed in an iron retort kept at a temperature of approximately 700° F. and steamed for 70 hrs. Coal treated in this manner has the property of absorbing gases to a high degree, although the outward physical appearance shows no change.

GAS

The natural gas used was taken from the mains at the Bureau of Mines laboratories, Pittsburgh, Pa. This gas is supplied by the Consolidated Gas Company. On account of having ethane present, this gas is not so desirable as a pure methane gas, but on account of the accessibility and ease of application it was used in this work.

The average analysis of the gas during the time in which these experiments were made was as follows:

	Per cent
Methane	89.5
Ethane	10.1
Nitrogen	0.4

For computing the theoretical yield the gas was assumed to contain 90 per cent methane and 10 per cent ethane.

CHLORINE

The chlorine used was supplied by the Electro Bleaching Gas Co., of New York, in containers of 100 lbs. each.

APPARATUS

Fig. 1 shows the general plan of the apparatus for testing the effect of varying temperature and humidity on the reaction.

The gas and chlorine rates were regulated by flow meters calibrated against the gases used. The flow meters were of a very small capacity and were calibrated by passing a given volume of the gas from a

TABLE I—RESULTS WITH WAR-GAS CHARCOAL AS CATALYZER

Test No.	Humidity Per cent	Average Temperature Deg. C.	Av. Chlorine Rate Liters per Hr.	Av. Gas Rate Liters per Hr.	Time of Run Hrs.	Products Recovered Cc.	Theoretical Yield Cc.	Percentage Efficiency Per cent	—Distillation Results— 65° to 80° C. Per cent		Above 80° C. Per cent	Remarks
										Sp. Gr.		
1	1.1 per cent H_2O vapor	250	2.5	1	6	6.5	24.1	27	80	1.59	20	Chlorination not complete. Unable to use required amount of chlorine for complete chlorination
2	1.1 per cent H_2O vapor	300	4	1	6	15	24.1	62	90	1.60	10	Reacted smoothly without deposition of carbon or explosions
3	1.1 per cent H_2O vapor	350	4	1	6	22.5	24.1	93	84	1.59	16	Reacted smoothly without deposition of carbon or explosions
4	1.1 per cent H_2O vapor	400	4.5	1	6	24	24.1	99	95	1.60	5	Reacted smoothly without deposition of carbon or explosions
5	1.1 per cent H_2O vapor	450	4	1	5	17	20.0	85	90	1.60	10	Reacted smoothly without deposition of carbon or explosions
6	1.1 per cent H_2O vapor	500	4	1	6	23.5	24.1	97	85	1.59	15	Carbon began to deposit and smoke badly. Catalyzer ignited but did not explode. Dense white fumes formed throughout the run
7	Gas saturated	400	5	1	6	19.5	24.1	81	90	1.58	10	It was necessary to use an excess of chlorine to chlorinate completely
8	Water removed	400	3.5	1	6	15.5	24.1	64	85	1.58	15	No fumes formed. Could not use four volumes of chlorine without coming through unacted upon

burette through the flow meter, at such a rate that by keeping the two columns of liquid in the U-tube at a certain height, a certain length of time was required to empty the burette. From these data the rate can be determined. After calibrating several points, a scale was made to read the rate directly.

The reaction tube shown in Fig. 1 contained 100 g. of catalyzer protected on either end by glass wool. An electric furnace surrounded the tube and the temperature was read on a millivoltmeter in conjunction with the thermocouple shown in the drawing. The hot gases after leaving the reaction chamber passed through a triple-walled condenser for cooling, then through a trap, sodium hydroxide scrubber, and two ice baths as shown. Most of the solid carbon hexachloride separated out in the cooler, while the carbon tetrachloride, being heavier than water or the sodium hydroxide solution, settled to the bottom of the scrubber and ice baths. The chief object of the sodium hydroxide solution was to remove the hydrochloric acid formed during the reaction. In all the tests made on this apparatus the gas rate was 1 l. per hr. For higher rates the apparatus shown in Fig. 2 was used.

After each run the distillates were collected from the scrubbers and ice baths, separated in a separatory funnel, measured, and then treated with a small piece of stick sodium hydroxide, to remove the dissolved chlorine, and calcium chloride, to remove the water. The distillations were carried out in a 50 cc. distillation flask at a rate of 2 drops per sec.

On all tests shown in Table I but a few drops came over below 70° C., indicating that very little, if any, was chloroform.

The gravities were determined with a specially designed plummet of small size which could be used on a Westphal balance and gravities on as low as 4 cc. of product were easily determined. Table I shows the results in tabulated form.

The reaction begins at a little below 250° C. and tends upward to around 500° C., where carbon begins to deposit and the catalyzer is attacked. The best results were obtained with a small amount of moisture present (1 per cent by volume). This tends to help the reaction.

All the products boiling below 85° C. were water-white and free from carbon.

CALCULATION OF YIELD

Yields were calculated from the volume of natural gas used, assuming that a liter of methane weighs 0.65 g. and ethane 1.22 g. when measured at 25° and 740 mm. pressure, the average condition under which the natural gas was measured. One liter of natural gas (90 per cent CH_4, 10 per cent C_2H_6) completely chlorinated should produce 4.01 cc. of liquid chlorination products, CCl_4 and C_2Cl_6.

The carbon hexachloride is very soluble in the carbon tetrachloride and that which crystallized out in the cooler was added each time to the product from the scrubber and distilled together. The distillate above 80° C. consisted of a mixture of carbon tetrachloride and carbon hexachloride. This could be separated by fractional distillation. The process is long and tedious and takes several distillations and subsequent coolings in an ice-salt bath, to freeze out the carbon hexachloride.

No other chlorine compounds have been identified in the products obtained by using four or more volumes of chlorine to one of gas when the rate of natural gas was 1 l. per hr.

When all the products boiling between 65° C. and 80° C. from the eight tests were put together and distilled, less than 1 cc. came over below 65° C., indicating a negligible amount of chloroform present.

The percentage efficiency of each run was obtained by multiplying the volume of gas used by 4.01 to give the theoretical yield which would be expected if the gas were chlorinated to carbon tetrachloride and carbon hexachloride and then the volume of products recovered was divided by the theoretical yield. This gave the efficiency on the basis of the amount of gas used.

Certain modifications of the apparatus were necessary in order to handle larger quantities of gas. The scrubbers were designed to work with low pressure and to be convenient for removal of the products and hydrochloric acid formed.

Fig. 2 shows the modified form including the scrubbers, drying tube, ice baths, and sampling device for testing the residual gas for methyl chloride.

The gas rates were determined with flow meters as

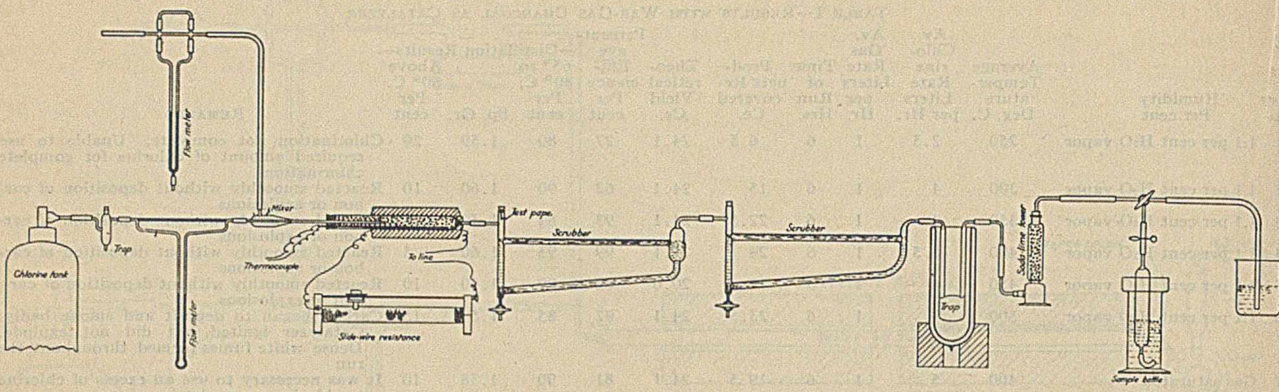

FIG. 2—MODIFIED FORM OF APPARATUS, INCLUDING SCRUBBERS, DRYING TUBE, ICE BATHS, AND SAMPLING DEVICE

in the previous work. The gas and chlorine were introduced into the reaction tube through a mixer made on the order of an injector. The reaction tube is shown in Fig. 2, also the electric furnace surrounding it. After trying a great many tubes of different lengths and diameters, the one found most suitable for chlorinating up to 6 l. of gas per hr. was of Pyrex glass 16 in. long and 1$^1/_2$ in. in diameter drawn down at one end so as to make connection with the scrubber. The tube protruded out of the furnace about 6 in. and this end was covered with asbestos paper to exclude the light. By having the gases mix in the cool part of the tube in the presence of the catalyzer, no explosions were produced on entering the heated section. The tube contained 200 g. of the catalyzer, held in place by glass wool placed at each end. This was then closed with a two-holed rubber stopper; through one hole passed the thermocouple well and through the other, the tube leading from the mixer.

The furnace was made by winding 40 ft. of No. 22 nichrome wire in the form of a helix, wrapping on an asbestos mandrel, and covering with a mixture of calcined magnesium oxide and sodium silicate, then covering this with several layers of asbestos paper. After drying, the furnace is ready for use.

TABLE II

TEST No.	Catalyzer	Humidity	Av. Temp. Deg. C.	Av. Gas Rate Liters per Hr.	Av. Chlorine Rate Liters per Hr.	Time of Run Hrs.	Product Recovered Cc.	Theoretical Yield Cc.	Per cent Efficiency (a)	Per cent Efficiency (b)	Distillation Results in Per cent of Recovered Product: To 70° C. Per cent	Sp. Gr. 20/20	70° to 85° Per cent	Sp. Gr. 20/20	Above 85° C. Per cent	Sp. Gr. 20/20
9	War-Gas Charcoal	1.1 per cent H_2O vapor	375	3.4	19.0	6	77.0	81.8	94	95	10	1.55	85	1.58	5	1.65
10	War-Gas Charcoal	1.1 per cent H_2O vapor	385	5.6	22.6	6	126	134.7	94	95	10	1.54	64	1.58	26	1.61
11	War-Gas Charcoal	1.1 per cent H_2O vapor	395	5.3	24.6	5	105	106.3	99	99	3	1.55	82	1.59	15	1.63
12	War-Gas Charcoal	1.1 per cent H_2O vapor	325	2.5	15.0	6	42.0	60.1	70	72	20	1.55	72	1.56	8	1.64
13	War-Gas Charcoal	1.1 per cent H_2O vapor	400	4.0	16.0	16.5	217.1	264.7	82	82	0.0	..	78	1.59	22	1.62
14	Bachite	1.1 per cent H_2O vapor	395	4.0	16.0	18.0	238.7	288.7	83	84	7	1.54	70	1.58	22	1.61
15	Bachite	1.1 per cent H_2O vapor	375	2.7	14.0	6.5	65.0	70.4	92	93	4	1.56	65	1.59	31	1.60
16	Bachite	1.1 per cent H_2O vapor	370	4.1	17.3	3.0	32.0	49.3	65	69	41	1.50	38	1.55	21	1.60
17	Steamed Coal	1.1 per cent H_2O vapor	380	2.2	8.2	6.5	55.0	57.2	96	96	1	1.57	75	1.58	24	1.61
18	Steamed Coal	1.1 per cent H_2O vapor	390	3.9	16.0	15.5	155.0	242.6	64	71	63	1.48	14	1.53x	32	1.62

(a) On assumption that products are CCl_4 and C_2Cl_6. (b) On assumption that product to 70° C. is $CHCl_3$ and the rest CCl_4 and C_2Cl_6.

TABLE III

Compound	Formula	At 25° C.		Boiling Point Deg. C.	Specific Gravity
Methyl chloride	CH_3Cl	Gas		—23.7	0.9915 at —23.7
Dichlormethane	CH_2Cl_2	Liquid		41.8	1.378 at 0/4
Chloroform	$CHCl_3$	Liquid		61.2	1.50 at 15/15
Carbon tetrachloride	CCl_4	Liquid		76.7	1.58 at 20/20
Ethyl chloride	CH_3CH_2Cl	Gas		12.5	0.923 at 2/2
Dichlorethane	CH_2ClCH_2Cl	Liquid		83.7	1.259 at 15/15
Ethylidene chloride	CH_3CHCl_2	Liquid		57.4	1.18 at 15/15
Trichlorethane	$CH_2ClCHCl_2$	Liquid		115.0	1.45 at 15/15
Trichlorethane	CH_3CCl_3	Liquid		74.5	1.32 at 15/15
Tetrachlorethane	CH_2ClCCl_3	Liquid		135.0	1.61 at 0/0
Tetrachlorethane	$CHCl_2CHCl_2$	Liquid		147.0	1.59 at 15/15
Pentachlorethane	$CHCl_2CCl_3$	Liquid		159.0	1.71
Carbon hexachloride	CCl_3CCl_3	Solid	M. P. =	187.0	2.0

A thermocouple indicated the temperature in the reaction tube at all times. It was found that the temperature was somewhat higher at the point where the gases entered the reaction tube, due to the heat of reaction, and that after the reaction had commenced very little heat was necessary to maintain the desired temperature; the higher the rate of gas, the less heat was necessary.

The hot gases, on leaving the reaction chamber, are passed through low-pressure scrubbers of a special design shown in Fig. 3. These scrubbers, containing water, cool the heated gases and remove the hydrochloric acid formed during the reaction; the carbon tetrachloride, carbon hexachloride, and chloroform, which are heavier than water, sink to the bottom and can be drawn off by means of the stopcocks provided for the purpose at the bottom of each scrubber. One scrubber was found sufficient to completely remove the hydrochloric acid, but two were used to aid in condensing the products. Starch-potassium iodide test papers were hung at the entrance of each scrubber to indicate the presence of chlorine. The unchlorinated natural gas and other gases after leaving the scrubbers pass through a trap enclosed in an ice-salt bath. Here most of the water vapor is frozen out and the dichlormethane, and other chlorides, condensed.

The gas next passes through a drying tower containing soda lime and calcium chloride, thence through a 3-way stopcock and on out of the apparatus through a water seal. By means of the 3-way stopcock samples of the residual gas could be taken at pleasure for the analysis of methyl chloride.

Table II shows results of chlorinating larger amounts of gas, using the three most promising catalyzers. A great many charcoals, cokes, etc., were tried but the yields, from a carbon tetrachloride standpoint, were not as good and are not given in this report.

Increasing the gas rate produced products of a boiling point below 70° C. The boiling point and specific gravity of these fractions indicate a mixture of chloroform and carbon tetrachloride. The products boiling above 85° C. indicate a mixture of carbon tetrachloride, carbon hexachloride, and other chlorine products. These percentage yields may be in error to some extent, due to the above assumptions, but are of value in that they are useful for comparing the relative efficiency of the different catalyzers.

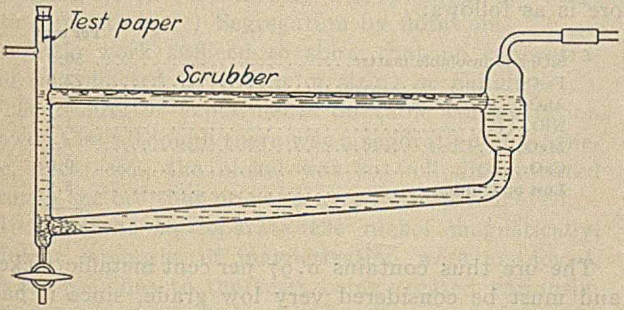

FIG. 3—LOW-PRESSURE SCRUBBER

Table III shows the different chlorides of methane and ethane with their boiling points and their specific gravity, as given in Watts' chemical dictionary and Landolt-Bornstein tables. These are given here for comparison of the products obtained by chlorination of natural gas.

POSSIBILITIES

Processes and methods must be found to use the large supply of chlorine which will be available at the conclusion of peace. Natural gas is a very cheap commodity in out-of-the-way places, and chlorine can be made by using part of the natural gas for power. In this way the expense for raw material will depend only on the value of the natural gas.

Chloroform besides being used in surgery is a good solvent.

Carbon tetrachloride is a good solvent, non-explosive and non-inflammable. It can be used for the extraction of certain fats, resins, waxes, dry cleaning, and for fire-extinguishing compounds.

Carbon hexachloride has no uses at present but can be reduced to ethane tetrachloride which is a good solvent used extensively in the manufacture of motion picture films, aëroplane dope, varnish manufacture, paint remover, etc.,

CONCLUSIONS

Apparatus is shown and described for the chlorination of natural gas.

Results of tests are given pertaining to the complete chlorination of the gas.

Results show that natural gas can be completely chlorinated on a laboratory scale at one operation.

The temperature range extends from about 225° C. to 500° C. when using war-gas charcoal.

Moisture helps the reaction.

At a rate of 1 l. of natural gas per hr. the methane goes completely to carbon tetrachloride and the ethane to carbon hexachloride when using a maximum amount of chlorine.

When larger rates of gas were used chloroform was found along with the carbon tetrachloride.

That carbon tetrachloride and chloroform can be produced successfully is proven, provided the right catalyzer is used, the conditions of the reaction are carefully watched, and efficient means for removing the products are used.

Ethane is chlorinated much more easily than methane and at a lower temperature. Catalyzers for complete chlorination must be such that they have a high absorption value for chlorine.

ACKNOWLEDGMENTS

In compiling this report the authors wish to acknowledge the helpful suggestions made by G. B. Taylor, chief chemist of the Pittsburgh Station, Major A. C. Fieldner, of the Chemical Warfare Service, Lt. S. H. Katz and Sgt. Linchfield for supplying two of the catalyzers, M. H. Meighan and W. L. Parker for carrying on the tests, and F. E. Donath, glass blower, for making the scrubbers and other parts of the apparatus.

BUREAU OF MINES
DEPARTMENT OF INTERIOR
WASHINGTON, D. C.

THE TANNIN CONTENT OF REDWOOD

By CHARLES C. SCALIONE AND DAVID R. MERRILL

Received December 16, 1918

The rapid depletion of the more accessible supplies of tanbark oak (*Pasania densiflora*), which is the only natural source of tannin largely utilized on the Pacific Coast, suggested the desirability of a study of the wood of, the coast redwood (*Sequoia sempervirens*), which is known to contain tannin and of which a large supply is available in the form of refuse from the lumber industry.

With this idea in view, samples of bark, heartwood, and sapwood were obtained from Mendocino County. The bark was shredded and ground in a mill to pass a 20 mesh screen. Samples of the heartwood and sapwood were prepared by sawing, and grinding the sawdust to pass 20 mesh. The moisture contents were determined by drying samples to constant weight. The undried samples were extracted by soaking them for several hours in warm water, pouring off this extract, and extracting the residue with more water in an extractor of the Soxhlet type. The extraction was stopped when the extract gave a negative test with the salt gelatin reagent for tannin. The mixed solutions were diluted to volume, and clarified by adding washed kaolin and sucking them into a flask through an alundum extraction thimble. After this treatment the samples passed the requirements for optical clearness as given in the A. L. C. A. specifications.

The following results were obtained using the A. L. C. A. hide powder method. The results are calculated to a dry basis in each case.

	Bark Per cent	Sapwood Per cent	Heartwood Per cent
Soluble solids	2.76	4.77	25.7
Non-tannins	1.89	3.62	13.5
Tannin	0.86	1.15	12.2

It is evident from these figures that the only part of the redwood which has any possible value as a source of tannin is the heartwood. The principal source of raw material here would be the sawdust. The proportion of soluble non-tannins is high, which is in part due to the method of extraction used. The extract gave a qualitative test for pyrogallol derivatives. The liquors were quite dark from the coloring matter which occurs in the redwood. A sample tanning was run on some strips of hide. The grain developed quickly and struck through in about four days. The outside of the hide was colored a dark purplish brown, but the color did not penetrate through the hide. For heavy sole leather this material might be satisfactory.

Another possible source of tannin from redwood is in the liquor which collects on steam-kilning the wood. While a quantitative analysis of these liquors was not made, they appeared to contain about 7 to 10 per cent tannin when the salt gelatin test was made. In the same connection it should be noted that Scalione and Blakemore[1] found that the leaves of *Ceanothus velutinus* were quite rich in tannin. This shrub covers a large acreage in certain regions of California and could be collected in large quantities at but small cost.

The experimental work outlined above was performed in the chemical laboratory of the University of California in the fall of 1917.

American University Experiment Station
Washington, D. C.

TREATMENT OF LOW-GRADE NICKEL ORES[2]

By C. W. Davis

Received November 4, 1918

INTRODUCTION

This investigation was undertaken at the Golden, Col., Station of the Bureau of Mines in an attempt to find some practical method for the commercial separation of nickel from low-grade ores. The use of nickel in nickel steel for the manufacture of gun forgings, structural work, automobile parts, etc., makes it indispensable in normal times and doubly so under conditions brought about by a state of war. Although the United States is the largest refiner of nickel, the crude copper-nickel matter comes principally from the Sudbury district of Canada and from New Caledonia. A comparatively small quantity of nickel is recovered in the refining of blister copper from domestic ores, and no direct production of nickel from nickel ores in the United States is known to have been made since 1909, at which time the American Lead Company operated a smelter at Fredericktown, Mo., for a short period.[1] Altogether the situation for the production of nickel from ores found in the United States is not encouraging.[2]

Two nickel ores were used in this work, one from North Carolina, the other from Chichagof Island, Alaska.

THE NORTH CAROLINA ORE—The North Carolina ore occurs as an extensive deposit near Webster, Jackson County. This ore, as received, was in two forms, the lump and the fine. The lump material was a weathered, massive conglomerate, containing inclusions of mica, magnetite, and ferric oxide with incrustations of serpentine and genthite. When pulverized, a brown powder resulted which resembled ferric oxide. The fine portion, which constituted more than three-quarters of the total ore, was similar to the ground lump material but of a somewhat lighter color.

An analysis of a representative sample of the nickel ore is as follows:

	Per cent
SiO_2 and insoluble matter	56.5
Fe_2O_3	22.0
Al_2O_3	4.1
NiO	1.2
MgO	7.2
CaO	0.0
Loss on ignition	8.9
	99.9

The ore thus contains 0.97 per cent metallic nickel and must be considered very low grade, since it has been shown[3] that an ore from New Caledonia containing less than 4.4 per cent nickel, as silicate, is of no commercial value at present, the cost of treatment equalling the value of the nickel contained. The same thing is true of the sulfide ore from Sudbury carrying 2.03 per cent nickel. In fact it is considered unprofitable to treat a Sudbury ore for nickel alone if it runs less than 3 per cent nickel. The genthite portion of the North Carolina ore when roughly separated gave a content of 9.5 per cent nickel oxide.

W. L. Morrison,[4] who did considerable work on ore from Webster, which averaged 1.75 per cent nickel oxide, states: "The present plant for commercial operations is out of the question. The wet process now existing is also out of the question. The only process available for this ore at present is the electric furnace process in a first-class, efficient plant."

THE ALASKA ORE—The massive sulfide ore occurring at Chichagof Island, Alaska, consists mainly of pyrite, chalcopyrite, and pentlandite. An average analysis is as follows:

	Per cent		Per cent
Cu	1.7	Ca	1.7
Ni	3.7	Mg	0.5
Fe	36.5	S	22.6
Al	4.5	SiO_2	20.4

In portions the nickel runs as high as 5.7 per cent, and the copper up to 4 per cent.

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[1] This Journal, 8 (1916), 411.

[2] Published by permission of the Director of the Bureau of Mines.

[1] Report of the Royal Ontario Nickel Commission, 1917.

[2] *Eng. and Min. J.*, Jan. 20, 1917.

[3] Report of the Royal Ontario Nickel Commission, *Loc. cit.*

[4] *Trans. Am. Electrochem. Soc.*, 20, 315.

Treatment of this ore has been attempted but none of the methods tried were successful. The Seattle Station of the U. S. Bureau of Mines has effected a removal of copper by flotation. It has also given the tails from this separation a table treatment thereby securing a nickel concentration of 11 per cent. The recovery, however, is only 21 per cent. The material treated at this Station consisted of tails from the copper flotation separation furnished by the Seattle Station. A few tests were also made on table concentrates from these tails. The massive ore was not available for experimental purposes.

CONCENTRATION

An effective concentration would render the ores suitable for treatment by various well-known methods. Since the Seattle Station had tried various schemes of concentration, this phase of the treatment of the Alaska nickel ore was not considered here.

In search of a way to concentrate the North Carolina ore, the following methods were employed: (*a*) Sizing tests, (*b*) Panning, (*c*) Tabling, (*d*) Magnetic separation, (*e*) Segregation by flotation.

A little work sufficed to show that no concentration was effected by means of sizing or panning.

The results of experiments on table concentration showed that although there was a separation of magnetite, mica, etc., the nickel was so well disseminated through the ore that no concentration was achieved.

In attempts to separate the nickel magnetically, different strengths of magnetization were employed, the ore previous to the tests being treated variously. About 30 per cent of the untreated ore was magnetic, while a roast at 500° C. made 80 per cent of the material magnetic. Neither of these treatments resulted in a concentration of the nickel. A reduction of the North Carolina ore by producer gas or charcoal at 900° C. gave a product which was magnetically concentrated from 0.97 per cent nickel to 3.6 per cent, the recovery being 45 per cent.

Morrison[1] was unable to remove the nickel from this ore by reduction followed by tabling.

It was thought that the North Carolina ore could be converted to the sulfide and then concentrated by flotation, or that the reduced ore could be floated at once. A number of tests on the ore which had been reduced or sulfidized showed a maximum concentration of nickel of from 0.97 per cent to 1.1 per cent. The Alaska ore, as has been stated, was concentrated by the Seattle Station by flotation.

Failure to get an adequate concentration led to the various schemes which follow. These may be outlined as: (1) extraction with various solvents of (*a*) the unsaturated ore, (*b*) the reduced ore, (*c*) the reduced and oxidized ore, and (*d*) the chloridized ore; (2) volatilization of the nickel as the chloride; and (3) a sulfide and sulfate treatment to render the nickel soluble in water or dilute acids.

EXTRACTION OF THE UNTREATED ORES

The ore from North Carolina was submitted to the various extractions shown in Table I in the search for a suitable solvent for the nickel.

TABLE I

TREATMENT OF THE ORE	Extraction of Nickel Per cent
Extracted with excess HNO_3 and $KClO_3$	100
Extracted with excess HCl	58
Extracted with excess HNO_3	90
Extracted with excess Cl_2 soln	10
Extracted with excess NaOH soln	None
Extracted with excess NH_4OH soln	None
Extracted with excess NH_4Cl soln	None
Extracted with excess $(NH_4)_2CO_3$ soln	None
Extracted with excess $(NH_4)_2SO_4$ soln	Trace
Extracted with excess H_2SO_4 soln.[1]	30
Extracted with excess $Fe_2(SO_4)_3$ soln.[2]	None
Extracted with excess $FeSO_4$ soln.[3]	15
Extracted with excess $FeCl_3$ and $CaCl_2$ soln.[4]	None
Extracted with excess hot water after fusing with $Na_2S_2O_7$	30

[1] Morrison (*Loc. cil*) leached ore from North Carolina with sulfuric acid, extracting 29 per cent of the nickel.

[2] Hybinnette (*Chem. Abs.*, **10**, 563) treats ore with ferric sulfate to dissolve the nickel.

[3] It has been stated by W. Koehler (*Elec. Met. Ind.*, **6**, 145) that ferrous sulfate would dissolve nickel oxide forming nickel sulfate and iron oxide.

[4] Herrenschmidt (*J. Soc. Chem. Ind.*, **11**, 613) extracts nickel from its ores with a solution of ferric and calcium chlorides.

The Alaska ore digested with an excess of 2 per cent sulfuric acid gave an extraction of 5 per cent of the nickel, while a sodium carbonate fusion of the ore rendered none of the nickel soluble in water.

EXTRACTION OF THE REDUCED ORE

The North Carolina ore was reduced with producer gas at 1000° C. and extracted with various reagents as shown in Table II.

TABLE II

TREATMENT OF THE REDUCED ORE	Extraction of Nickel Per cent
Extracted with excess NH_4OH	None
Extracted with excess H_2SO_4, 2 per cent	100
Extracted with excess $CaCl_2$ soln., made acid with HCl	50
Extracted with excess $FeSO_4$	20
Extracted with excess NH_4Cl	5
Extracted with excess $(NH_4)_2SO_4$	5
Extracted with excess $(NH_4)_2CO_3$ soln	10
Extracted with excess KCN soln., 1.4 per cent	30
Extracted with excess HCl, 1 per cent	70
Extracted with excess HNO_3, 1 per cent	65
Extracted with excess $Fe_2(SO_4)_3$, large excess sat. soln	95

The sulfuric acid required for the extraction of 90 per cent of the nickel from the reduced ore was 360 lbs. of acid per ton of ore treated. This is a far greater quantity than could be used commercially, the large amount being necessary because the iron in the reduced ore was attacked as readily as the nickel.

The Alaska ore, roasted free from sulfur, was reduced and a few tests made as indicated in Table III.

TABLE III

TREATMENT OF REDUCED ORE	Extraction of Nickel Per cent
Extracted with excess H_2SO_3 soln	10
Extracted with excess $Fe_2(SO_4)_3$ soln	70
Extracted with excess H_2SO_4, 2 per cent	85

A large acid consumption was necessary in this case also, due to the iron content of the ore.

Attempts to find conditions of oxidation such that the iron would be insoluble in dilute acid and the nickel rendered soluble were fruitless.

EXTRACTION AS THE CHLORIDE

Croasdale[1] finds that when a sulfide ore is roasted with salt and sulfur the chlorine is freed to act on the metal in the ore. A series of tests were made to see if the nickel in the North Carolina ore could be converted into a soluble chloride. The ore was roasted with salt and with a mixture of salt and sulfur. The best extraction of the nickel as the chloride from this ore was, with water, 10 per cent, and with 1 per cent

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[1] *Loc. cit.*

[1] "Volatilization of Nickel as the Chloride," *Eng. & Min. J.*, August 1913.

acid, 37 per cent. This is but little better than the extraction secured from untreated ore. These results are in accord with those obtained by Rutherford,[3] that is, that nickel extraction as the chloride either with water or dilute acid is not satisfactory.

Morrison[2] heated the North Carolina ore with ammonium chloride and with sodium chloride, and also passed chlorine gas over the dry and moist ore. He found that this did not improve the sulfuric acid extraction.

VOLATILIZATION AS THE CHLORIDE

Croasdale[3] showed that a sulfide ore mixed with salt formed volatile chlorides on heating. Rutherford[3] states that an oxidized nickel ore to which sulfur and salt have been added can be heated so as to volatilize part of the nickel as the chloride. It was thought that a satisfactory volatilization might take place with the ore from North Carolina, the nickel chloride being collected in a Cottrell precipitator. This ore was roasted with salt, calcium chloride, lime, and sulfur in various proportions. It was also heated with the passage of chlorine and hydrochloric acid gas. A volatilization of about 50 per cent of the nickel together with considerable iron was obtained by heating a mixture of 100 parts ore, 10 parts salt, and 2 parts sulfur for some time at 1000° C.

EXTRACTION OF THE SULFIDIZED ORE

Since nickel has a strong affinity for sulfur it was suggested[4] that the silicate ore could be disintegrated by roasting it with sulfur and then extracting the nickel with dilute acid. The best conditions found for this treatment gave an extraction of 70 per cent, the acid consumption being about the same as that required for a 90 per cent extraction of nickel from the reduced ore, that is, 360 lbs. of sulfuric acid per ton of ore treated.

EXTRACTION OF THE SULFATIZED ORE

Eustice[5] finds that an oxidized ore of nickel, iron, aluminum, etc., can be treated so as to render the iron insoluble, the nickel being made soluble. He does this by heating the dry ore, passing sulfur dioxide over it, and then leaching with hot, dilute sulfuric acid. The North Carolina ore treated by this method gave an extraction of 30 per cent of the nickel.

Borchers[6] states that nickel can be removed from a sulfide ore containing iron by roasting to convert the nickel to the sulfate, leaving the iron as the oxide. Pecourt[7] says that an oxidized ore heated with sulfur or pyrite and then roasted at a low red heat can be leached with water for its nickel content. Herrenschmidt[8] finds that a nickel oxide ore heated with sulfur dioxide and air will give a water-soluble nickel sulfate. Eustice[9] roasts the ore with sulfuric acid at 500° C. and leaches with hot, dilute sulfuric acid.

To convert the nickel of the North Carolina ore to the sulfate, samples of the ore were roasted with sulfur and oxidized in air, roasted with pyrite and oxidized in air, roasted while passing sulfur dioxide and air over it, roasted with calcium sulfate, and roasted with sulfuric acid. Dilute sulfuric acid removed but 30 per cent of the nickel from any of the samples. Water extracted about 25 per cent of the nickel from the sulfuric acid roast. In the other cases, only a trace of the nickel was rendered soluble in water.

Morrison[1] roasted the North Carolina nickel ore with sodium sulfate and charcoal which did not affect the extraction.

The Alaska sulfide ore was given a sulfatizing roast in which 10 per cent of the nickel was water-soluble and 30 per cent soluble in dilute acid.

FUSION WITH SODIUM BISULFATE

By fusing the reduced ore from North Carolina with an equal weight of niter cake, 90 per cent of the nickel was rendered water-soluble; with one-half as much niter cake as ore, the water-soluble nickel was 60 per cent.

TABLE IV

TEST No.	Ni in Sample Per cent	Weight Ore Grams	Weight $NaHSO_4$ Grams	Temperature ° C.	Time of Heating Min.	Approximate Extraction Nickel Per cent	REMARKS
1	2.3	1	0.25	400	30	10	....
2	2.3	1	0.25	500	10	None	....
3	2.3	1	0.25	500	30	None	....
4	2.3	1	0.25	700	15	None	....
5	2.3	1	0.5	400	30	30	....
6	2.3	1	0.5	450	30	50	....
7	2.3	1	0.5	500	30	50	....
8	2.3	1	0.5	500	120	75	Crude $NaHSO_4$ used
9	2.3	1	0.5	700	5	None	Crude $NaHSO_4$ used
10	2.3	1	0.5	700	15	None	Crude $NaHSO_4$ used
11	2.3	1	1.0	350	30	30	....
12	2.3	1	1.0	400	30	70	....
13	2.3	1	1.0	400	15	75	....
14	2.3	1	1.0	500	10	75	....
15	2.3	1	1.0	500	30	75	....
16	2.3	1	1.0	500	30	90	....
17	2.3	1	1.0	500	45	80	....
18	2.3	1	1.0	500	120	95	....
19	2.3	1	1.0	500	60	95	Crude $NaHSO_4$ used
20	2.3	25	25.0	500	120	95	Crude $NaHSO_4$ used
21	2.3	1	1.0	500	5	75	....
22	2.3	1	1.0	500	5	60	....
23	2.3	1	1.0	500	30	10	....
24	2.3	1	1.5	400	5	80	....
25	2.3	1	1.5	500	30	95	....
26	2.3	1	1.5	500	30	90	....
27	2.3	1	1.5	500	180	95	....
28	2.3	1	1.5	700	5	90	....
29	2.3	1	2.0	400	30	90	....
30	2.3	1	2.0	600	5	90	....
31	2.3	1	0.75	500	120	85	....
32	3.4	1	0.25	500	9	15	....
33	3.4	1	0.50	500	10	40	....
34	3.4	1	1.0	240	240	40	....
35	3.4	1	1.0	300	120	40	....
36	3.4	1	1.0	400	45	75	....
37	3.4	1	1.0	500	30	75	....
38	3.4	1	1.0	500	45	75	....
39	3.4	1	1.0	500	120	70	....
40	3.4	1	1.5	500	10	85	....
41	3.4	25	37.5	500	120	85	Crude $NaHSO_4$ used
42	3.4	1	2.0	500	30	90	....
43	3.4	1	2.0	500	120	90	Crude $NaHSO_4$ used
44	3.4	1	2.0	700	5	60	....
45	3.4	1	2.0	700	15	60	....
46	3.8	1	0.75	500	120	50	Crude $NaHSO_4$ used
47	3.8	1	1.0	500	120	60	Crude $NaHSO_4$ used
48	3.8	1	1.5	500	120	90	....
49	3.8	25	50.0	500	120	90	....
50	8.1	1	1.0	500	120	70	....
51	8.1	1	2.0	500	120	75	....
52	8.1	1	3.0	500	120	90	....
53	8.1	10	30.0	500	120	85	Crude $NaHSO_4$ used
54	11.0	1	2.0	500	120	40	....
55	11.0	1	3.0	500	120	85	....
56	11.0	10	30.0	500	120	85	Crude $NaHSO_4$ used

A fusion of the Alaska ore after dead roasting with sodium bisulfate made 15 per cent of the nickel water-soluble. By fusing this ore, which had been dead roasted and reduced, with crude acid sodium sulfate

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[1] "The Chloride Treatment of Nickel Ores," *J. Can. Min. Inst.*, **8**, 336.

[2] *Loc. cit.*

[3] *Ibid.*

[4] C. L. Parsons, U. S. Bureau of Mines.

[5] *Chem. Abs.*, **11** (1917), 31.

[6] *Ibid.*, **7** (1913), 2039.

[7] *J. Soc. Chem. Ind.*, **29**, 97.

[8] *Loc. cit.*

[9] *Chem. Abs.*, **11** (1917), 1.

[1] *Loc. cit.*

a satisfactory recovery of the nickel was obtained in the water leach.

To determine the best conditions for extracting the nickel from the Alaska ore by roasting with sodium bisulfate, several experiments were performed, the results being shown in Table IV. In all of these experiments the ore was roasted free from sulfur and then reduced with charcoal at 900° C.

The results indicate that the quantity of sodium bisulfate required for a satisfactory treatment of the Alaska ore depends upon the percentage of nickel present, the ratio of ore to acid being, for a 2.3 per cent ore, 1 to 1; for a 3 to 4 per cent ore, 2 to 3; and for an 8 to 11 per cent ore, 1 to 3.

The temperature best suited for the roast was 500° C. while the time required for treatment of small samples was 30 min.

With the quantities used, the procedure is a roast rather than a fusion, the resulting material being in the form of a friable lump.

NITRIC ACID TREATMENT OF ALASKA ORE

Nitric acid heated with pyrite oxidizes it to the sulfate, freeing oxides of nitrogen, which can be removed by heating, and recovered by absorption in towers.[1]

A preliminary trial showed that the Alaska nickel ore was readily attacked by nitric acid. To determine the best conditions for treatment experiments shown in Tables V and VI were carried out.

TABLE V

Test No.	Ratio of Ore to Acid by Weight (70% HNO_3)	Temperature Deg. C.	Time of Heating Hrs.	Nickel Extracted with Water Per cent	HNO_3 Left in Residue Per cent by Weight
1	1 : 5	100	1	100	28
2[1]	1 : 5 and excess H_2SO_4	100	1	100	5.1
3	Excess	140	1	100	10.7
4	Excess	240	1	95	2.0
5	1 : 1	250	2	95	1.2

[1] Test 2 was tried because there was not sufficient sulfur in the ore to satisfy the reactions assumed by Westby (*Loc. cit.*).

TABLE VI

Ratio of Ore to Acid by Weight (70% HNO_3)	Extraction of Nickel Per cent
1 : 2	100
1 : 1	95
1 : 0.9	80
1 : 0.75	75
2 : 1	50
3 : 1	30
4 : 1	20

The best conditions were a 1 : 1 ratio of ore to acid, 250° C., and 2 hrs. of heating. The extraction was 95 per cent, and 1.2 per cent of the nitric acid remained with the ore.

It is thus seen that with a good recovery of the evolved oxides of nitrogen a commercial treatment of the Alaska ore by means of nitric acid is possible.

Mond's process, the volatilization of the nickel as carbonyl by means of carbon monoxide, is only applicable when the material treated has a high nickel content. Therefore, no attempts were made to treat the ores by this method.

SUMMARY

1—No satisfactory concentration of the ores was obtained by sizing tests, panning, tabling, magnetic concentration, or flotation. Magnetic treatment of the reduced North Carolina ore brought the concentration of nickel from 0.97 per cent to 3.6 per cent, the recovery being 45 per cent.

2—An excess of concentrated nitric acid or aqua regia extracted the nickel from the finely ground ores by hot digestion. Other solvents in large excess dissolved only part of the nickel.

3—Hot, dilute sulfuric acid (2 per cent), in excess, extracted the nickel from the ores which had been reduced with water gas at 1000° C. A large excess, however, was required to react with the iron present before much of the nickel was attacked.

4—The nickel in the reduced ores was largely extracted with an excessive amount of ferric sulfate solution.

5—No state of oxidation was found at which the nickel was soluble in dilute acid without having the iron soluble also.

6—The best extraction of nickel as the chloride from the North Carolina ore was, with water, 10 per cent, and with 1 per cent acid, 37 per cent. The acid requirement is nearly the same as that for the extraction of nickel from untreated ore.

7—By mixing the North Carolina ore with an excess of salt and sulfur, and heating for some time at 1000° C., it was found possible to volatilize 50 per cent of the nickel as the chloride.

8—A sulfide roast of the North Carolina ore followed by a treatment with dilute sulfuric acid gave an extraction of about 70 per cent; the acid consumption, however, was prohibitive.

9—By fusing the reduced North Carolina ore with an equal weight of niter cake, 90 per cent of the nickel was rendered water-soluble; with one-half as much niter cake as ore, only 60 per cent was water-soluble.

10—The quantity of niter cake required for the extraction of the nickel from roasted and reduced Alaska ore varied with the nickel content; the ratio of the ore to sodium bisulfate was, for a 2.3 per cent ore, 1 to 1; for a 3 to 4 per cent ore, 2 to 3; and for an 8 to 11 per cent ore, 1 to 3.

11—The best temperature for the niter cake roast was 500° C.

12—Thirty minutes were sufficient for the fusion of small quantities of reduced ore with niter cake.

13—By treating the Alaska nickel ore with an equal weight of nitric acid (70 per cent), and heating for 2 hrs. at 250° C., 95 per cent of the nickel was made water-soluble, while all but 1.2 per cent of the nitric acid was driven off. Most of this acid could be recovered by absorption.

CONCLUSIONS

Results obtained from the work on the low-grade nickel ore from North Carolina indicate that it cannot be profitably treated with the chemical market as it is at present; but that a silicate ore even of as low grade as the one examined might be economically worked, if of low iron content, by reduction and subsequent leaching with dilute sulfuric acid.

With a favorable price for large quantities of niter cake, the sulfide ore from Alaska might be treated for

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[1] Westby, *Met. & Chem. Eng.*, March 15, 1918.

the removal of nickel by roasting the tails from the copper flotation separation free from sulfur, reducing with charcoal, roasting with niter cake, and extracting with water, the nickel to be recovered electrolytically or by precipitation with lime after the removal of iron by means of calcium carbonate. The complexity of this treatment would be an important factor in determining whether the process could be used.

The Alaska ore might be treated with nitric acid, heated to remove most of the oxides of nitrogen, and the nickel extracted with water, the nitric acid being recovered by water absorption. The quantity of nitric acid recovered on large runs would largely determine the availability of this treatment.

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I wish to thank Dr. R. B. Moore, of the Rocky Mountain Station, under whose direction this work was carried out, and to express my appreciation of the many helpful suggestions received from other members of the Rocky Mountain Station of the United States Bureau of Mines at Golden, Colorado. I also desire to gratefully acknowledge the assistance rendered by Mr. M. H. Caron, of the Netherlands Government, who was so kind as to reduce a quantity of the North Carolina ore in his experimental reduction furnace.

Bureau of Mines
Golden, Colorado

THE MODIFICATION OF THE COMPOSITION OF VEGETABLE OILS, WITH SPECIAL REFERENCE TO INCREASING UNSATURATION[1]

By Horace L. White

Received January 17, 1918

INTRODUCTION

The possibility of the modification of the constants of fats and oils of animal and vegetable origin, but more particularly because of the abundance of those of vegetable origin, is a matter of great economic importance. If a vegetable oil could be dehydrogenated, that is, if its fatty acids could be modified so as to contain more unsaturated linkages, there is the possibility of greatly increasing its value in the paint industry. A brief consideration of the respective iodine values of linseed and soy bean oils will indicate this more clearly. Linseed oil with an iodine number around 180 is one of the best examples of a drying oil, while soy bean oil with an iodine number around 126 is classified as a semidrying oil. Nemzek[3]* has pointed out the limited uses of soy bean oil in paints and he is authority for the statement that in 1916 there were imported into the United States 98,171,275 lbs. of soy bean oil. If some of the constants of this oil could be modified, its value, particularly in the paint industry, would be greatly increased.

Many observers have pointed out the modifications of oils that seem to take place spontaneously, but which in reality are caused by the influence of light, temperature, bacterial and enzyme action, and inorganic catalysts. This investigation is devoted to a study of the biochemical reactions induced by the processes of germination, and of enzyme and bacterial action on the degree of unsaturation and the extent of hydrolysis of linseed and soy bean oils. In addition, attention has been directed to the action of light, heat, and the presence of inorganic catalysts on the same constants.

EXPERIMENTAL

From reference in the literature it is evident that but few attempts have been made to dehydrogenate oils. The use of nickel[5] in the absence of hydrogen has been suggested. In the field of biochemistry the observations of Hartley and others[6,7] on the desaturating power of the pig's liver, as shown in the fatty acids obtained from the liver, is of great interest. The results[8,9] obtained in a study of the effects of germination of various oil-bearing seeds seems to indicate a saturation of unsaturated fatty acids during the process, yet the behavior of the castor bean[10] in this particular shows some variation.

The question was raised as to whether there might not be conditions of metabolism during germination and growth of soy beans (*Glycine hispida*) of such a nature as to increase the degree of unsaturation of the fatty acids. The prevailing idea in the arrangement of the conditions of growth was to make them abnormal in order to develop any latent powers of the plant. This was accomplished by growing the plants in a greenhouse in diffuse light and at lower temperatures than ordinarily employed.

Other samples were sprouted in darkness and some were grown in the sunlight at ordinary temperatures. The germination was carried through three stages: Stage I, in which the sprout was ½ cm. long; Stage II, in which the plants were from 4 to 6 cm. in height with cotyledons standing at right angles to the hypocotyls; and Stage III, in which the plants were from 6 to 12 cm. long and the first set of leaves had formed.

Table I—Constants of the Oil of Soy Beans Germinated and Grown in Diffuse Light

	Resting Seed Control	Stage I Germinated Sprout ½ Cm. Long	Stage II Growth Height 4 to 6 Cm.	Stage III Growth Height 6 to 12 Cm.
Wt. 100 beans, grams	15.6800	37.0520	71.1560	....
Moisture, per cent	4.80	61.90	86.60	....
Ether extract (moisture-free), per cent	18.44	18.51	13.31	10.11
Color of oil	Amber	Green	Red Green[1]	Greenish
Specific gravity	0.9234	0.9215	0.9272	....
Acid number	1.0	30.2	2.6	12.5
Iodine number	131.1	122.6	133.1	121.10
	129.9	...	133.0	120.95
Iodine number	133.9	125.5	136.2	117.7
Fatty acids	135.6	125.2	133.6	116.1
Reichert-Meissl number	0.30	...	1.05	....
Unsaponifiable matter, per cent	1.21	1.01	1.14	2.75
Sterols, per cent	0.27	0.43	0.46	0.86

[1] Red by reflected light, green by transmitted light.

The whole plant was used for analysis. Each plant was washed free from sand, dried at 37° C. in an incubator, and the oil extracted by ethyl ether in the cold. After distilling off most of the ether, the oil was heated to 110° C. for 2 hrs., while a current of dry carbon dioxide was bubbled through it to remove traces of ether and water. The method of analysis and of purification of reagents used were those described by Holland.[12] Iodine numbers were deter-

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[1] Abstract of a thesis submitted to the University of Wisconsin for the degree of doctor of philosophy in agricultural chemistry, 1917.

* Numbers refer to corresponding numbers in "Bibliography," p. 651.

mined by the Hanus method. Table I shows some of the constants of the oils.

The results given in Table I show that the iodine number of the ether extract of soy beans grown in diffuse light does not fall much below that obtained from the seed, and seem to indicate that while the oil is being used for the nourishment of the growing plant in diffuse light the processes of metabolism continue to supply fatty acids of practically the same degree of unsaturation, at least up to the formation of the first set of leaves. The drop in iodine number of fatty acids in Stage III indicates a rapid utilization of unsaturated acids, possibly for the formation of sugars.

For comparison, beans were planted in sand and grown in the light to Stages II and III. The results are shown in Table II.

TABLE II—CONSTANTS OF SOY BEAN OIL FROM BEANS GROWN UNDER VARYING CONDITIONS

DESCRIPTION	Ether Extract (Dry Basis) Per cent	Acid Number	Iodine Number	Iodine Number Fatty Acids
Resting seed	18.44	1.0	131.1 129.9	133.9 135.6
Stage I—Germinated seed	18.51	29.8	122.6	125.2 125.5
Stage II—Diffuse light	13.31	2.6	133.1 133.0	133.6 136.2
Stage II—Sunlight	5.00	16.6	134.1 133.7	... ...
Stage III—Diffuse light	10.11	12.5	121.10 120.95	116.1 117.7
Stage III—Darkness	8.34	...	128.7 130.1	... ...
Stage III—Sunlight	3.61	1.85	128.1 130.5[1] 130.4	... ...

[1] Petroleum ether extract.

From the analytical results given in Table II, the conclusion is reached that the processes of germination and growth of soy beans up to the stage of the formation of the first set of true leaves do not greatly modify the degree of unsaturation of the oils in the ether extract. There is, moreover, no evidence of increasing unsaturation of the oil.

Working along the same general line, that of creating abnormal conditions, the effect of carbon dioxide on germination and iodine number of oil was studied. Carbon dioxide was bubbled through a mass of beans in distilled water, with chloral hydrate (0.1 g.) for a preservative, for varying lengths of time. The effect of carbon dioxide is shown in Table III.

TABLE III—EFFECT OF CARBON DIOXIDE ON GERMINATION AND IODINE NUMBER

TREATMENT	EXTENT OF GERMINATION	Iodine No. Ether Extract
Resting seed, control	....	129.9 131.1
Carbon dioxide for 1 hr. a day, 2 days	Slight, seed coat intact	128.0 129.0
Carbon dioxide for 1/2 hr. a day, 6 days	Slight, seed coat intact	118.1 121.8

It is evident that the exclusion of oxygen by carbon dioxide for a period of 6 days decreases the degree of unsaturation of the oil.

The possible stimulating effect of dilute solutions of manganous chloride which was noted by Brenchley[15] as favoring germination and growth of starchy seeds was studied with soy beans, but with inconclusive results.

BACTERIAL AND ENZYME ACTION

From many samples of raw linseed oil there separates out on standing a heavy flocculent deposit which is known to the trade as "foots." From the oil filter presses the same material is obtained as a dark colored semisolid material known as "filter press foots."

A sample of raw linseed oil, containing 40 per cent "foots" by volume, was used in a preliminary examination as to the nature of the bacterial contents of the foots, and the effects of their metabolism on some of the constants of linseed oil.

On shaking some of this oil in a mixture of sterile sand and water and plating out the resultant liquid on nutrient agar, a heavy growth of organisms, chiefly bacteria with some molds, was obtained. The bacterial colonies seemed to be of the same general form. A pure culture was obtained from one of the colonies and was used in a further study of the characteristics of the organisms which were similar to those of *B. subtilis*.

In order to determine whether the organisms in linseed oil "foots" had any relation to the acid number and iodine number of the oil, samples of raw linseed were inoculated with "foots" known to contain the organism described above. Four-ounce sterilized sample bottles were filled with oil, plugged with cotton, and a short cork inserted in the neck of the bottle above the cotton. Controls were prepared by heating at 10 lbs. pressure on each of three successive days. In some cases 10 per cent of water was added. The samples were analyzed after decantation and filtration through anhydrous sodium sulfate.

TABLE IV—OILS INOCULATED WITH BACTERIA AND KEPT AT 38° C.

TREATMENT OF SAMPLE	Acid No. At once	Acid No. 5 Mo.	Acid No. 18 Mo.	Iodine No. At once	Iodine No. 5 Mo.	Iodine No. 18 Mo.
Oil, not filtered	2.75	4.3	5.7	184.06 184.43	173.3 173.5	154.2 ...
Oil, filtered through paper	....	2.9	5.6	....	170.6 172.6	153.9 155.4
Oil, sterilized	....	3.0	6.0	....	172.2 173.4	149.5 151.6
Oil + "foots"	....	3.8	5.5	....	170.7 172.5	157.7 158.6
Oil sterilized + "foots"	....	3.7	5.4	....	171.4 174.0	157.6 ...
Oil + 10 per cent water	....	7.2	6.5	....	169.3 171.2	157.0 ...
Oil sterilized + 10 per cent water, sterilized	3.3	4.1	6.4	184.49 184.83	171.8 173.0	153.7 155.0
Oil sterilized + "foots" + 10 per cent water	....	8.6	7.6	....	174.6 175.2	164.4 164.4

In all samples the acid number has doubled in 18 mo. The inoculation with organisms affects the acid number when water is present, but not otherwise. As already pointed out,[16,19] the necessity for heating and clarifying oils to prevent rapid hydrolysis is further shown by the difference in the rate of change of acid number in 5 mo. between the unfiltered oil and the samples of filtered and of sterilized oil.

TABLE V—HYDROLYSIS OF OILS KEPT AT 37° C.

50 g. Oil Emulsified with 50 g. Water Containing 1 Per cent Gum Arabic, Kept at 37° C.

SAMPLE	Acid No. At Beginning	Acid No. 5 Wks.	DESCRIPTION OF OIL
D 18	18.6	20.2	Acid-refined linseed oil
D 19	1.2	1.8	Alkali-refined linseed oil
D 20	3.0	6.7	Raw linseed oil
D 21	5.1	12.6	Acid-refined oil
D 22	5.9	6.8	Boiled linseed oil
D 23	9.1	11.9	Corn oil (old sample)
D 24	17.5	19.7	Cottonseed oil (old sample)
D 25	5.5	5.8	Castor oil (old sample)
D 26	1.8	5.9	Soy bean oil, imported
D 27	2.7	12.3	Soy bean oil, American No. 2

In order to observe the effect of naturally occurring impurities, such as bacteria and enzymes in the oils, when mixed with water, emulsions of equal weights of oil and water with gum arabic were kept in full, stoppered bottles at 37° C. for 5 wks. The changes are shown in Table V.

The acid numbers of the untreated oils, as raw linseed oil and the soy bean oils, show an increase of from 100 to 600 per cent in 5 wks. These results emphasize the necessity of heating and filtering such oils before storage and use.

Extensive experiments were carried on, the details of which cannot be given here, to determine if there were any enzymes in flaxseed that could desaturate soy bean oil, as it is recognized that there is inherent in the flax plant the ability to synthesize an oil with a larger per cent of unsaturated acids than is found in soy bean oil. The results were negative in all experiments. Similar attempts were made with fresh pig's liver which has been shown[6] to have the power of desaturating fatty acids to a marked degree. After incubation of oil and tissue for 42 days at 37° C. there was no increase in iodine number.

ACTION OF LIGHT, HEAT, AND CATALYSIS

The extent of the hydrolysis of oils by various agencies is a matter of great economic importance in certain industries, and methods for its control are being given consideration in industrial laboratories. The agencies causing hydrolysis are discussed in detail by workers in industrial and biological chemistry.[16,19,2,17,18] Neuberg[22] has shown, also, that triolein when emulsified with a little sodium oleate is easily hydrolyzed by the action of sunlight if a uranyl salt is present. It was decided to repeat some of his work, using salts of other metals in addition to uranyl acetate, and replacing sodium oleate by a vegetable emulsifier. Two sets of samples of emulsified oil were prepared, using Indian gum as an emulsifier, and adding 0.1 g. of the catalyst in each case. One set of samples were kept at 37° C. in absence of light for 100 days, while the second set of samples was kept in a greenhouse for the same period. The catalysts employed were lead acetate, uranyl acetate, ferrous sulfate, manganous chloride, cobalt acetate, and zinc lactate. At the close of the 100-day period the oils were separated from the emulsification by filtration through anhydrous sodium sulfate, or by extraction with ether, and acid and iodine numbers determined.

Summarizing the results obtained by the use of catalysts: At 37° C. for 100 days the acid number of the control increased from 2.5 to 4.3. Only one sample of oil, that containing manganous chloride, showed a higher acid number, being 23.7. No satisfactory explanation can be given for this high number and it is not given much weight in the final conclusion arrived at relative to the use of catalysts. Exposed to the light for 100 days, the acid number of the control did not change. The oil containing zinc lactate had an acid number of 6.3, while that containing cobalt acetate had an acid number of 4.8. All other samples were below 3.0. A peculiar action of zinc lactate was noted—the oil was bleached to a marked degree, while the iodine number of the sample was the lowest (176.6) of any in the series, the control being 184.9. In no instance was the iodine number increased by the use of catalysts.

EFFECT OF HEAT AND THE ULTRAVIOLET LIGHT

Continuing the general line of experiments on the effect of heat and light on oils, it was decided to study the effect of ultraviolet light on these constants. Accordingly, samples of raw soy bean oil were subjected to the action of ultraviolet light while exposed in Petri dishes at a distance of 10 cm. from the bulb of a Cooper-Hewitt lamp. Other samples, consisting of 40 g. oil, 80 cc. water, or 80 cc. of a *N*/100 solution of a catalyst, were thoroughly emulsified and exposed to the light for 6 hrs. In another series, lampblack and finely divided nickel on kaolin was used. It was soon noticed that the heat from the lamp was intense, and its effect might be sufficient to explain any action taking place. However, the acid number of the sample of raw oil, emulsified oil, oil and lampblack, and oil emulsified with lampblack are about the same as that of the untreated raw oil; therefore, the higher acid number obtained by the use of *N*/100 ferrous sulfate and manganous chloride and of nickel may be considered as due to catalytic action. In every experiment, however, the iodine number has been lower, indicating an increase in the degree of oxidation of the acids set free. In this connection a sample of soy bean oil was mixed with lampblack and heated to 250° C. in an atmosphere of carbon dioxide. While hydrolysis proceeded rapidly under these conditions, the iodine number remained fairly constant, due to the protective influence of the atmosphere of carbon dioxide.

The effect of ultraviolet light and of heating in presence of carbon dioxide on acid number and iodine number are shown in Table VI.

TABLE VI—ACTION OF ULTRAVIOLET LIGHT ON ACID AND IODINE NUMBERS OF OILS IN THE PRESENCE OF CATALYSTS

Time of Exposure Hrs.	Treatment of Sample	Acid Number	Iodine Number
0	Raw soy bean oil	2.4	132.0 123.4
6	Oil, only	2.7	115.5 116.5
6	Oil, emulsified	2.8	117.4 118.1
6	Oil emulsified + *N*/100 $FeSO_4$	4.4	108.6 108.7
6	Oil emulsified + *N*/100 $MnCl_2$	3.8	110.3 110.3
6	Oil + 1 g. lampblack	2.9	112.9 113.9
6	Oil emulsified + 1 g. lampblack	2.7	114.3 114.4
7	Oil + 1 g. Ni	3.4	108.7 108.9
7	Oil emulsified + 1 g. Ni	3.7	110.5 111.5
	To note effects of heat alone, oil + lampblack heated to 110° for 6 hrs., then to 250° for 1 hr. in atmosphere of carbon dioxide. Results obtained were	13.9	119.4 119.9

The effect of heat was studied by the use of an acid-refined oil, which was presumably free from enzymes and bacteria. The results shown in Table VII indicate the changes brought about by heat alone and by heat and storage at 37° C. for 35 days.

TABLE VII—EFFECT OF HEAT ON ACID NUMBER OF HIGH ACID OIL

Days Time	Treatment of Sample	Acid Number
0	Oil used in series	7.0
0	Heated at 15 lbs. pressure for 1/2 hr.	11.7
35	Heated 1/2 hr. and kept at 37° C.	25.0
35	Oil, control at 35° C.	7.7

Oils which have not been acid-refined do not react to heat in such a degree. The hydrolytic action of heat over 100° is marked, and this must be taken into consideration in bacteriological examinations involving the sterilization of oils.

CONCLUSION

1—The processes of germination and growth of soy beans up to a height of 8 to 12 cm., even under favorable conditions of growth, do not result in an increase of unsaturated acids in the ether extract from such plants. On the other hand, while there is a decrease in iodine number of the extracted material, this decrease is not as pronounced as is the case with some other oily seeds. The soy bean seems to maintain acids of a high degree of unsaturation for the metabolism of the young plant up to the stage of the formation of the first set of leaves.

2—Bacteria and enzymes exert a marked hydrolytic action on oils in the presence of sufficient water, but in dry oils their action is slight. They have no action tending to increase the unsaturation of oils. From a practical standpoint, because of their presence in oils and sediments of oil containers, the possibilities of their hydrolytic action should be carefully considered.

3—The hydrolytic action of heat should be kept in mind in the sterilization of all fatty materials for bacterial culture purposes.

4—Salts of some metals, in certain concentrations, at 37° C. or in sunlight, act as catalyzers and increase hydrolysis, but they do not act to increase unsaturation.

5—Ultraviolet light acting on oils and emulsions containing salts exerts a slight hydrolyzing action.

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REACTION PRODUCTS OF ALKALI-SAWDUST FUSION ACETIC, FORMIC, AND OXALIC ACIDS AND METHYL ALCOHOL[1]

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In 1829 Gay-Lussac[2] discovered that oxalic acid is formed by fusing cellulose, sawdust, sugar, etc., with caustic potash. This process was used in the manufacture of oxalic acid by Dale[3] in 1856. Later Thorn[4] made a systematic study of the formation of oxalic acid by fusion of sawdust with sodium and potassium hydroxides separately and with mixtures of the two.

These earlier investigators, however, say very little about other products formed by the action of alkalies on sawdust. In connection with researches on the formation of acetic acid by the decomposition of lignocellulose, W. H. Higgin patented a process for the production of sodium acetate from alkaline waste liquor from straw and esparto boiling in paper manufacture.[5] Following this, Cross, Bevan, and Isaac[6] conducted a series of experiments on the action of alkalies on typical carbohydrates at elevated temperatures, with the object of determining, among other things, the maximum yield of acetic acid. Although their work was confined largely to the simpler carbohydrates, they obtained from 18 to 28 per cent of acetic acid from pine wood. Gases given off were found to be one-third to one-half hydrogen and to amount to 2 to 3 per cent of the substance decomposed. Oxalic acid was formed to some extent. They also found the yield of acetic acid was increased as the proportion of alkali to carbohydrates is increased from one to three. Potassium hydroxide proved better than sodium hydroxide and acted at a lower temperature.

In 1911 patents were taken out covering the production of oxalates[7] and acetates[8] by the action of alkali and air on woody fiber at elevated temperatures. Patents have also been obtained for the production of organic acids from waste pulp liquor[9] and attempts to improve the method of producing oxalic acid from sawdust have been made.[10]

Whatever success these various processes have met with in practice, the facts are that prior to the war the chief sources of oxalic and acetic acids were producer gas and hardwood distillates, respectively.

The demand for acetic acid for war purposes has exceeded the supply and has led to the seeking of new sources of this important chemical. The present investigation was therefore undertaken to determine the amount of acetic acid obtainable from various species of wood, in the form of sawdust, by fusion with

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[1] Read at the 56th Meeting of the American Chemical Society, Cleveland, September 10 to 13, 1918.

[2] *Ann. chim. phys.*, **41** (1829), 398.

[3] Eng. P., 2,767, **1856**; 3031, **1856**.

[4] Dingler's *Polytechnisches Journal*, **210** (1873), 24; Hubbard, "Utilization of Wood Waste," Edition II, Chapter III.

[5] Eng. P., 13,408, **1891**.

[6] *J. Soc. Chem. Ind.*, **2** (1892), 966.

[7] U. S. P., 1,001,937.

[8] U. S. P., 1,002,034.

[9] U. S. P., 999,551, 1,217,218.

[10] Eng. P., 23,682, **1893**; 2,308, **1897**; U. S. P., 1,018,092, 1,065,577; *Chem. Abs.*, **5** (1911), 3729.

alkali—a treatment which gives the largest yield of acetic acid.[1] Hardwood sawdust was used principally, since it is less suitable for the production of ethyl alcohol[2] and also since hardwoods give larger yields of acetic acid on destructive distillation.

While the production of acetic acid was the chief aim in this work, it was appreciated that other products of value might be produced in sufficient quantities to warrant recovery. Consequently yields of oxalic acid, formic acid, and methyl alcohol were also determined.

EXPERIMENTAL

Ten-gram samples of sawdust were employed. The samples were placed in iron crucibles 7.5 cm. in diameter and 6.2 cm. deep, and enough 1 : 1 alkali added to give the desired proportion of alkali to sawdust. Owing to the scarcity and high cost of caustic potash, caustic soda was used throughout the experiments. In the preliminary runs on basswood the crucibles were not covered and were heated on a sand bath for the length of time indicated. In all subsequent runs the contents of the crucibles were brought to the desired temperature on a sand bath and the crucibles then placed in an electric oven for the length of time indicated in each run. During the preliminary heating the crucibles were covered with lids, having a hole large enough to admit a thermometer, as this arrangement permitted a more uniform heating of the contents of the crucible. From time to time the mass was stirred.

After heating, the reaction mixture was leached with water. Where much woody material remained, as in the runs at lower temperatures, this was filtered off and the filtrate made up to 200 cc., but in the runs at 170° and above, the unfiltered leach liquor was made up to this volume. Fifty-cc. portions were taken for analysis.

The alkaline liquor always contained some woody material either in suspension or solution, which on acidification was thrown down. The action of very strong phosphoric acid on this material apparently gave rise to some acetic acid not previously produced by the interaction of the alkali and sawdust.[2] The following procedure was therefore adopted in determining acetic acid.[3] A 50-cc. sample was placed in a 250 cc. flask fitted with a rubber stopper carrying a 50 cc. separatory funnel and an outlet tube, including a Kjeldahl bulb, leading to a condenser. Fifteen cubic centimeters of phosphoric acid (85 per cent H_3PO_4) were added through the separatory funnel and the mixture distilled until the volume of liquid in the flask was reduced to 50 cc. The volume was then maintained at approximately 50 cc. by adding water through the separatory funnel while 300 cc. of distillate were collected. Although higher homologues are probably formed in small amounts, the acids in the distillate appear to be almost entirely formic and acetic. One-half of the distillate was titrated with $N/10$ sodium hydroxide, using phenolphthalein as indicator, and the per cent total volatile acid was calculated in terms of acetic acid. The other half was treated with the number of grams of mercuric oxide corresponding to the number of cubic centimeters of $N/10$ alkali required in the above titration, and digested for 3 hrs. on the steam bath. The mixture was then transferred to the 250 cc. flask used in the determination of total acid, an excess (25 cc.) of phosphoric acid added, and the acidified mixture distilled to small volume and then washed with 100 cc. of water added through the separatory funnel. In this way about 250 cc. of distillate were obtained, which was titrated with $N/10$ sodium hydroxide, using phenolphthalein as indicator, and the acid calculated as acetic acid. The molecular difference between the total acid and the acetic acid represents formic acid. Since there is no point in the original distillation with phosphoric acid at which the evolution of acid is entirely complete, an accuracy greater than 1 per cent cannot be claimed for the results dependent on this portion of the analysis.

Oxalic acid was determined, using 50 cc. of the leach liquor. This was acidified with acetic acid and boiled to expel carbon dioxide. The solution was then made alkaline with ammonium hydroxide, boiled, and filtered to remove precipitated iron. An excess of a saturated solution of calcium acetate was added to the boiling filtrate and the calcium oxalate allowed to settle. The precipitate was filtered off, dried, and ignited at red heat to remove organic matter and to decompose the oxalate. The residue which contained small amounts of iron was then dissolved in hydrochloric acid and the calcium determined in the usual way as sulfate.[1]

PRELIMINARY RUNS—Basswood (*Tilia americana*) gives a high yield of acetic acid on simple acid hydrolysis[2] and was consequently selected for the preliminary runs. The 20-mesh sawdust was placed in a crucible, the alkali solution added, and the two thoroughly mixed. The mixture darkens as the temperature rises. At about 130° boiling sets in, partial solution takes place, and the mixture becomes black.

TABLE I

Ratio Alkali to Sawdust	Mean Temp. of Run Deg. C.	Time of Heating Hrs.	Volatile Acid Calc. as Acetic Acid (Dry Base)
			Per cent
2 : 1	105	3	8.6
2 : 1	Steam Bath	24	7.6
2 : 1	Steam Bath	48	9.1
		Min.	
3 : 1	145	30	10.1
3 : 1	145	45	12.1
3 : 1	170	15	10.1
3 : 1	170	15	10.1
3 : 1	173	30	12.1
3 : 1	205	30	23.1
3 : 1	205	60	25.8
3 : 1	205	105	26.5
3 : 1	205	165	29.0
3 : 1	210	30	6.1
3 : 1	230	30	26.4
3 : 1	230	60	25.3
3 : 1	230	110	26.4
3 : 1	230	150	24.3
3 : 1	245	10	22.2
3 : 1	245	15	18.2

Calcium hydroxide was the alkali used in this run. Ratio of water to alkali 4 : 3.

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[1] Cross and Bevan, "Cellulose," p. 191.

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[1] Treadwell-Hall, "Analytical Chemistry," **2**, 72.

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TABLE II

			170° C.			200° C.			230° C.			260° C.			290° C.		
SPECIES	Hrs. Time	Ratio NaOH to Sawdust	Total Volatile Acid Calc. as Acetic Per cent	Acetic Acid Per cent	Oxalic Acid ($H_2C_2O_4.2H_2O$) Per cent	Total Volatile Acid Calc. as Acetic Per cent	Acetic Acid Per cent	Oxalic Acid ($H_2C_2O_4.2H_2O$) Per cent	Total Volatile Acid Calc. as Acetic Per cent	Acetic Acid Per cent	Oxalic Acid ($H_2C_2O_4.2H_2O$) Per cent	Total Volatile Acid Calc. as Acetic Per cent	Acetic Acid Per cent	Oxalic Acid ($H_2C_2O_4.2H_2O$) Per cent	Total Volatile Acid Calc. as Acetic Per cent	Acetic Acid Per cent	Oxalic Acid ($H_2C_2O_4.2H_2O$) Per cent
White Oak (*Quercus alba*)	3/4	3 : 1	9.3	4.1	6.6	14.7	5.9	12.5	25.7	11.0	37.5	....	....	...	....	....	...
	1 1/2	3 : 1	9.5	4.3	6.6	17.7	7.1	19.6	26.7	12.0	39.5	....	....	...	....	....	...
	3	3 : 1	15.9	6.4	24.1	26.2	10.2	31.5	24.5	17.0	38.4	....	....	...	....	....	...
	6	3 : 1	21.2	8.4	....	23.6	13.6	55.3	20.6	17.6	33.3	....	....	...	....	....	...
	12	3 : 1	30.3	11.4	38.0	21.6	15.6	62.5	19.9	18.9	40.4	....	....	...	....	....	...
	24	3 : 1	25.2	....	....	....	....	....	....	....	....	....	....	...	....	....	...
	48	3 : 1	27.4	....	....	....	....	....	....	....	....	....	....	...	....	....	...
Hard Maple (*Acer saccharum*)	3/4	3 : 1	7.7	4.3	....	16.5	7.3	....	22.0	11.5	....	....	....	...	....	....	...
	1 1/2	3 : 1	8.0	4.7	....	22.6	10.0	24.9	23.8	14.1	42.0	....	....	...	....	....	...
	3	3 : 1	9.6	5.3	....	27.3	12.8	46.4	19.3	17.8	58.7	....	....	...	....	....	...
	6	3 : 1	18.1	8.1	....	23.4	15.7	59.3	21.0	18.1	46.4	....	....	...	....	....	...
	12	3 : 1	16.0	7.2	....	32.2	16.3	....	22.9	19.1	....	....	....	...	....	....	...
Elm (*Ulmus americana*)	3/4	3 : 1	10.2	6.7	....	17.7	9.9	....	23.6	12.8	....	20.0	18.2	...	7.0[1]	....	...
	1 1/2	3 : 1	9.7	6.1	....	19.0	9.9	26.8	24.7	15.5	33.9	11.6[1]	10.8[1]	...	20.6	18.4	2.9
	3	3 : 1	13.4	7.8	....	20.9	11.2	34.6	20.9	19.1	56.1	20.4	19.8	1.3	21.4	21.4	2.9
	6	3 : 1	15.8	8.6	....	27.9	14.4	73.6	24.9	18.7	50.6	22.2	21.2	...	0.8[1]	....	0.1
	12	3 : 1	18.8	9.5	....	31.4	13.9	....	21.1	18.5	....	22.0	20.3	...	14.1[2]	13.5	0.1
Longleaf Pine (*Pinus palustris*)	3/4	3 : 1	6.0	2.2	1.5	13.0	4.2	14.9	19.5	7.9	43.6	....	....	...	....	....	...
	1 1/2	3 : 1	6.6	2.3	2.2	12.7	4.1	13.5	22.0	9.4	54.6	....	....	...	....	....	...
	3	3 : 1	9.1	3.1	6.5	17.6	6.4	30.0	18.4	12.0	68.9	....	....	...	....	....	...
	6	3 : 1	24.0	8.4	37.2	17.4	14.4	70.0	16.4	14.0	69.3	....	....	...	....	....	...
	12	3 : 1	32.6	12.6	58.0	21.4	14.7	74.0	16.2	14.6	67.4	....	....	...	....	....	...

[1] Ignited. [2] Partially charred.

As the water boils off, the temperature gradually rises and the mixture becomes thicker and lighter in color. At 170° the mixture is quite stiff and rolls up when stirred. Fusion begins at 190° to 200°, and at 220° the mass is a paste. Soon after fusion begins, a marked exothermic reaction sets in, the temperature rises quite rapidly, and there is considerable evolution of gas. The color changes to light yellow on fusion and to greenish yellow as the reaction proceeds. On cooling, the mass becomes hard and the yellow color changes to brown on contact with the moisture of the air. The resulting product is almost completely soluble in water, giving an almost black solution. The original wood particles are perceptible as such until fusion takes place. In the case of the lime run no fusion took place, the reaction mixture became light colored and crumbled when stirred. Under varying conditions the results obtained are found in Table I.

The results show that both length of time of heating and the temperature at which this heating is carried out are factors which determined the yield of total volatile acid and that a maximum is reached for a half-hour period of heating at 230° and for a 2 3/4-hr. period at 205°.

EXPERIMENTS WITH WHITE OAK, HARD MAPLE, AND ELM—To determine the optimum conditions as to time of heating and temperature for the production of acetic acid from sawdust the above woods, from which a large percentage of commercial sawdust is obtained, were selected. Runs were made on longleaf pine for the purpose of comparison with the hardwoods. The preliminary runs with basswood indicated that the most favorable temperature lay between 170° and 245°. Consequently, runs were made at 170°, 200°, and 230° on all three woods, and at 260° and 290° on elm. The time was varied from three-quarters of an hour to 12 hrs., except in two runs on oak, where the time was extended to 24 and 48 hrs. Sawdust produced at the laboratory sawmill was used, and for the sake of uniformity was passed through an 8-mesh sieve. The runs were made in groups of five and the results of some typical series are recorded in the table. Percentages are calculated on the dry weight of the wood.

The yield of total volatile acid reaches a maximum at 170° and a 12-hr. heating period with oak and pine, and at 200° for the same period with maple and elm. Roughly, however, only 50 per cent or less of this acid is acetic. The yield of acetic acid increases both with time and temperature up to 230° for a 3-hr. period, so that these appear to represent the optimum conditions for the production of acetic acid. The results on elm indicate that it is possible to shorten the heating period by raising the temperature to 260°, but at this higher temperature there is danger of the reaction mixture igniting. The yield of oxalic acid is highest for the longer periods of heating at 200°. At higher temperatures the yield decreases and at 260° most of the oxalate previously formed is decomposed. Pine gives a higher yield of oxalic and a lower yield of acetic acid than the hardwoods.

The formation of oxalic acid appears to be independent of the acetic acid produced. On the other hand, at least part of the formic acid formed is converted into oxalic acid at 200° and over as indicated by a decreasing percentage of total acid and increasing percentages of acetic and oxalic acids. Some of the acetic acid results from hydrolysis of acetyl groups in the lignocellulose, but the greater portion of it is probably produced by a more profound change of the original wood substance. Cross, Bevan, and Isaac[1] obtained large yields of acetic acid from cane sugar under similar conditions—a compound which contains no acetyl groups or acetic acid residues.

Experiments with smaller ratios of alkali to sawdust not only gave smaller yields of acid for corresponding temperature and heating periods, but the reaction is difficult to control, only partial fusion takes place, and the mass is very apt to char as a result of the heat

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[1] *Loc. cit.*

generated by the exothermic reaction. The results of these experiments are given in the following table:

TABLE III

			170° C.		230° C.		
SPECIES	Hrs. Time	Ratio NaOH to Sawdust	Total Volatile Acid Calc. as Acetic Per cent	Acetic Acid Per cent	Total Volatile Acid Calc. as Acetic Per cent	Acetic Acid Per cent	Oxalic Acid ($H_2C_2O_4.2H_2O$) Per cent
White Oak	¾	1½ : 1	12.2	4.9	12.3[1]	11.2	20.0
	1½	1½ : 1	14.4	5.2	12.2[1]	7.7	26.9
	3	1½ : 1	14.2	5.2	12.3[1]	11.6	37.7
	6	1½ : 1	15.3	5.4	23.6[2]	12.2	40.3
	12	1½ : 1	16.0	5.5	22.4[2]	13.9	39.8
White Oak	¾	2 : 1	....	...	21.9[2]	....	38.9
	1½	2 : 1	....	...	6.1[1]	....	12.5
	3	2 : 1	....	...	21.4[2]	....	40.5
	6	2 : 1	....	...	14.1[1]	....	35.8
	12	2 : 1	....	...	8.9[1]	....	19.2

[1] Charred.
[2] Partially charred.

The minimum amount of alkali for maximum production of acids under favorable conditions appears to be approximately 3 parts to 1 of sawdust.

In order to check on a somewhat larger scale the results thus far obtained and also to investigate the volatile materials formed in the course of the reaction between sodium hydroxide and sawdust at higher temperatures, duplicate runs were made using a 10 l. autoclave. The autoclave is of the ordinary type and is provided with a stirring device and an outlet tube connected to a coil condenser. Thermometer tubes are provided for securing the temperatures of the charge and the escaping vapors. The heating unit consists of a sodium-potassium nitrate bath heated by a gas flame. The temperature of the bath is determined by a recording thermometer.

The size of the charge found most suitable was 2 lbs. (907.2 g.) of bone-dry sawdust, and this amount, with 6 lbs. of alkali, was used in all runs. The conditions which it was attempted to approximate were those for the maximum production of acetic acid together with as large an amount of oxalic acid as possible, that is, a 3-hr. heating period at approximately 230°.

The results obtained on runs with oak, elm, and maple are given in Table IV. The methyl alcohol was determined by taking the specific gravity of a distillate obtained by fractionally distilling the original distillate and again distilling the methyl alcohol fraction after acidification with sulfuric acid to remove volatile bases. A 12-in. Hempel column was used, and the distillations were continued until the temperature of the vapor passing over became 100°. Acetone was determined in the final methyl alcohol distillate by the iodoform reaction, the excess of iodine being titrated with thiosulfate solution.[1]

TABLE IV

SPECIES	Temp. during 3-Hr. Heating Period Av.	Deg. C. Max.	Total Volatile Acid Calc. as Acetic Per cent	Acetic Acid Per cent	Oxalic Acid ($H_2C_2O_4$.-$2H_2O$) Per cent	Methyl Alcohol Per cent	Acetone Per cent
Oak	225	235	18.3	15.9	2.6	2.37	0.004
Elm	227	235	20.9	17.5	5.8	2.33	0.003
Maple	231.5	234	19.3	15.1	3.5	2.51	0.004

The results agree very well with those previously obtained, except for oxalic acid. A subsequent run at 200° on oak gave the following yields:

	Per cent
Total volatile acid	20.4
Acetic acid	13.9
Oxalic acid	35.0

The temperature reached in the above runs appears, therefore, to have been high enough to decompose most of the oxalate previously formed.

The yield of methyl alcohol is greater than that obtained by the destructive distillation of these woods,[1] but less than is theoretically possible from the methoxy content of the wood as determined by the Zeisel method.[2] As was to be expected, the amount of acetone produced is negligible.

In order to determine at what stage during the reaction the larger portion of methyl alcohol is produced, the original distillates were collected in three fractions and the methyl alcohol in each determined.

TABLE V

SPECIES	Fraction	Vol. of Original Fraction Cc.	Temp. of Reaction Mixt. Deg. C.	Methyl Alcohol Grams	Total Methyl Alcohol Per cent
Oak	1	2095	Up to 162	5.51	22.13
	2	424	172–177	1.26	5.06
	3	490	177–235	18.13	72.81
Elm	1	1492	Up to 159	3.72	26.55
	2	576	159–183	0.73	5.21
	3	610	183–235	9.56	68.24
Maple	1	1230	Up to 160	4.07	17.51
	2	1010	160–180	1.97	8.48
	3	311	180–234	17.20	74.01

The figures show that about 30 per cent of the methyl alcohol is produced by simple hydrolysis, while approximately 70 per cent results from the more drastic action involved in the fusion of the alkali and wood. It appears probable that there are methyl esters as well as methyl ethers in the original lignocellulose.

ALKALI RECOVERY—Since any process for the production of acetic acid and other valuable products from sawdust, using such a large excess of alkali, must involve the recovery of most of this alkali to be successful commercially, preliminary experiments were made to determine how and to what extent the sodium hydroxide used could be recovered. These experiments having indicated the possibility of recovery of a sufficiently large percentage of alkali as carbonate to make this process a practical one, further experiments were conducted to determine more exactly what result could be attained. In general, the method employed was to treat a given volume of the solution of the melt with carbon dioxide to a point where a test portion no longer reacted alkaline to phenolphthalein after treatment with an excess of barium chloride. It was then concentrated to the desired strength and crystallized at room temperature or lower as desired. Crystallization was hastened by "seeding" the solution with a few crystals of $Na_2CO_3.10H_2O$. The crystals were filtered off on a Buchner funnel, using muslin as a filtering medium. Approximately 200 cc. of water were used in each of the washings, which were carried out by removing the crystals each time from the funnel and mixing them thoroughly with the wash water. Since sodium carbonate has a negative heat of solution there was no difficulty encountered

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[1] Sherman, "Organic Analysis," p. 30.

[1] Forest Service *Bulletins* 129 and 508.

[2] Cross and Bevan, "Cellulose," p. 189.

TABLE VI

									Distribution of Acid						Distribution of Alkali					
Run No.	Wood Used in Fusion	Vol. at Time of Crystallization	Grams per 100 Cc. Calc. as NaOH at Time of Crystallization	Approximate Temp. at Crystallization Deg. C.	Vol. of Mother Liquor Cc.	Volume of Washings Cc. 1	Volume of Washings Cc. 2	Volume of Washings Cc. 3	Acetic Acid in Mother Liquor Per cent	Acetic Acid in Washings Per cent 1	Acetic Acid in Washings Per cent 2	Acetic Acid in Washings Per cent 3	Acetic Acid in Mother Liquor and Washings Per cent	Acetic Acid in Crystals Per cent	Alkali in Mother Liquor Per cent	Alkali in Washings Per cent 1	Alkali in Washings Per cent 2	Alkali in Washings Per cent 3	Alkali in Mother Liquor and Washings Per cent	Alkali in Crystals Per cent
1	Oak	660	28.8	10	258	212	186	202	65.6	22.4	7.4	2.3	97.7	2.3	21.8	14.2	10.9	10.1	57.0	43.0
2	Elm	1150	24.9	13	352	376	278	330	52.4	30.9	11.1	3.6	98.1	1.9	14.3	12.1	8.5	10.0	44.9	55.1
3	Elm	950	30.1	25	298	242	179	177	60.5	27.8	6.1	2.5	96.9	3.1	17.8	15.4	12.2	10.3	55.5	44.5
4[1]	Elm	1250	30.0	15.5	415	340	298	250	61.4	22.8	9.0	2.7	95.9	4.1	14.9	11.6	10.5	7.6	44.9	55.1
5[1]	Elm	1050	35.0	20.0	292	386	252	401	56.6	29.0	10.4	2.8	98.8	1.2	11.5	17.6	18.4	21.0	68.4	31.6
6[2]	Elm	925	30.9	25.0	290	258	216	225	76.5	16.6	2.9	2.6	98.9	1.0	22.9	17.4	13.3	12.4	66.0	34.0
7	Maple	950	27.4	17.0	295	255	256	236	58.1	25.4	11.8	3.0	98.3	1.7	16.7	15.1	13.9	11.7	57.5	42.5

[1] Selective washing employed. [2] Centrifuged instead of filtered.

in maintaining the reduced temperatures employed in some of the runs. Results obtained under varying conditions are given in Table VI.

From 96 to 99 per cent of the acetic acid is separated from the crystals by three washings, while 45 to 68 per cent of the alkali is also carried into solution, the amounts depending upon the temperature at which the process of separation is carried out and the volume of wash water used. To make the operation successful with respect to the recovery of alkali it would be necessary to remove a much larger percentage of the alkali from the mother liquor and washings. This could be done by selective washing as carried out in Runs 4 and 5 on elm. In these runs the following scheme was followed:

1—First washings from previous runs added to original solution, the solution treated with carbon dioxide, concentrated, and the carbonate "seeded" out.

2—Second washings from previous runs used for first washing.

3—Third washings from previous runs used for second washing.

4—Fresh water used for third washing.

Run 4 resulted in 95.9 per cent of the acetic acid going into the mother liquor and washings, and represents the amount of acetic acid which would be recovered unless one or more additional washings with pure water proved feasible. Since the washings obtained would be used for washing in subsequent runs, the only alkali lost would be that contained in the mother liquor, which in this case amounts to 14.8 per cent of the total alkali contained in the original solution and wash water used, or 20.1 per cent of the alkali in the original solution. This loss of alkali could be further reduced by cooling the mother liquor. In the case under consideration, if the 415 g. of mother liquor were cooled to 0°, only 22.2 g. of alkali, calculated as sodium hydroxide, would remain in solution, representing a loss of 7.77 per cent of the alkali used. A similar result could be obtained by concentrating the mother liquor to approximately 100 cc. and allowing the carbonate in solution to crystallize at room temperature.

To check the above conclusions, the mother liquor in Run 5 was cooled to 0° C. and the carbonate crystals formed filtered off. It was found that the loss of alkali could be reduced in this way to 9 per cent of the original amount used, 5.4 per cent of which is in combination with the acetic acid present in the mother liquor. It seems probable, therefore, that a recovery of alkali of 85 to 90 per cent could be obtained without difficulty.

The runs on the different species were made primarily to determine what effect, if any, the organic matter in solution or suspension might have in carrying out the separation of acid and alkali. Any effect this material has is negligible, and since it is concentrated in the mother liquor the crystals are probably sufficiently free from organic matter to make calcining unnecessary before causticizing.

SUMMARY

The data given show that 17 to 20 per cent of acetic acid can be obtained from hardwood sawdust by fusion with sodium hydroxide.

A simultaneous production of oxalic acid amounting to approximately 50 per cent of the dry weight of the wood is obtained.

If the reaction is carried out in a closed vessel, a simultaneous production of methyl alcohol results amounting to 2.4 per cent; but, as the temperature is increased beyond 200°, the yield of oxalic acid is considerably reduced.

At lower temperatures both formic and acetic acids are produced, amounting to approximately 15 per cent each.

Higher yields of oxalic acid than those obtained by Thorn[1] with pine wood and caustic soda have been obtained. It appears that the yields of this acid obtained with caustic soda will more nearly approach those obtained with caustic potash if the temperature is kept at approximately 200°, the heating prolonged, and the ratio of alkali to sawdust maintained at 3 : 1.

Somewhat lower yields of acetic acid than those obtained by Cross, Bevan, and Isaac[2] with caustic potash have been obtained using caustic soda.

It has been found possible to recover as much as 91 per cent of the alkali used.

FOREST PRODUCTS LABORATORY
IN COÖPERATION WITH THE UNIVERSITY OF WISCONSIN
MADISON, WISCONSIN

AN AËROBIC SPORE-FORMING BACILLUS IN CANNED SALMON

By ALBERT C. HUNTER AND CHARLES THOM

Received April 19, 1919

Failures in the sterilization of canned goods are well recognized from the occurrence of swelled cans, cans which give out foul odors when opened, or of glass jars in which there is turbidity or other visible

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[1] *Loc. cit.*

[2] *Ibid.*

evidence of decomposition. The presence of living bacteria in such products without active spoilage is less well known, but accounts for some of the discordant bacteriological results which have been frequently attributed to errors in manipulation. Such living bacteria may bear no relation to the present condition of the product whether sound or spoiled. Bacteriological examination of about 500 cans of salmon has furnished a striking example of such survival.

The salmon examined represented nine brands packed at different factories and included salmon designated by the trade as red or sockeye salmon, coho or silver salmon, chum or dog salmon, and humpback or pink salmon. Routine examination designed to test sterility was first applied. When living organisms were found, all species were isolated and studied to test their relationship to the conditions met with. The large number of unsterile cans encountered, 44.7 per cent (Table I), forced a careful discrimination between unsterility and active spoilage.

The cans were first examined for leaks or dents and as to whether or not they were "swells" or "springers." They were then opened aseptically by means of a flamed can opener. By means of a sterile pipette, from 5 to 10 mm. in diameter and not tapered at the end, a small amount of the salmon was transferred to each of two Petri dishes. Care was taken to obtain some of the flesh together with the liquor. Small amounts were also carefully placed in each of two test tubes and about 5 g. in dextrose broth. Dextrose agar was poured over the fish in the Petri dishes and the test tubes and all cultures were incubated at 37° C. for 4 days. Notice was taken of the odor and general appearance of the fish in each can and a record of this was kept with the bacteriological data.

Table I gives a summary of the cans examined and the number and per cent of cans found not sterile.

TABLE I

BRAND	Number Examined	Number Not Sterile	Per cent Not Sterile
A	202	110	54.4
B	66	38	57.5
C	72	31	43.05
D	32	19	59.37
E	32	19	59.37
F	24	13[1]	54.1
G	24	7	29.1
H	32	0	0
I	46	0	0
TOTAL	530	237	44.7

[1] These 13 cans were "swells" and did not show the characteristic organism discussed in this paper.

A study of this table shows that nearly one-half of these cans of salmon were found to contain living bacteria in contrast to the findings of Weinzirl[1] who reports very few unsterile cans of salmon. In some brands the proportion of non-sterile cans is greater than 50 per cent, while in other cases, for example, the fish from Brands H and I, all the cans examined were found to be sterile. The presence of these living bacteria has little significance as to the quality of the product at the time the can is opened, since some of the sterile cans were found, on chemical examination, to contain putrid and decomposed fish, while many of the cans from which bacteria were grown contained fish apparently sound.

Comparative study of the organisms found in these cans showed that a particular variety had been found in 224 out of 237 non-sterile cans, or 42.2 per cent of all cans examined. The 13 unsterile cans failing to show this species were the "swells" belonging to a single group of Brand F. Cans showing a mixed flora are not uncommon but in many cases this form alone survived the processing. This organism was first isolated from still another lot of salmon in this laboratory by Mrs. Obst during the summer of 1918. The frequency of this species in salmon, together with its survival in commercially processed goods, makes a study of its characteristics especially important. The other organisms found were isolated for study but thus far have furnished no significant information.

DESCRIPTION OF THE ORGANISM

The morphological, cultural, and biochemical features of this organism as described here indicate that it is probably a member of the mesentericus group, although not clearly identified with any of the well-known species.

MORPHOLOGY

Bacillus 3.2 $\mu \times 0.7 \mu$
Forms spores within 24 hrs.
Spore-forms measure 1.6 $\mu \times 0.8 \mu$
Motile
Gram-positive

CULTURAL CHARACTERS

Grows on all media
Produces red ring in dextrose agar
Growth on nutrient agar slant along streak, wrinkled, gray
Growth on dextrose agar slant spreading, tough and wrinkled
On dextrose agar plates growth covers entire surface of plate
Heavy pellicle in plain broth, medium clear
Pellicle on dextrose broth, medium dark brown
Gelatin liquefied
Litmus milk peptonized turned brown in 48 hrs.

BIOCHEMISTRY

No gas in dextrose and lactose broth with and without fish
No indole in tryptophan broth
Acid produced in dextrose and lactose broths. Later turns alkaline
2.8 per cent normal acid produced in dextrose broth plus fish. Much less in lactose broth
Spores of this organism very resistant to heat

The outstanding feature of this organism is the production of a dark red ring when grown on solid carbohydrate medium. This ring is produced in the medium at about a half-inch from the growth on the slant or from the growth on the surface of the column of agar. When sterile fish is present in the medium, this red color is often imparted to it and a marked softening of the fish takes place. No such red ring is obtained when the organism is grown on plain agar.

The action of this organism on sterilized salmon is very marked. Approximately 500 g. of fish were ground in a food chopper and sterilized for 90 min. at 15 lbs. pressure. This fish was inoculated with 10 cc. of a 48-hour broth culture of the organism and incubated at 37° C. for one week. Within that time the fish became very soft, in fact, liquid, and gave off a very offensive odor. The color of the decomposed fish was a dark brown. Chemical examination[1] of the decomposed salmon in this particular case failed to show the presence of indol, skatol, or hydrogen

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[1] "The Bacteriology of Canned Foods," *J. Med. Res.* **39** (1919), [3] 394.

[1] Determinations made by Dr. H. W. Houghton, of the Food Investigation Laboratory, Bureau of Chemistry.

sulfide, although a very pronounced test for methyl mercaptan was obtained. Further work, however, is necessary to establish the correlation between the action of this organism on the salmon and the decomposition products resulting therefrom.

The spores of this organism are resistant to heat and in broth culture have been found to survive heating in the Arnold sterilizer at 100° C. for one hour. Broth cultures of the spores survived 15 lbs. pressure in the autoclave for 15 min., but were killed at 15 lbs. pressure for 30 min. It is very evident that these forms when embedded in the center of the salmon within the can may survive the temperature of processing in the cannery.

Study of the detailed records summarized in Table I shows that some cans of Brands H and I, in which all cans were found sterile, consisted of markedly decomposed fish. In the other samples with part of the cans sterile there was no correlation between sterility and the soundness of the fish except in Brand F, in which active spoilage is reported. An obligate aërobe such as this may be found in viable condition in a can properly sealed and showing no apparent spoilage. In fact, organisms of several species were found in cans of fish in which no physical or chemical evidences of spoilage were detected. Some cans containing soft and obviously putrid fish contained no living organisms.

The presence of these organisms may result in quick decay when opening the can supplies the oxygen needed for activity. On the other hand, their presence may or may not supply information as to the previous history of the material canned. Such correlation depends upon the establishment of a correlation between a particular microörganism and a condition or process. The salmon organism is a heat-resistant spore-former capable of decomposing salmon with great rapidity, but its exact source and significance in the canned products remains to be demonstrated.

The survival of such an organism shows that the method of cooking or processing the commercial product has failed to produce sterility. The temperature may not have reached the proper limit, the period may have been too short, or the heat may not have been evenly applied, hence some cans escaped the adequate cooking which sterilized the remainder. The large number of unsterile cans found among well-known brands of salmon points to a widespread failure in factory operation.

Sterility merely means that whatever organisms may have been present in the material at some time are now dead. The material itself may have been rotten or putrid from the activity of these organisms before canning, hence totally unfit for food. Some of this salmon was manifestly putrid but not in active spoilage as it came from the can. The evidences of decay were, however, manifest to sight and smell. In specially prepared foods these evidences are commonly masked or more or less completely destroyed. Jams, jellies, apple butter, canned pumpkin, mince meat, soup stock, and tomato products such as catsup, pulp, and paste, may be made up in large part of decomposed material yet so comminuted and so flavored in cooking as to leave neither visible evidence nor flavor to guide the consumer who would unhesitatingly reject the raw materials if he could examine them. Yet these products are commonly sterile. Sterility is not to be confused with fitness for food; it does establish the presumption that the material under examination is in the same condition as when packed.

Similar observations have been made in this laboratory in a considerable variety of canned foods. Living bacteria rather frequently are found in canned foods which show no signs of decomposition which are apparent to the senses. The organism described in this paper is only one of many forms, both cocci and bacilli, isolated from canned products apparently sound. This leads to the conclusion that lack of fermentation or active spoilage of canned food is not a guarantee of sterility. This condition in sardines is discussed by Obst.[1] The bacteria in the product may be in a dormant state while in the can and only grow when more favorable conditions are supplied. Many of the bacteria isolated, as the organism described above, are obligate aërobes and could not grow under the anaërobic conditions occurring in a properly exhausted and sealed can.

Processing, to use the commercial term, should then be distinguished from sterilization.

SUMMARY

Bacteriological examination of 530 cans of salmon, representing 9 brands, showed 237 unsterile cans. 224 of these cans contained the same organism of the mesentericus group either in pure culture or in connection with other species. Only 13 of these cans showed active spoilage.

The organism is an obligate aërobic spore-former, gram positive, motile, and produces a dark red ring about a centimeter below the colony in carbohydrate media. It decomposes fish rapidly.

Such obligate aërobic spore-formers may be present in viable condition in canned products without any appearance of spoilage.

Actual sterility is very properly the aim of the packer. The survival of viable organisms in the final product may occasionally be unavoidable but calls for a careful survey of their source and significance with a view to their complete destruction.

Bureau of Chemistry
Department of Agriculture
Washington, D. C.

TEMPERATURE-TIME RELATIONS IN CANNED FOODS DURING STERILIZATION

By Geo. E. Thompson

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I—INTRODUCTION

It is well known that the death rates of the bacteria which caused spoilage in canned foods depend on the temperature and composition of the substrate. As these death rates, under varying conditions of temperature and substrate, become accurately established, a knowl-

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[1] "A Bacteriologic Study of Sardines," *J. Infect. Dis.*, **24** (1919), 158.

edge of the temperature-time relations in the cans during the sterilizing process is desirable as an aid to their application in the scientific study of food sterilization.

Only a few brief reports concerning the temperature variations in canned foods during sterilization have been published. J. Kochs and K. Weinhausen,[1] by the use of maximum thermometers, determined the maximum temperatures attained in given times, under practical conditions, in cabbage, carrots, asparagus, green peas, etc. A. W. Bitting and K. G. Bitting,[2] by using both thermocouples and mercury thermometers, secured complete temperature-time curves for pumpkin, sweet potatoes, tomatoes, peaches, etc., while being heated in a water bath.

It is the purpose of this paper to state the results of experiments on temperature measurement in cylindrical cans during the sterilizing process and to see what use may be made of the mathematical theory of heat conduction in extending the value of these results. It is certain that the application of this experimental data will be greatly extended if it can be put in the form of mathematical equations which may be used for plotting temperature-time curves.

It is not claimed that the present paper contains all data and results necessary for the practical utilization of the method in either home or commercial canning, but rather it is to be regarded as a preliminary communication outlining methods of procedure for the preparation of reference tables and curves. A more extended discussion of the development of the theory will probably be published later in the research bulletin series of the Iowa Agricultural Experiment Station.

The procedure used consisted in determining, by means of thermocouples embedded in the center of cans of food, the temperature-time curves when the cans are subjected to various temperatures in hot water, steam, cool air, and cool water. The effect of the size and shape of container on the heat penetration has been calculated and values of the diffusivity, *i. e.*, $\frac{\text{conductivity}}{\text{specific heat} \times \text{density}}$, found for a variety of canned foods. The mathematical theory has been quite fully developed, and a study made of the correspondence of theoretical and experimental temperature-time curves. It is shown to be possible to use a mathematical expression for plotting curves from which may be found the temperature of some food substances at any time and at any point in the can, provided the initial temperature distribution in the can and the bath temperature are known. The accuracy of this method depends on the nature of the food.

II—PREPARATION OF MATERIALS FOR CANNING

The fruits and vegetables were chosen with the idea of securing as great a variety of conditions as practicable. Those which require a large amount of free liquid to fill the cans permit considerable convection and those requiring no liquid permit practically none.

The food was prepared for canning as follows:

ASPARAGUS—The stalks of asparagus were cut in lengths approximately equal to the height of the can, blanched in boiling water during the time indicated in Table II, and then cold dipped. They were then packed in the can as neatly as possible and the free space filled with water.

CARROTS—The carrots were peeled and sliced, the slices being circular and about ½ in. in thickness, and no careful attempt being made to have all pieces alike in size or shape.

CHARD—Stalks and leaves were both used. After blanching and cold dipping, the chard was packed into the cans without regard to the arrangement of the stalks in the can. They were pressed down rather closely so as to get a maximum amount in the can. Hot water was used to fill the free space. Undoubtedly a considerable amount of air was left in the cans by this process of filling.

CHERRIES—The cherries were washed and packed directly into the cans. No. 3 syrup, made by adding 3 lbs. 9 oz. of sugar to 1 gal. water, was used.

CORN—The corn was blanched on the cob in boiling water and cold dipped. It was then cut from the cob as quickly as possible; placed in the cans and filled with hot water. Golden Bantam and Country Gentleman were the varieties used. The Golden Bantam corn was not all of even sized grains and sometimes a little over mature. The initials G. B. and C. G. in Table II indicate the two varieties. The C. G. was in prime condition. The corn was cut into whole grains and the cob not scraped.

PEAS—The peas were hulled and blanched in boiling water for the length of time indicated in Table II, and then cold dipped. Ordinary tap water was used as liquid for filling.

STRAWBERRIES—The berries were washed in cold water and packed directly into the cans without blanching. No. 3 syrup was used.

SPINACH—Spinach was prepared in the same manner as chard except blanched in steam. The spinach used was of the New Zealand variety.

STRING BEANS—Stringless, green pod variety, broken in about 2-in. lengths was used. Free space was filled with water.

SQUASH—The squash used in these experiments had been processed once so that it was in a pasty form at the beginning of these experiments. Information concerning the water content cannot be supplied.

III—APPARATUS AND EXPERIMENTAL METHOD

COLD PACK METHOD—The hot water sterilizing bath used in the cold pack method consisted of an 8-gal. Wearever aluminum, steam-jacketed cooker, filled with tap water. This gave a very easy means of controlling the temperature of the bath, it being possible to bring the water from room temperature to boiling in from 20 to 30 min. Two general methods of procedure were employed. In one, the bath was brought to the boiling point and the can suddenly dropped in; in the other, the can was put in when the

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[1] *Ber. Kgl. Gart.-Lehranst. Dahlem*, **1906–07**, 146.

[2] National Canners' Association Research Laboratory, *Bull.* **14**, 32–8.

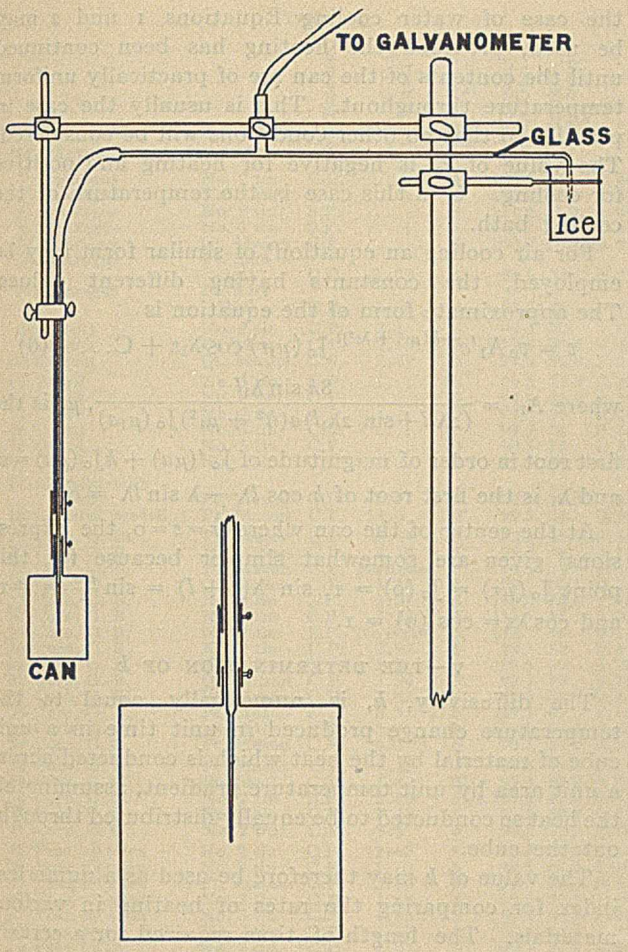

Fig. 1

bath reached 60° or 70° C., and the bath temperature was then gradually brought to the boiling point. These are the methods most commonly employed in the cold pack process.

The temperature readings were usually made with a thermocouple and sensitive galvanometer (1.88×10^{6} volt/mm.) calibrated by reference to a mercury thermometer. In a few cases a mercury thermometer was used. The thermocouple was of bare constantan wire (No. 27) and enameled copper wire (No. 30), mounted as shown in Fig. 1. The wires were protected by enclosure in glass and rubber tubing. The glass tube was narrowed down to about 2 mm. diameter at the point where it entered the can, and at the end was drawn out very thin and sealed. The presence of the thin glass surrounding the junction did not prevent the junction from attaining the temperature of its surroundings promptly. A test showed that in 20 sec. after immersion in boiling water the junction was practically at the temperature of the water.

This junction was placed as near the center of the can as possible. In locating the center of glass cans the surface of the food was considered to be the top of the can. The other junction was placed in a bath of cracked ice.

The can was supported by a brass tube held fast to the can by solder. The glass tube containing the thermocouple entered the can through this brass tube. In order to make the interchange of cans easy, the brass tube was made in two pieces held together by a collar with set screws. The same method of support was employed for glass as for tin cans.

STEAM PROCESSING—The steam processor consisted of a piece of heavy steam-pipe, 12 in. long and 8 in. in diameter, with cast-iron plates bolted on the ends. The top plate was fastened with thumb nuts, in order that it might be easily removed. The steam was let in at the bottom and condensation was discharged through a second opening in the bottom. Another small leak was left in the top, so that any air not forced out at the bottom had opportunity to escape. The small volume of the processor made it possible to attain any desired pressure in a few seconds.

It was necessary to lead the thermocouple wires in through a steam-tight joint, capable of withstanding a gauge pressure of at least 20 lbs. per sq. in. Fig. 2 shows details of this connection. The pressure was regulated by hand by means of a needle valve.

IV—SUMMARY OF MATHEMATICAL THEORY

In developing the mathematical theory, it is assumed that the heat penetration takes place entirely by conduction. Obviously, convection plays an important part in many cases but it is thought that if the convection is very local in character, the theory will still apply approximately enough for ordinary purposes, the convection being in effect equal to an increase in conduction.

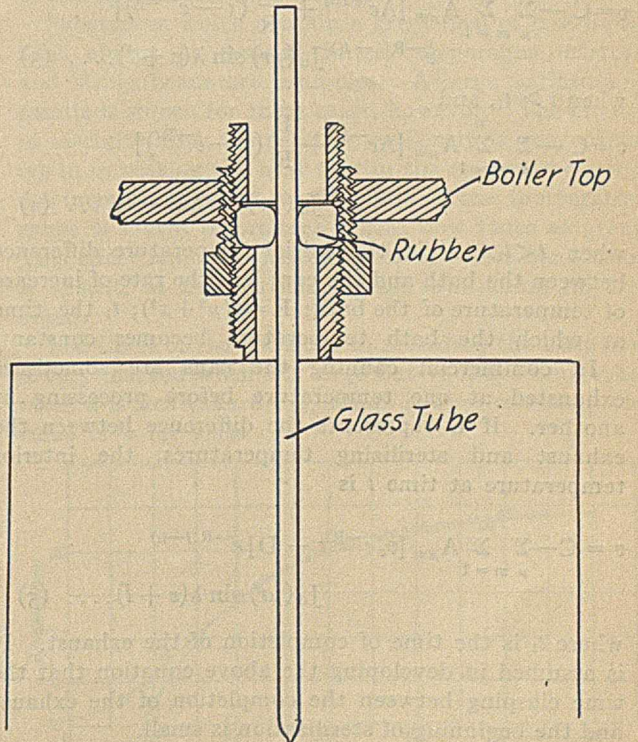

Fig 2

The simplest case we have to consider is the one in which the contents of the can are of uniform temperature throughout before immersion in the sterilizing bath, and in which the bath is maintained at uniform temperature after the immersion. In this case the temperature v, at any time t, and at any point in the can, is given by the expression:

$$v = \mathrm{C} - v_o \sum_{\mu} \sum_{m=1}^{\infty} \mathrm{A}_{\mu m}\, e^{-k(\mu^2+\lambda^2)t}\, \mathrm{J}_o(\mu r) \sin \lambda(z+l) \, .. \quad (1)$$

where v_o is the difference in initial temperatures of can and bath; r and z are the cylindrical coördinates of a point in a can, the origin being at the center of the can; μ a root of $\mathrm{J}_o(\mu a)$; $\lambda = \frac{m\pi}{2l}$; $\mathrm{A}_{\mu m}$ is a constant depending on the initial temperature distribution in the can; C is the centigrade temperature of the bath; k is the diffusivity of the material and is equal to $\frac{\text{conductivity}}{\text{specific heat} \times \text{density}}$.

A simple approximate form of this equation which serves well enough for all practical purposes is:

$$v = \mathrm{C} - \mathrm{A}_1 v_o\, e^{-k(\mu_1^2+\lambda_1^2)t}\, \mathrm{J}_o(\mu_1 r) \sin \lambda_1(z+l) \, .. \quad (2)$$

This is merely the first term of Equation 1. The other terms become smaller and smaller as t increases and finally may be neglected with small error.

Another case which will be considered is one in which the bath temperature, after the can has been put in, increases uniformly to the boiling point and remains constant thereafter. The solution[1] for this case is:

$$v = \mathrm{C} - \sum_{\mu} \sum_{m=1}^{\infty} \mathrm{A}_{\mu m} \left[\mathrm{A}e^{-\mathrm{R}t_1} + \frac{\mathrm{B}}{\mathrm{R}}(1 - e^{-\mathrm{R}t_1})\right] e^{-\mathrm{R}(t-t_1)}\, \mathrm{J}_o(\mu r) \sin \lambda(z+l) \, ... \quad (3)$$

when $t > t_1$, and

$$v = \mathrm{C} - \sum_{\mu} \sum_{m=1}^{\infty} \mathrm{A}_{\mu m} \left[\mathrm{A}e^{-\mathrm{R}t} + \frac{\mathrm{B}}{\mathrm{R}}(1 - e^{-\mathrm{R}t})\right] \mathrm{J}_o(\mu r) \sin \lambda(z+l) \, ... \quad (4)$$

when $t < t_1$. A is the initial temperature difference between the bath and the can; B is the rate of increase of temperature of the bath; $\mathrm{R} = k(\mu^2 + x^2)$; t_1 the time at which the bath temperature becomes constant.

In commercial canning the cans are sometimes exhausted at one temperature before processing at another. If D represents the difference between the exhaust and sterilizing temperatures, the interior temperature at time t is

$$v = \mathrm{C} - \sum_{\mu} \sum_{m=1}^{\infty} \mathrm{A}_{\mu m} \left[v_o e^{-\mathrm{R}t_1} + \mathrm{D}\right] e^{-\mathrm{R}(t-t_1)}\, \mathrm{J}_o(\mu r) \sin \lambda(z+l) \, ... \quad (5)$$

where t_1 is the time of completion of the exhaust. It is assumed in developing the above equation that the time elasping between the completion of the exhaust and the beginning of sterilization is small.

We have now to consider the case of cooling. The contents of the can remain hot for some time after the removal of the can from the sterilizing bath. For the case of water cooling Equations 1 and 2 may be used, provided the heating has been continued until the contents of the can are of practically uniform temperature throughout. This is usually the case in practice so that no other conditions will be considered. The value of v_o is negative for heating and positive for cooling. C in this case is the temperature of the cooling bath.

For air cooling an equation[1] of similar form may be employed, the constants having different values. The approximate form of the equation is

$$v = v_o \mathrm{A}_1' e^{-k(\mu_1^2+\lambda_1^2)t}\, \mathrm{J}_o(\mu_1 r) \cos \lambda_1 z + \mathrm{C} \, ... \quad (6)$$

where $\mathrm{A}_1' = \frac{8h \sin \lambda_1 l}{(2\lambda_1 l + \sin 2\lambda_1 l)\, a(h^2 + \mu_1^2)\, \mathrm{J}_o(\mu_1 a)}$, μ_1 is the first root in order of magnitude of $\mathrm{J}_o'(\mu a) + h\mathrm{J}_o(\mu a) = 0$, and λ_1 is the first root of $h \cos l\lambda - \lambda \sin l\lambda = 0$.

At the center of the can where $r = z = 0$, the expressions[2] given are somewhat simpler because for this point $\mathrm{J}_o(\mu r) = \mathrm{J}_o(0) = 1$, $\sin \lambda(z+l) = \sin \frac{m\pi}{2} = \pm 1$, and $\cos \lambda z = \cos(0) = 1$.

V—THE DETERMINATION OF k

The diffusivity, k, is numerically equal to the temperature change produced in unit time in a unit cube of material by the heat which is conducted across a unit area by unit temperature gradient, assuming all the heat so conducted to be equally distributed throughout the cube.

The value of k may therefore be used as a numerical index for comparing the rates of heating in various materials. The length of time required for a certain temperature to be reached under a given set of conditions is inversely proportional to k.

In finding the value of k for a given substance we make use of Equation 2 and an experimental temperature-time curve for the substance when placed in a can of known dimensions and subjected to known temperature conditions. In order to use Equation 2 we must specify a uniform temperature distribution in the can before being placed in the bath and also a uniform and unchanging bath temperature.

TABLE I

KIND OF CAN	Diameter Cm.	Length Cm.	μ_1	λ_1	$\mu_1^2+\lambda_1^2$
Tin:					
No. 1	6.7	10.0	0.718	0.314	0.616
No. 2	8.4	11.4	0.572	0.275	0.403
No. 2½	10.3	12.0	0.472	0.262	0.292
No. 3	10.4	12.2	0.463	0.258	0.282
Glass:					
Pint, Ball Ideal	8.9	10.2	0.540	0.308	0.387
Pint, Foster Seal Fast	8.6	11.2	0.558	0.280	0.401
Pint, Sure Seal	8.6	11.4	0.558	0.276	0.399
Pint, Mason	7.9	11.4	0.608	0.276	0.447
Qt., Ball Ideal	9.9	15.6	0.485	0.201	0.277
Qt., Foster Seal Fast	10.2	15.9	0.470	0.197	0.260
Qt., Sure Seal	....	....	.....	.....	.....
Qt., Mason	9.9	15.9	0.485	0.201	0.262
Half-gal., Mason	....	....	.....	.....	0.210

As an example, let us determine the value of k for a pint Mason jar filled with corn. An experimental curve for this is shown in Fig. 3. The constants for several kinds of cans are shown in Table I. $\mu_1 a$ is the

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[1] The author is indebted to Professor James McMahon, of Ithaca, N. Y., for Equations 3 and 4.

[1] Carslaw, "Introduction to the Theory of Fourier's Series and Integrals," p. 327.

[2] $\mathrm{J}_o(\mu r) = 1 - \frac{(\mu r)^2}{2^2} = \frac{(\mu r)^4}{2^2.4^2} + \frac{(\mu r)^6}{2^2.4^2.6^2} + \, ...$ and is called a Bessel function of the zero'th order.

TABLE II

No.	MATERIAL	Kind of Can	How Processed	Ratio of Solid to Liquid	Time of Blanching. Min.	Bath Temperature Deg. C.	Initial Temperature Deg. C	k
1	Asparagus	No. 2 tin	C.P.	....	4	100.0	30.0	0.847
2	Asparagus	No. 2 tin	C.P.	....	4	100.0	29.0	1.505
3	Asparagus	No. 2 tin	S.P.	....	4	111.0	31.0	3.64
4	Asparagus	No. 3 tin	S.P.	....	4	111.0	24.0	2.61
5	Asparagus	Qt. Mason	C.P.	....	4	100.0	34.0	0.935
6	Asparagus	Pt. Sure Seal	C.P.	1.79	4	99.5	24	0.736
7	Asparagus	Pt. Sure Seal	C.P.	1.68	4	99.5	24	0.513
8	Carrots	No. 2 tin	C.P.	2.1	6	99.5	60	1.61
9	Carrots	Pt. Mason	C.P.	2.15	5	99.5	57.5	0.413
10	Carrots	Qt. Mason	C.P.	2.27	5	99.5	59.0	2.27
11	Chard	No. 3 tin	C.P.	....	10	99.5	52.5	0.26
12	Chard	No. 2 tin	C.P.	....	10	99.5	33.0	0.19
13	Chard	No. 2 tin	C.P.	....	10	99.5	57	0.249
14	Chard	No. 3 tin	C.P.	....	10	99.5	36	0.366
15	Chard	No. 3 tin	C.P.	....	10	99.5	53	0.232
16	Chard	No. 2 tin	C.P	....	10	99.5	34	0.153
17	Cherries, with seeds	Pt. Mason	C.P.	3.77	0	99.5	24.0	0.42
18	Cherries, seeded	Pt. Mason	C.P.	13.3	0	99.5	24	0.225
19	Corn, G. B.	Pt. Mason	C.P.	2.44	5	99.5	55.0	0.34
20	Corn, G. B.	Pt. Mason	C.P.	4.79	5	99.5	52	0.17
21	Corn, G. B.	Pt. Mason	C.P.	No liquid	5	99.5	39	0.106
22	Corn, G. B.	Qt. Mason	C.P.	3.48	5	99.5	60.5	0.258
23	Corn, G. B.	No. 2 tin	S P.	2.07	5	118.0	58.0	1.16
24	Corn, G. B.	No. 2 tin	S.P.	4.33	5	113	56	0.301
25	Corn, G. B.	No. 2 tin	S.P.	No liquid	5	117	48	0.114
26	Corn, G. B.	No. 2 tin	C.P.	2.97	5	99.5	58	0.417
27	Corn, G. B.	No. 2 tin	C.P.	3.3	5	99.5	60	0.287
28	Corn, G. B.	Qt. Mason	C.P.	3.54	5	99.5	58	0.238
29	Corn, G. B.	Pt. Mason	C.P.	2.62	6	99.5	59.5	0.405
30	Corn, G. B.	Pt. Mason	C.P.	8.5	5	99.5	43.0	0.137
31	Corn, G. B.	No. 2 tin	S.P.	3.7	5	109.0	52.5	0.68
32	Corn, G. B.	Pt. Mason	C.P.	4.3	5	99.5	51.0	0.163
33	Corn, G. B.	Pt Mason	C.P.	5.16	5	99.5	41.0	0.148
34	Corn, G. G.	Pt. Ideal	C.P.	3.82	5½	99.5	59.0	0.233
35	Corn, C. G.	No. 2 tin	S.P.	3.66	5½	105.0	47.0	0.321
36	Corn, C. G.	No. 2 tin	C.P.	3.45	5	99.5	59.0	0.228
37	Corn, C. G.	No. 2 tin	C.P.	3.5	5	99.5	58.0	0.194
38	Peas, all sizes	No. 2 tin	C.P.	2.42	8	99.5	61.0	1.31
39	Peas, all sizes	No. 2 tin	C.P.	1.70	6	99.5	63.0	1.46
40	Peas, all sizes	Pt. Mason	C.P.	2.16	5	99.5	54.0	0.573
41	Peas, all sizes	No. 2 tin	C.P.	1.80	5	99.5	57.0	1.66
42	Peas, all sizes	No. 3 tin	C.P.	1.73	5	99.5	60.5	1.61
43	Peas, small	No. 2 tin	C.P.	1.77	5	99.5	62.5	1.71
44	Peas, large	No. 2 tin	C.P.	1.83	5	99.5	57.0	1.66
45	Peas, large	No. 3 tin	S.P.	1.76	5	115.0	50.0	3.1
46	Peas, large	No. 2 tin	C.P.	2.05	5	99.5	61.5	1.86
47	Spinach	No. 2 tin	C.P.	4.43	5	99.5	39.0	0.175
48	Spinach	No. 2 tin	C.P.	4.67	10	99.5	45.0	0.153
49	Spinach	No. 2 tin	C.P.	4.00	10	99.5	35.0	0.181
50	Spincah	Pt. Mason	C.P.	3.33	5	99.5	38.0	0.145
51	Squash	No. 2 tin	C.P.	....	..	99.5	19.0	0.105
52	Squash	No. 1 tin	C.P.	....	..	99.5	18.0	0.102
53	Squash	No. 3 tin	C.P.	....	..	99.5	24.0	0.110
54	Squash	No. 2 tin	S.P.	....	..	128.0	30.0	0.104
55	Strawberries	Pt. Ideal	C.P.	2.22	0	99.5	24.0	0.256
56	String beans	Pt. Mason	C.P.	1.91	5	99.5	58.0	0.59
57	String beans	Qt. Mason	C.P.	1.60	5	99.5	59.5	0.75
58	String beans	Pt. Mason	C.P.	1.75	5	99.5	55.0	0.58
59	String beans	No. 2 tin	C.P.	1.23	7	99.5	58.5	1.08
60	String beans	No. 2 tin	S.P.	1.38	5	118.0	62.0	1.92
61	String beans	No. 2 tin	S.P.	1.95	5	117.0	50.0	1.14
62	String beans	No. 2 tin	S.P.	1.90	5	117.0	47.0	1.21
63	Water	Pt. Mason	C.P.	....	..	99.5	31.5	0.72
64	Water	Qt. Mason	C.P.	....	..	99.5	27.5	0.93
65	Water	No. 2 tin	C.P.	....	..	99.5	24.5	1.60

first root in order of magnitude of $J_o\ (\mu a) = 0$ and is found from mathematical tables to be 2.405. Hence $\mu_1 = \frac{\mu_1 a}{a} = \frac{2.405}{3.95} = 0.608$, where a is the radius of the can. $\lambda_1 = \frac{\pi}{2l} = \frac{3.14}{11.4} = 0.276$, where $2l$ is the height of the can. The value of A is found from the expression.

$$A_{\mu m} = \frac{4(1 - \cos m\pi)}{\pi(\mu a)\ J_1\ (\mu a)}.$$

$$A_1 = \frac{4(1 + 1)}{\pi \times 2.405 \times 0.52} = 2.04,$$ since $m = 1$ and $(\mu a) = 2.405$ for the first term of the series of Equation 1. This value of A_1 is the same for all cases in which the initial temperature distribution is uniform, no matter what the variations of the bath temperature. The double summation sign $\sum\limits_{\mu} \sum\limits_{m=1}^{\infty}$ means that μ and m are to be given all possible positive values in pairs and all terms so obtained added algebraically. The values of μ are those computed from the roots of $J_o\ (\mu a) = 0$ and the values of m are to be positive integers. The curve shows that a temperature of 90° C. is reached in 30.5 min. C = 99.5° C. and $v_o = 47.5°$ C. Making appropriate substitutions in Equation 2 we have

$$90 = 99.5 - 47.5 \times 2.04\ e^{-k(\overline{0.608}^2 + \overline{0.276}^2)30.5.}$$

Since we are dealing with the center of the can the terms $J_o\,(\mu_1 r)$ and $\sin \lambda_1\ (z + l)$ are each equal to unity. Simplifying we have

$$\frac{9.5}{97} = 0.098 = e^{-13.6k.}$$

In the table of exponentials we find the value of x which gives $e^{-x} = 0.098$ to be 2.32. Hence,

$$13.6\ k = 2.32 \text{ and } k = \frac{2.32}{13.6} = 0.170.$$

Table II gives the values of k for the various materials tested. These values are expressed in centimeter-gram-minute units.

VI—DISCUSSION OF RESULTS

The results of nearly all the tests made are shown in Table II. The initials C. P. and S. P. stand for cold pack and steam process, respectively. The rest of the table is self-explanatory.

Substances which contain a great deal of free liquid heat almost as fast as water. Asparagus, carrots, and string beans are examples. A large variation in results is shown for these cases, however. The change of viscosity with temperature evidently is very effective in increasing the heat flow in the steam processing. An increase of about 15 per cent in the temperature range is shown to produce a heat flow twice as great. This effect is not noticeable in cases where convection is absent, as in corn and squash containing no free liquid.

The effect of the glass can in retarding the heat flow is very marked when k is large but vanishes altogether when k is less than 0.375, which is approximately the value of k for glass.

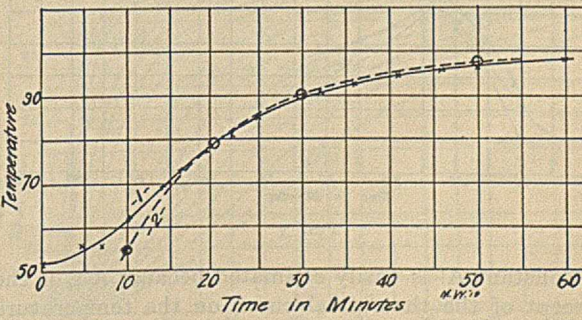

FIG. 3

It will be seen on examination of the figures that the theoretical curve follows the experimental quite closely regardless of the kind of container and the nature of the material. This is also true of the large number of curves which are not shown.

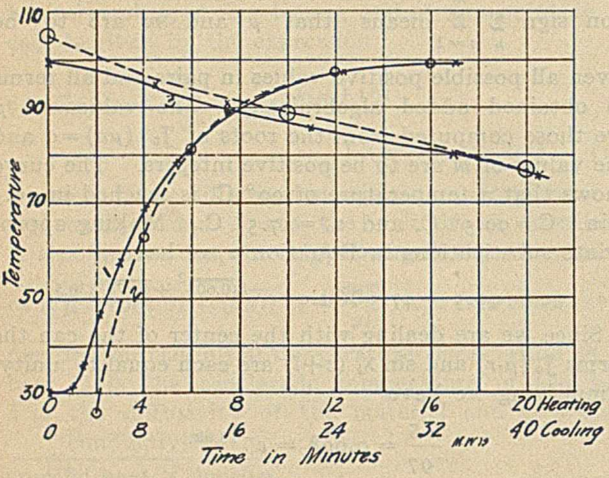

FIG. 4

Curve 1 in Fig. 3 is an experimental curve for corn in a pint Mason jar. Curve 2 is the theoretical as computed from Equation 2. The reason why the two curves vary from each other greatly at the beginning is because the terms in Equation 1 which are neglected in forming Equation 2 become larger when time is small. The value of k for this case is 0.170, bath temperature 99.5° C.

Curves 1 and 3 of Fig. 4 are the experimental heating and cooling curves for asparagus in a No. 2 tin can. Curve 2 is from Equation 2 and Curve 4 from Equation 6. The temperature of the bath was 100° C. and of the air 28° C. The constants in Equation 4 have been determined by the cut-and-try method rather than from the formula given in the summary of mathematical theory. Before these formulas can be used, several physical constants which are rather difficult to determine accurately must be known. In the few attempts that have been made to use these formulas very poor agreement between the theoretical and experimental curves for air cooling was secured so that this method has been abandoned for the present in favor of the cut-and-try method. The constant A′ is easily estimated because $A'v_0$ is the intercept of the theoretical curve on the temperature axis, considering the air temperature zero. The trend of the experimental curve indicates pretty definitely the point of intersection of the theoretical curve with the axis.

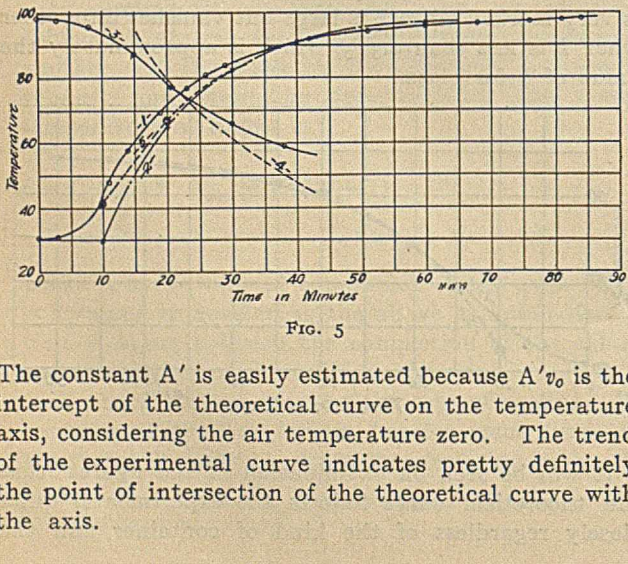

FIG. 5

The fact that these constants cannot be easily obtained in a straightforward manner from the theory is sure to restrict the usefulness of the theory in the case of air cooling. It is hoped that this difficulty may be overcome by further study.

Fig. 5 shows five curves for a can of corn as follows: 1, the experimental heating curve; 2, the approximate form of theoretical curve as computed from Equation 2; 3, the experimental cooling curve for water-cooling; 4, the approximate form of cooling curve computed from Equation 2; 5, the theoretical heating curve as computed from Equation 1, all terms of appreciable value being retained. The temperature of the sterilizing bath was 99.5° C., of the cooling bath 30° C.; k had the value 0.175 for heating and 0.129 for cooling. The container was a No. 2 tin can.

The curve computed from Equation 1 is shown in Fig. 5 only and is included for the purpose of showing the close agreement between Equations 1 and 2 after a short time has elapsed.

In corn the shape of the experimental curve differs from the theoretical in a way not found in very many substances. In most substances the value of k increases slightly as the temperature increases, but in corn as the starch goes into solution there is a decrease of k. This effect is shown by the difference in the slopes of the experimental and theoretical curves. This variation makes it necessary to employ a value of k in computing the cooling curve different from that used for heating. The cooling curves shown in Fig. 5 agree very poorly with each other. A great deal of this difference may be attributed to failure to keep the water of the cooling bath in good circulation.

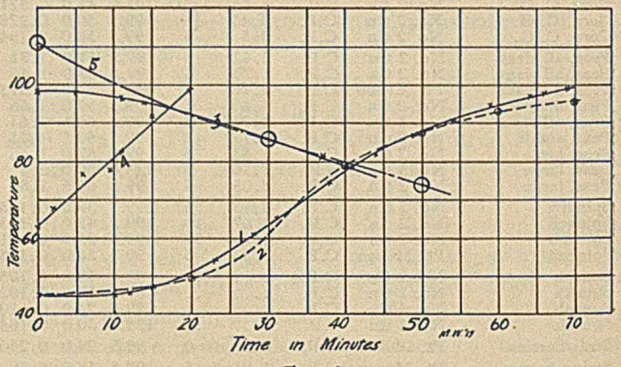

FIG. 6

In order to determine the effect of the solution and gelatinization of the starch in corn, one No. 2 can was processed on three successive days; 46 min. on the first, 84 on the second, and 40 on the third. The can was cooled in water after the first and second processings. The values of k on the three successive days were 0.287, 0.175, and 0.182. These results show that the first processing completed the change in the starch.

Fig. 6 shows the results obtained with spinach contained in a pint Mason jar and placed in a bath of variable temperature, the variation being from 63° C. to 99.5° C. The cooling was in air at 26° C. Curve 1 is the experimental heating curve; Curve 2, the theoretical as computed from Equations 3 and 4; Curve 3, the experimental; and Curve 5, the theoretical cooling curve; Curve 4 shows the variation of the bath temperature.

The percentage of free liquid as might be expected influences very greatly the rate of heat penetration. Fig. 7 shows the results obtained for corn. The points in the circles are for glass cans and those in the squares for tin. Where the square is accompanied by the letter S, the processing was by steam. Three points are not shown in this figure, namely: (8.5, 0.137), for the cold-pack method, (∞, 0.110) and (∞, 0.120) for the steam process.

It is evident from consideration of this figure that steam is much more effective when the percentage of free liquid is large, the heat flow being about double that obtained at the lower temperature. The fact that this difference vanishes when there is no free liquid indicates that it is entirely due to the effect of temperature on the convection. k is determined in each case on the basis of unit temperature difference so that unless some of the supposed constants vary, the results should be the same.

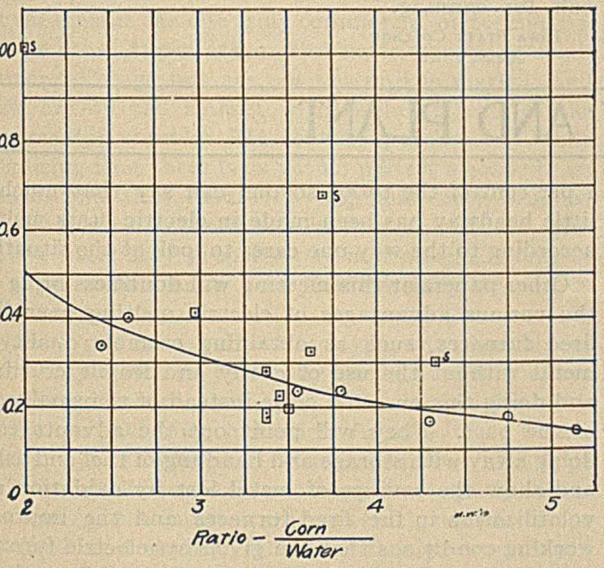

Fig. 7

It will be noticed also that the values for glass cans lie more nearly on a smooth curve than those for tin. This is perhaps due to a more uniform pack in the glass since it is possible to observe carefully as the can is being filled.

In one case a mixture of one part water to five of corn was carefully stirred while being heated to 55° C. previous to packing into the can. A rather pasty mixture with k equal to 0.105 was obtained.

The smallest value of k obtained in any trial is 0.102, which is about equal to the value for water, barring convection. Squash in paste form and corn without liquid give about this value for k. Any other pasty substance would probably give the same value. This fact points to the conclusion that the limiting value is that for pure conduction in water and that occluded air does not retard appreciably the flow of heat.

It is undoubtedly possible to modify the mathematical formula to take account of the variations of

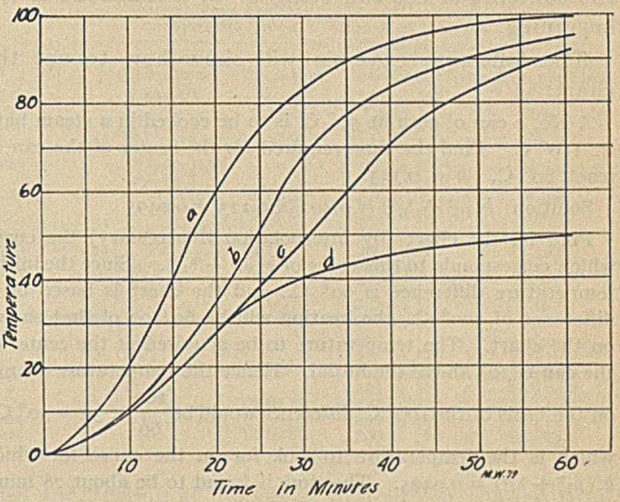

Fig. 8

k with temperature and time but it is doubtful whether such procedure is desirable at the present time. The experimental heating curves shown have been chosen almost at random so that they do not necessarily include those which agree most closely with the theoretical.

The effect of variations in the bath temperature may be seen by referring to Fig. 8. Curve a is computed from Equation 1. The initial temperature of the contents of the can was 0° C. throughout and the bath maintained at 100° C. from the beginning. Curve b was computed from Equations 3 and 4. The conditions were the same as in Curve a, except that the bath temperature varies uniformly from 50° C. to 100° C., reaching the latter value after 20 min. Curve c was computed from Equations 1 and 5. The bath temperature was maintained at 50° C. for 20 min. and then suddenly increased to 100° C. Curve d is computed from Equation 1, the bath temperature being 50° C. continuously.

VII—CHART OF TEMPERATURE-TIME RELATIONS

The chart shown in Fig. 9 may be used for determining approximately the temperature, at the center of a can, at any time after immersion in the sterilizing bath which is maintained at constant temperature.

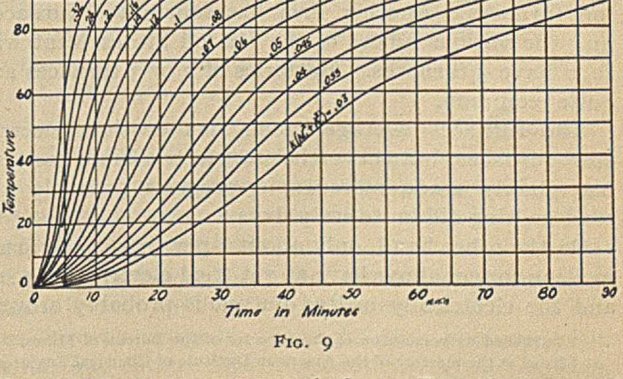

Fig. 9

The curves are computed from Equation 1 and based on an initial temperature difference of 100° C., the contents of the can being 0° C. throughout at the beginning.

The following example will show how to use the chart:

A No. 2 can of corn at 50° C. is to be cooked in a steam bath at 110° C. Find the time required for the center of the can to reach 80° C. $k = 0.123$.

Solution: $k(\mu_1^2 + \lambda_1^2) = 0.402 \times 0.123 = 0.0495$

Find on the chart (by interpolation if necessary) the curve which corresponds to this value of $k(\mu_1^2 + \lambda_1^2)$. Since the initial temperature difference is 60° C., and the chart is based on a difference of 100° C., the heating will be 60/100 of that shown on the chart. The temperature to be acquired at the center of the can is 30° above the initial. Hence the temperature change on the basis of the 100° C. difference would be $\frac{100}{60} \times 30 = 50°$ C., which is the temperature to look for on the curve for which $k(\mu_1^2 + \lambda_1^2) = 0.0495$. The time is found to be about 28 min.

The time for water cooling is found by using the same chart in a similar way. Suppose we wish the time for the center of the can to cool from 110° C. to 60° C., assuming that the material is of uniform temperature throughout at the beginning of the cooling. The initial temperature difference is 90° C. and the amount of cooling is 50° C. The equivalent on the chart would be as follows:

$$\frac{100}{90} \times 50 = 55.5° \text{ C.}$$

The chart shows 30 min. as the time required for this change.

VIII—CONCLUSION

In this paper the author has purposely omitted a great many details of computation which are of small interest to the reader. The computations involved in the curves of Fig. 8 would need several pages for presentation so that it is deemed wise to omit them.

No chart similar to Fig. 9 has yet been devised for the cases involving variable bath temperatures, in fact, it will perhaps be found impossible to combine all results into a single chart.

Undoubtedly a great deal remains to be done before results of the kind presented by this paper can be put to the greatest use in solving the bacteriological problems of food canning.

The author wishes to express his thanks to Dr. R. E. Buchanan of the bacteriology department for suggesting and directing these experiments; also to the horticultural department for furnishing the materials for canning.

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LABORATORY AND PLANT

UTILIZATION OF ELECTRIC BRASS FURNACES[1,2]

By H. W. GILLETT

Received May 21, 1919

Under the caption "Electric Furnaces *vs.* Crucibles," a recent issue of the house organ of one of the crucible companies states:[3] "We understand that as a matter of fact, the electric furnace thus far has made very little headway in the melting of brass and bronze." This statement may be either true or erroneous according to one's point of view.

Electric furnaces for steel are fairly common to-day, there being about 300 in the United States. The first furnace started up 13 years ago, and in the first 5 years thereafter the number rose to only four.

Four years ago there was no electric brass furnace in commercial operation. To-day some 40 firms are using or now installing approximately 100 electric brass furnaces. One rolling mill has about 30, though most of these are small 300 lb. furnaces. One smelting and refining company is using four 1 ton and four $^3/_4$ ton furnaces. Another firm has four 1 ton furnaces and the various offices of the United States Mint will soon have 5 furnaces. Batteries of 2 or 3 furnaces are quite common.

The furnaces average much smaller than electric steel furnaces, but, nevertheless, electric brass melting has plainly made more rapid progress than electric steel melting did in its early days.

On the other hand, only about 1 per cent of the firms melting copper alloys have as yet tried electric furnaces, and the electrically melted output is probably around 1 per cent of the total, so one can say that much or little headway has been made in electric brass melting according to the way one cares to look at the situation.

Other papers at this meeting will doubtless bring out the various advantages of electric melting over fuel-fired furnaces, such as obtaining crucible quality of metal without the use of costly and fragile crucibles, and doing this on a ton scale instead of the small scale of the past. They will point out the advantages of doing away with storage and handling of fuel and ashes, and show the savings of metal lost by oxidation and volatilization in fuel-fired furnaces and the improved working conditions that are given by electric furnaces chosen with proper reference to the conditions of use. These have been shown by furnace after furnace in plant after plant.

There is one other advantage which has so far hardly received the emphasis it deserves. While the prices of coke and oil may fluctuate widely, the price of electric power is a fairly stable, predeterminable charge. Central stations, which, save in rare instances, are the source of power for electric brass melting, are public utilities whose rates are regulated and thus stabilized. The foundryman can therefore predict his melting costs with accuracy for a much longer period than he can when he uses fuel.

With the advantages of electric melting now thoroughly demonstrated by commercial operation of many furnaces, no brass melter can afford to refuse to study the question of their application to its own work. Yet there are foundry conditions under which no electric furnace can economically compete with fuel-fired furnaces, or under which some types of electric furnaces cannot compete, while others can.

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[1] Published by permission of the Director of the Bureau of Mines.

[2] Read at the meeting of the American Institute of Chemical Engineers, Boston, June 18, 1919.

[3] Anon., "Electric Furnaces *vs.* Crucibles," *Graphite*, **21** (1919), 4451.

TABLE I—PERFORMANCE OF ELECTRIC BRASS FURNACES

Name	Type	Power Supply Kw.	Charge Lbs.	Power Factor	Material	Output Tons per Day on Material Given		Power Consumption Kw.-Hrs. per Ton on Material and Time of Operations Given	Consumption of Graphite Electrodes Lbs. per Ton
						10-Hr. Operation	24-Hr. Operation		
Ajax-Wyatt	Vertical ring induction	30	300	85	Yellow brass	1 to 1½	....	300 to 350[1]	None
		30	300	85	Yellow brass	......	3 to 3½	225 to 310	None
		60	600	72	Yellow brass	2½ to 3	....	250 to 300[1]	None
		60	600	72	Yellow brass	2½ to 3	6 to 7	185 to 250	None
Baily	Granular resistor	105	800 to 1500	98 to 100	Yellow brass	2½ to 3½	....	400 to 500[1]	None
		105	800 to 1500	98 to 100	Red brass	2½ to 3	....	450 to 550[1]	None
		105	800 to 1500	98 to 100	Yellow brass	......	6 to 10	275 to 350	None
		105	800 to 1500	98 to 100	Red brass	......	6 to 9	325 to 400	None
Snyder	Direct arc	100	600	35 to 70	Leaded bearing bronze	1¾	....	380	(Experimental)
		300	2000	30 to 60	Leaded bearing bronze	......	12 to 18	260 to 320	3 to 5
Rennerfelt	Indirect arc	100	500	75 to 90	Red brass	1½	....	450 to 500	3 to 6
		125	1000	75 to 90	Bronze	2 to 2½	....	375 to 425	3 to 5
		125	1000	75 to 90	Bronze	......	7 to 10	325 to 375	3 to 5
		300	2000	75 to 90	Leaded bearing bronze	......	10 to 16	300 to 350	3 to 5
Rocking	Indirect arc	40	125	80 to 90	Red brass	¾	....	400	(Experimental)
		225	1300	80 to 90	Red brass	3½	....	325 to 340	2¼ to 4
		225	1300	80 to 90	Red brass	......	8½	250 to 275	2¼ to 4
		300	2000	80 to 90	Red brass	6 to 7	....	275 to 325	2¼ to 4
		300	2000	80 to 90	Red brass	......	16 to 20	225 to 275	2¼ to 4
		300	2000	80 to 90	Yellow brass	6 to 7	....	250 to 300	2¼ to 4
		300	2000	80 to 90	Yellow brass	......	16 to 20	200 to 250	2¼ to 4

[1] Including necessary night heating.

It is possible, also, to choose the right type of electric furnace for the work in hand, but to operate it so that it will bring a loss instead of a saving. Each set of conditions must be studied by itself.

Five types of furnaces have advanced far enough so that the makers can cite truly commercial performances. Various other types are in the experimental or semi-commercial stage but are not yet on the market, and a few are on the market with some at least of the experimental troubles left for the purchaser. While recognizing that there is as yet no perfect electric brass furnace, and that future development may produce a type superior to those now in commercial use, prospective users may properly pay first attention only to the types which have been commercially proven in users' hands.

These types are (1) direct arc type, with the Snyder as the only make as yet really used on copper alloys out of the dozen of that type that are used for steel; (2) the vertical ring induction furnace type (Ajax-Wyatt); (3) the granular resistor, reflected heat type (Bailey); (4) the stationary indirect arc type (Rennerfelt); and (5) the indirect arc type with stirring of the melt (rocking furnace). Clamer,[1] Bailey,[2] von Baur,[3] Miller,[4] the writer,[5] and especially St. John,[6] have previously discussed the possibilities and limitations of these various types and a mere summary is sufficient here.

The Ajax-Wyatt is the most efficient in use of power, uses up no electrodes, gives thorough mixing of the charge and perfect temperature control, and has the steadiest electrical load. It must be "primed" with previously melted metal after a shut-down and hence is not well fitted for 10-hr. operation, though it can be used on 10 hr. operation by keeping some current on and holding some metal molten over night. The need for "priming" makes it difficult to change from one alloy to another. It has been mainly used on yellow brass, though it is applicable to red. Its greatest drawback is that so far no refractory lining has been found that will satisfactorily withstand the action of alloys containing over 3 per cent lead. It is best fitted for 24-hr. operations on the same alloy. It can be mechanically charged.

The Bailey is the least efficient in use of power, does not mix the charge, but has a steady electrical load and uses up no electrodes. This type cannot be powered as high as others without grave danger to the resistor troughs and is hence at a disadvantage as to the efficient use of power, especially in alloys of high melting point. It is best fitted for 24-hr. operation. When used for 10-hr. operation it is usually necessary to put power on part of the night to keep the empty furnace hot. It is not really charged mechanically. It has poor temperature control, due to its heat storage and consequent sluggishness. It can be used on any alloy, but is better fitted for yellow brass than for the higher melting alloys. Its greatest advantage is its simplicity of operation.

The Snyder or any other direct arc furnace is applicable only to true bronzes or other alloys low in zinc, 5 per cent zinc being the probable limit. It is entirely impractical for use on alloys high in zinc. The only installation used for copper alloys is used on lead bearing bronze, the new lead being added in the ladle. Much lead is volatilized from the scrap in the charge, and much fume results, giving bad working conditions. The installation of Snyder furnaces has a very poor power factor, though this is not necessary in a direct arc furnace.

The greatest advantage of the Snyder furnace in its limited field is its adaptability to mechanical charging, which aids in securing large output and hence in reasonable power consummation. One drawback is the single-phase arc load.

The Rennerfelt or any other stationary indirect arc furnace is most applicable to alloys low in zinc. It has been used on alloys up to 22 per cent zinc with fair results, but as the zinc increases above 10 per cent the metal losses increase, and 10 per cent zinc is prob-

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[1] "Melting Brass in the Induction Furnace," *J. Am. Inst. Metals*, **11** (1917), 381.

[2] "Resistance Type Furnace for Melting Brass," *Trans. Am. Electrochem. Soc.*, **32** (1917), 155.

[3] "The Rennerfelt Electric Arc Furnace," *Trans. Am. Electrochem. Soc.*, **29** (1916), 497.

[4] "The Electric Furnace as a Medium for Heating Non-ferrous Metals," *J. Am. Inst. Metals*, **11** (1917), 257.

[5] "A Rocking Electric Brass Furnace," THIS JOURNAL, **10** (1918), 459; "Melting Brass in a Rocking Electric Furnace," U. S. Bur. Mines *Bull.* **171** (1918).

[6] "The Present Status of Electric Brass Melting," *Chem. & Met. Eng.*, **19** (1918), 321.

ably the economical limit of its application. It has met with decided success in melting cupronickel, bronze, and silver at the Mint. It is not readily charged by mechanical means. The power consumption is fairly low.

The rocking type of indirect arc furnace is applicable to alloys of any zinc content, gives a low power consumption, is apparently efficient in small as well as large sizes, can readily be mechanically charged, has good temperature control and mixes the charge thoroughly. Its drawbacks are the single-phase arc load and the possibility of electrode breakage in rocking too early if unskillfully operated.

The performance of the various furnaces properly operated may be expected to lie in the ranges set forth in Table I.

The figures in Table I do not in all cases agree with the catalogue claims of the makers of the furnaces, as they are based on data obtained both from makers and users. The output and power consumption depend not only on the analysis of the charge but also on the condition of it, *i. e.*, whether all ingot, heavy scrap, light scrap, borings, or mixtures, as well as on the way the furnace is operated, just as gasoline consumption varies with the roads and the way the car is run. It will be noted that there is a wide variation in power consumption among the various types of furnaces, and that for the same type, the efficiency increases with the size.

If the types of furnace unfit for use on alloys high in volatile metals are confined to use on alloys free from or sufficiently low in such metals, and if the furnaces are kept tightly closed after the charge is melted, all types of electric furnaces will give very low metal losses indeed. No fuel-fired furnaces can compete with properly chosen electric furnaces on this score. Of course, the lost metal is mainly zinc and lead, so that the value of the loss in fuel-fired furnaces is not as great as it would at first sight appear to be when the percentage loss is considered. This loss, however, usually amounts to about as much as the fuel or labor cost, and, even with cheap zinc and lead, is worth eliminating.

In making a choice of furnaces the user must first eliminate those types which will not operate satisfactorily on alloys he must melt in them, for example, the rolling mills making yellow brass would thus eliminate the direct arc and un-rocked, indirect arc furnaces, and the makers of alloys high in lead and the people who must change from one alloy to another often would eliminate the Ajax-Wyatt. The user should then select from the remainder the type and size of furnace which will best fit his particular work. If he has very cheap power available, the granular resistor type may be chosen over a more efficient arc furnace because of the avoidance of electrode consumption. Where power is high, the balance would be against the granular resistor type. One rolling mill may prefer to continue to pour very small billets and may find the Ajax-Wyatt exactly suited to its needs. Another may wish to operate on a larger scale and may find a one ton rocking furnace more suitable. A maker of bronze who must take his power from a very small power plant may find that a single phase arc load would be unacceptable to the central station and hence might choose the two-phase Rennerfelt instead of the single-phase rocking furnace.

The size of furnace chosen will depend on the output desired and on whether 10- or 24-hr. operation is called for. While the largest sized furnace that can be kept busy should be used, it is poor economy to purchase a large furnace and then operate it with charges much under its capacity or to allow it to lie idle a good share of the time.

An electric furnace is expensive in first cost. The one or two furnaces required to melt 5 tons per day on 10-hr. operation will cost from $10,000 to $20,000 completely installed. For purposes of calculation, assume the cost to be $15,000. At 300 days per year the output is 1500 tons. Taking interest at 6 per cent, the interest is $900 per year or $3.00 per working day, this amount being lost every day the furnace is idle. At full output the interest charge is 60 cents per ton.

On the other hand, if one furnace costing $10,000 is operated for 300 days per year, 24 hrs. a day, with an output of 16 tons, the total output is 4800 tons, and daily interest charge $2.00 per day, or 12½ cents per ton.

On account of the initial cost and the interest charge, one should in general not have electric furnaces standing idle to handle small peaks of production in excess of the normal, but should utilize for this fuel-fired furnaces of lower initial cost.

On the other hand, the greater the number of electric furnaces which can be kept busy the lower the cost of power per ton.

Industrial power contracts usually have two factors, the demand charge and the energy charge. The first pays the power company for the equipment it must maintain to supply the maximum power needed, while the second depends on the total amount of power used.

Suppose we have a maximum demand of 300 kw. and that the average power consumption per ton of metal is 335 kw. hrs. per ton on 9-hr. operation, 275 on 18-hr. and 250 on 24-hr.; the total power used per day is then about 2000, 3565, or 5250 for the three cases. In a 25-day month this means 50,000, 91,000, 130,000 kw.-hrs. per month.

Assume that the plant, before it installed its electric furnace equipment, had a maximum demand in lights and motors of 200 kw., and used 20,000 kw.-hrs. per month for those purposes. Taking a concrete case where the power contract calls for a demand charge of $1.80 per kw. per month for the first 50 kw. and $1.00 per kw. per month for all over 50 kw., the energy charge schedule is: 2500 kw.-hrs per month at 2.0 cents per kw.-hr. for the next 35,000 kw.-hrs per month at 0.8 cent per kw.-hr.; for the next 310,000 kw.-hrs. per month at 0.5 cent per kw.-hr.; all over 347,500 kw.-hrs. per month at 0.4 cent per kw.-hr.

The 200 kw., 20,000 kw.-hrs. lighting and motor power cost as follows:

50 × $1.50 = $ 75.00
150 × 1.00 = 150.00
$225.00 Demand

2500 × $0.02 = $ 50.00
17500 × 0.008 = 140.00
$190.00 Energy Charge

Total $415.00 or 2.07½ cents per kw.-hr. used.

The plant now has 500 kw. maximum demand, and 70,000, 111,000, 150,000 kw.-hr. used per month on the three assumptions.

50 × $1.50 = $ 75.00
450 × 1.00 = 450.00
$525.00 Demand

Energy—Case 1— 2500 × $0.02 = $ 50.00
35000 × 0.008 = 280.00
32500 × 0.005 = 162.50
70000 $492.50 Energy
525.00 Demand
$1017.50 Total Charge
Less 415.00 Previous Charge for Lights and Motors
$602.50 Total Charge for Electric Furnace Power

$$\frac{602.50}{70000} = 1.205$$

The electric furnace power costs 1.205 cents per kw.-hr.

In Case 2 we have the same demand charge, but the energy charge is

2500 × $0.02 = $ 50.00
35000 × 0.008 = 280.00
73500 × 0.005 = 367.50
111000 $ 697.50 Energy
525.00 Demand
$1222.50 Total
Less 415.00 Lights and Motors
$ 807.50 Total Charge for Furnace Power

$$\frac{807.50}{91000} = 0.89$$

The furnace power costs 0.89 cent per kw.-hr.

In Case 3 we have

2500 × $0.02 = $ 50.00
35000 × 0.008 = 280.00
112500 × 0.005 = 562.50
$ 892.50 Energy
525.00 Demand
$1417.50 Total
Less 415.00 Lights and Motors
$1002.50 Total Charge for Furnace Power

$$\frac{1002.50}{130000} = 0.79$$

The furnace power costs 0.79 cent per kw.-hr.

And, if, in Case 4, the plant had three times the furnace installation figured above and used it 24 hrs. a day, or 900 kw. furnace demand (1100 kw. total); 450,000 kw.-hrs. per month furnace energy (470,000 total), the charge would figure

50 × $1.50 = $ 75.00
1050 × 1.00 = 1050.00
$1125.00 Demand
2,500 × $0.02 = 50.00
35,000 × $0.008 = 280.00
310,000 × 0.005 = 1550.00
122,500 × 0.004 = 490.00
$2370.00 Energy

$2370.00 Energy
1125.00
$3495.00 Total
Less 415.00 Lights and Motors
$3080.00 Total for Furnace Power

$$\frac{3080.00}{450000} = 0.685$$

The electric furnace power costs 0.685 cent per kw.-hr.

Tabulating these we get Table II

TABLE II

Case No.	1	2	3	4
Hours	9	18	24	24
No. furnaces	1	1	1	3
Kw.-hrs. per ton	335	275	250	250
Power price, cents per kw.-hr.	1.205	0.89	0.79	0.685
Cost, dollars per ton for power	$3.92	2.45	1.98	1.71

This table shows the advantage of continuous operation of electric furnaces, as well as that of large installations. The exact figures will vary in each particular case, but the ratios will remain approximately the same.

The cost of power is in most cases the largest single item in melting costs in electric furnace practice. Every effort must then be put forth to keep the cost down. The way to do this is to keep this furnace at work at its job, which is melting metal. This is important on 24-hr. operation but even more so on 8- to 10-hr. operation, for an extra heat per day on single-shift operation means that it is obtained at the end of the day when the furnace has recovered from cooling off through the night. Any furnace will illustrate this fact. Take an actual day's run of a small Rennerfelt on red brass, for example.

Heat	Charge Lbs.	Total Time Hrs. and Min.	Arc on Hrs. and Min.	Idle Time Hrs. and Min.	Kw.-Hrs. Used	Kw.-Hrs. per 100 Lbs.	Notes
1	497	2 : 45	2 : 05	40	211	42	Furnace at red heat from previous day's run
2	522	1 : 45	1 : 25	20	130	25	....
3	527	2 : 55	1 : 10	1 : 45	105	20	Delay waiting for molds
4	523	1 : 25	1 : 05	20	106	20	....
5	394	1 : 25	1 : 10	15	94	25	Waiting for molds—so held power input low
	2463	10 : 15	6 : 55	3 : 20	646	26	Av., or 520 kw.-hrs. per ton

This could have been run as follows, by eliminating all delays:

Heat	Charge Lbs.	Total Time Hrs. and Min.	Arc on Hrs. and Min.	Idle Time Charging and Pouring Hrs. and Min.	Kw.-Hrs.	Kw.-Hrs. per 100 Lbs.	
1	525	2 : 10	1 : 95	15	215	41	
2	525	1 : 40	1 : 25	15	130	25	
3	525	1 : 25	1 : 10	15	105	20	
4	525	1 : 20	1 : 05	15	100	19	
5	525	1 : 20	1 : 05	15	100	19	
6	525	1 : 20	1 : 05	15	100	19	
	3150	9 : 15	7 : 45	1 : 30	750	24	Av., or 480 per ton

The elimination of delays thus gives a 25 per cent increase in output in an hour less time, and decreases the cost of power per ton by about 40 cents.

With the exception of the granular resistor type in which it is difficult to hold metal after it is once ready to pour because the response to changes in power input is so slow, it is possible to hold metal ready to pour as long as one likes in any of the electric furnaces. This is a convenience in an emergency, but it is very poor practice from the point of view of furnace efficiency.

The use of as large ladles as it is practical to discharge the furnace into, so that the furnace is idle the shortest possible time during pouring, combined with mechanical overhead charging (in such furnaces as the Snyder and the rocking type which readily allow it), allows the furnace to work at its job of melting the greatest possible proportion of the time. On charges of all borings, especially in case of hand charging, briqueting would be desirable. Bundling of wire and similar scrap is almost essential. An electric furnace is like a motor truck in that the less time that is lost in loading and unloading, and the greater the number of hours per day it can be used, the lower the cost per ton melted in the one case and per ton mile in the other. Cutting down on waste time pays even better with the furnace than the truck, because the more power the furnace uses in 24 hrs., the lower the cost of the power per unit, while gasoline for the truck does not come much cheaper when bought in larger amounts. Another way that power can be saved in electric melting is to operate on a definite schedule of power used. The Ajax-Wyatt takes power at so steady a rate that a time schedule works just as well on that type, but the granular resistor furnace and the arc furnaces may vary considerably in rate of power input. After a few test runs, one can, for any particular alloy, particular proportion of ingot, scrap, and borings, and for any particular weight of charge, make out a perfectly definite schedule of kilowatt-hours needed on each heat. In 10 hrs. operation the kilowatt-hour per heat will be higher in the morning and approach or reach a lower constant figure at the end of the day.

By adhering to such a schedule and running on kilowatt-hour input instead of on a time schedule at a supposedly constant but actually variable kilowatt input, the heat can be brought out with astonishing regularity as to temperature. Each furnace should have its individual kilowatt-hour meter, and one readable to certainly not less than 5 kw.-hrs., and better 1 kw.-hr. With individual kilowatt-hour meters the performance of each furnace in a battery, and of each furnace tender can be watched. The kilowatt-hour meter is as important as the speedometer on a motor car or truck. Not all furnace makers supply them, but each furnace should have one.

Inasmuch as the heat losses through the walls and the electrodes are approximately constant even though the rate of power input may change, it is obvious that the higher the rate of power input, the more of it is usefully employed in melting. Suppose a furnace takes 100 kw. and loses 35 kw. through shell radiation and electrode losses, 65 kw. then do useful work. If the same furnace is given 125 kw. it may lose 37½ kw. in shell and electrode losses, but 87½ kw. do useful work. The furnace will do one-third more work in a given time at the higher rate. The upper limit of rate of input is that at which the local temperature is so high that refractories fail or that local overheating of the metal and consequent loss of volatile metals occur. It is quite probable that on the larger furnaces automatic control of power input would be desirable.

From the considerations noted above it is plain that the advantages of electric furnaces are most marked where a number of large furnaces or of small efficient furnaces can be used and especially where they can be used 24 hrs. a day. Rolling mills, smelting and refining plants, brass foundries of large manufacturing plants and the larger jobbing foundries are the plants which can most obviously use electric brass furnaces at a saving in melting costs. Such plants should think twice before deciding to go on with fuel-fired furnaces.

The smaller plants and jobbing shops having a small output and a variable one, especially if they are so located that power will cost much over $1^1/_4$ cents per kw.-hr., should think twice before installing an electric furnace. Even this class of furnace users may often find that the electric furnace will save some money in the long run, although under normal peace conditions the amount saved will be small compared to what it was during the war or may be at present.

Whether electric brass melting has or has not as yet made much headway, it at least has a foothold and apparently a firm one. It will be surprising indeed if inside the next decade the ratio of brass melted electrically to that melted by fuel does not surpass the ratio of steel melted electrically to that melted by fuel. All metallurgists will agree that the electric steel furnace is here to stay. They will soon agree that the electric brass furnace is here to stay, too.

MORSE HALL, CORNELL UNIVERSITY,
ITHACA, NEW YORK

CORROSION TESTS ON COMMERCIAL CALCIUM CHLORIDE USED IN AUTOMOBILE "ANTI-FREEZE SOLUTIONS"[1]

By PAUL RUDNICK

Received May 14, 1919

In view of the serious shortage and great increase in cost of glycerin and alcohol caused by the European war, the sale of calcium chloride solutions to prevent freezing of the cooling solution in motor vehicles was vigorously pushed. Three proprietary products of this type were submitted for an opinion as to whether

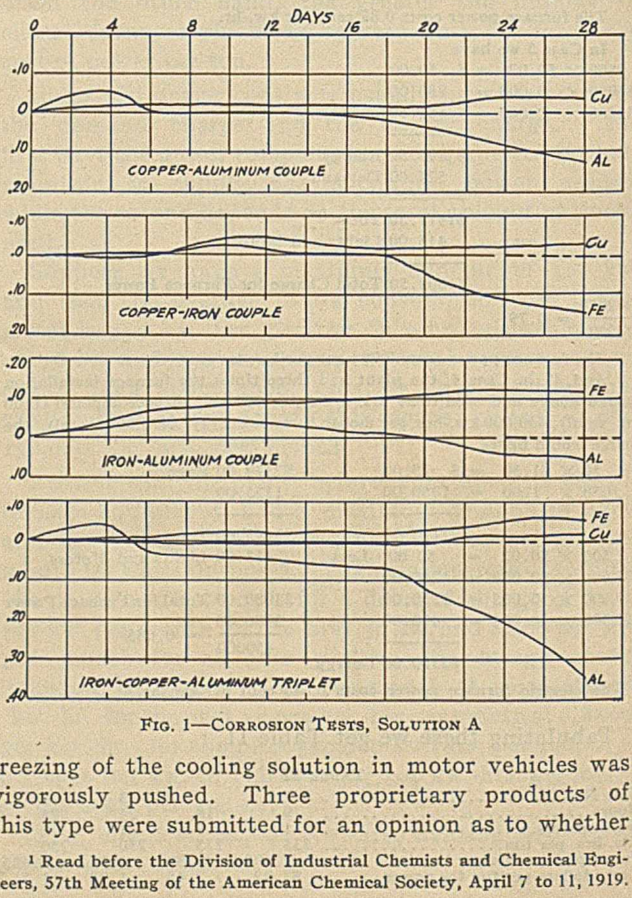

FIG. 1—CORROSION TESTS, SOLUTION A

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[1] Read before the Division of Industrial Chemists and Chemical Engineers, 57th Meeting of the American Chemical Society, April 7 to 11, 1919.

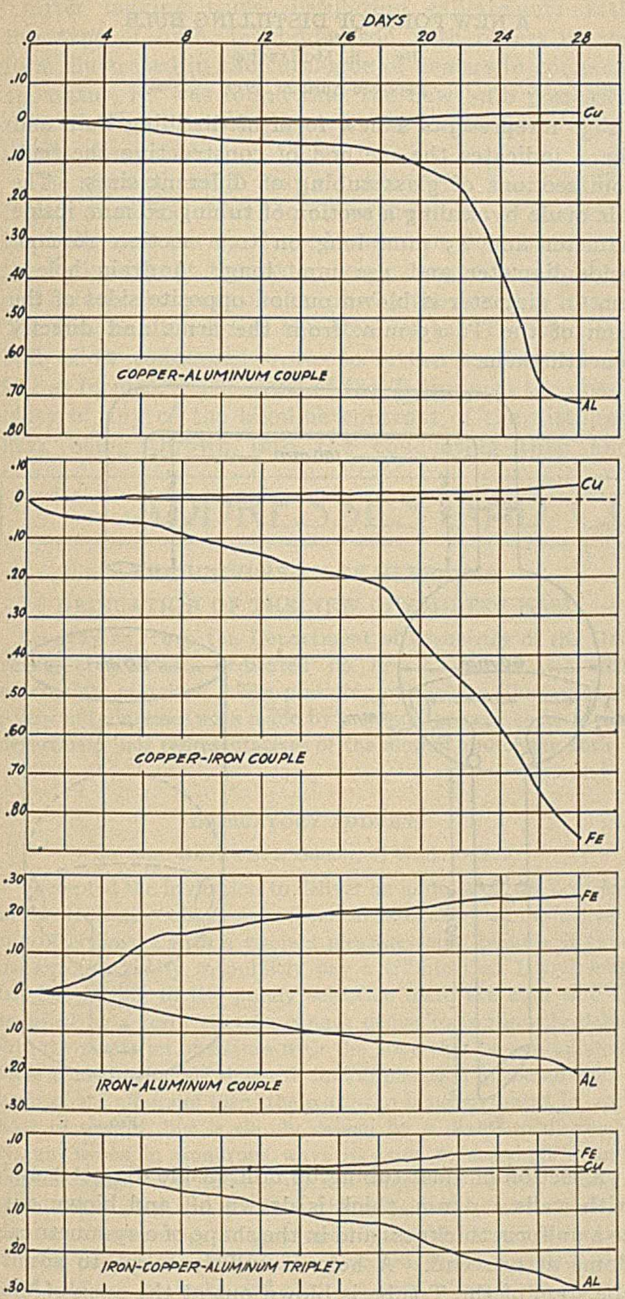

Fig. 2—Corrosion Tests, Solution J

such solutions might safely be used or whether harmful effects from corrosion might be expected.

These products were accordingly tested for their effect on aluminum, copper, and cast iron by suspending polished plates of these metals in solutions of the concentration directed or furnished by the manufacturers. The plates were suspended in pairs of copper and aluminum, copper and cast iron, and aluminum and cast iron, and also in sets of all three, by means of copper wire attached to the emergent ends of the respective plates. The solutions were continuously aërated during the test period, and were kept at a temperature of 30° to 40° C.

The tests were continued for 28 days, the loss or gain in weight of the plates being noted every other day. The results are clearly shown in the curves obtained by plotting the loss or gain in weight[1] against the time of immersion.

The most striking points developed are:

1—Aluminum was attacked most severely, iron next, and copper least, as would be expected.

2—The rate of corrosion increased sharply on the eighteenth to twentieth day of immersion. This is of special interest in view of the terms under which one of these products was offered for sale.[2]

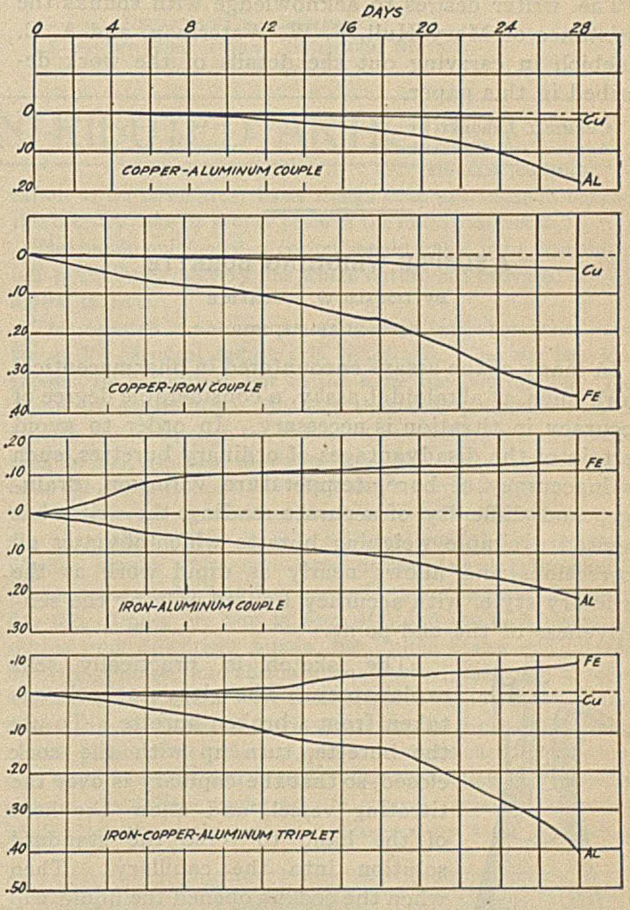

Fig. 3—Corrosion Tests, Solution T

The composition of the solutions varied from 28 to 30 per cent of calcium chloride and from 0.5 to 3.0 per cent of magnesium chloride. Solution T contained formaldehyde.[3]

The reaction of the solution was determined by measuring their hydrogen-ion concentration according to the well-known colorimetric method of Sörenson.[4]

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[1] In each curve gain in weight in grams is plotted above zero on the ordinate, loss of weight in grams below the zero.

[2] The offer consisted of a 14-day trial. If at the end of this time no damage had been incurred, the product was to be paid for. If any damage had occurred, the seller agreed to have the necessary repairs made at his expense and to make no charge for the solution.

[3] The formaldehyde was probably added to prevent corrosion in the hope that it would act in the same way as in the case of hydrochloric acid and iron, a fact which was first brought to my attention by Mr. A. V. H. Mory. The results show that formaldehyde does not prevent corrosion by calcium chloride.

[4] *Biochem. Z.*, **21** (1909), 131.

Solution T was distinctly acid (Ph = 4.5), solution J was practically neutral (Ph = 6.6), while solution A was distinctly alkaline (Ph = 8.0). The erratic behavior of solution A is probably due to its alkaline reaction.

Obviously calcium chloride is entirely unsuited for use in anti-freezing solutions in the cooling systems of motor vehicles in which aluminum or copper or both are in electrical contact with iron or steel. Rapid destruction, particularly of the aluminum parts, is to be expected. Actual experience has abundantly confirmed the results of the tests described.[1]

The writer desires to acknowledge with thanks the assistance of Mary Hull, F. W. Waterman, and A. C. Haebich in carrying out the details of the work described in this paper.

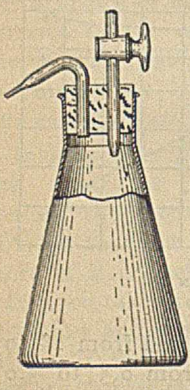
Chemical Laboratory
Armour and Company
Chicago, Illinois

A SIMPLE WEIGHING BURETTE

By Donald W. MacArdle

Received April 8, 1919

In many of the assays encountered in pharmaceutical work such as alkaloidal assay, a considerable degree of accuracy in titration is necessary. In order to avoid certain of the disadvantages of ordinary burettes, such as inaccuracy of bore, temperature variation, drainage, and difficulty of accurate reading, the writer has devised a simple weighing burette which obviates all corrections and allows nearly as rapid work as the ordinary style, with accuracy limited only by the sensitiveness of the end-point.



The sketch is practically self-explanatory. The glass stopcock was taken from a broken burette. To use the burette, turn up with the cock closed, so that the capillary is over the titrating vessel, and allow the heat of the hand to force the standard solution into the capillary. Then when the cock is opened the liquid will flow freely, and there will be no danger of loss through the cock. When near the end-point, the cock may be closed and the solution forced in drops by the heat of the hand.

A predetermined quantity of solution cannot be delivered without repeated weighings, but a little practice will enable the user to estimate the desired quantity within a few per cent.

A 100 cc. flask with rubber stopper, cock, and capillary, weighs about 40 g.

Analytical and Research Department
United Drug Company
Boston, Massachusetts

A NEW FORM OF DISTILLING BULB

By J. S. McHargue

Received April 23, 1919

Fig. 1 represents a new form of distilling bulb and Fig. 2 indicates the method of constructing the bulb from sections of glass tubing of different sizes. The T is made by sealing a section of tubing 10 mm. inside diameter and 45 mm. long on to a section 16 mm. inside diameter and 120 mm. long. A drain hole 5 mm. in diameter is blown out on opposite sides of the stem of the T, 15 mm. from the arms and directly beneath them.

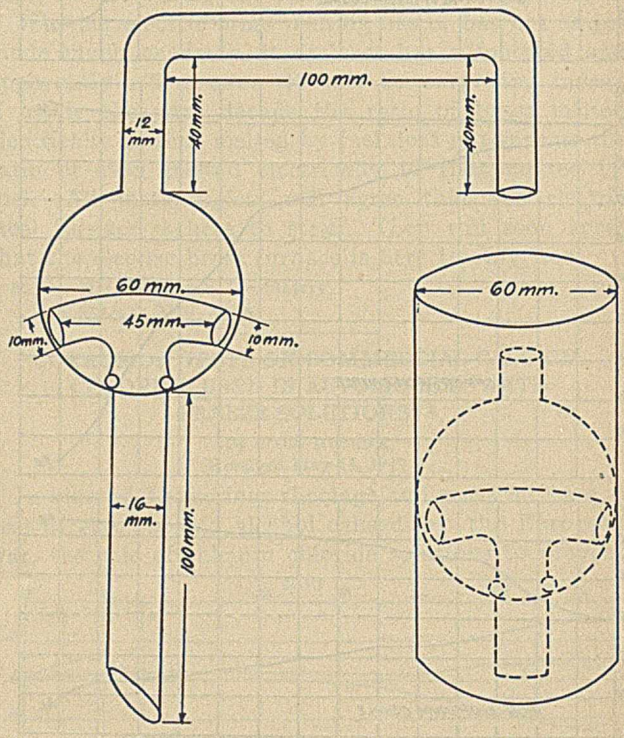


Fig. 1

Fig. 2

A section of glass tubing 60 mm. inside diameter and with walls 1.5 mm. thick is drawn off and blown out to a uniform thickness and in the shape of a symmetrical dome at one end. A hole of sufficient size to admit the stem of the T-tube is blown out at the apex of the dome. The stem of the T is inserted through this hole until the lower edges of the drain holes are opposite the rim of the hole in the large tube, and the two pieces sealed together at this point. The opposite end of the large tube is drawn off and blown out in such a way as to complete a symmetrical bulb of uniform thickness and 60 mm. in diameter. After blowing a hole of the proper size at a point on the bulb opposite the one made for the stem of the T, a tube of 12 mm. inside diameter is sealed on to make connection with a condenser tube. The form into which this tube is to be bent may vary, depending upon the most convenient manner of connecting a distilling flask to different types of condensers. In making the first bend in this tube above the bulb it is desirable that it be made in the direction that will preserve a right and left symmetry with respect to the arms of the T within the bulb.

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[1] In addition to its corrosive nature, calcium chloride has another serious disadvantage, namely, the fairly good electrical conductivity of its solution. In the case of leaks or other accidents, short-circuiting of the ignition system may easily happen.

After making some distillation experiments with this type of bulb, in comparison with others of the form illustrated in the catalogue of dealers in chemical apparatus, it was found that the new bulb possessed the following advantages over the types with which it was compared:

The stem of the T that connects with the distilling flask is of sufficient size to allow the steam to pass into the bulb and the condensed water to flow back into the flask without the latter being caught in a column and held in this part of the tube by the escaping steam. The two small holes in the stem of the T within the bulb allow condensed water to return to the flask as fast as formed. The arms of the T diminish the possibility of any of the alkaline contents of the distilling flask being thrown into the condensing tube and spoiling a determination. If soap bubbles should be forced into the upper part of the T they are either broken up in the arms of the T or are forced out at the ends of the arms and broken up in spray against the walls of the bulb. Steam flowing out of the two ends of the T keeps the bulb at a more uniform temperature, which lessens condensation in the bulb and hastens distillation. The arms of the T slope downward and the openings at the ends are large enough to prevent water from being held in them by back pressure and interfering with the passage of steam.

This form of bulb was designed by the writer and two test bulbs were made for us by Messrs. Eimer & Amend.

Department of Chemistry
Kentucky Agricultural Experiment Station
Lexington, Kentucky

ADDRESSES AND CONTRIBUTED ARTICLES

THE UNIVERSITY OF NEBRASKA
DEDICATION OF THE NEW CHEMISTRY HALL

On May 23, 1919 the Department of Chemistry of the University of Nebraska dedicated its new Chemistry Hall with appropriate exercises. The presiding officer was Chancellor S. Avery and addresses were made by past and present heads of the department and representatives of the alumni and of the state.

[Editor.]

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DEDICATORY ADDRESS

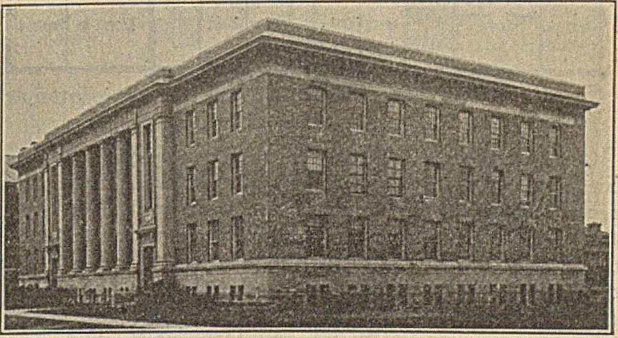
By Maj. Gen. Wm. L. Sibert, C. W. S., U. S. A.

I accepted the invitation to deliver an address on the occasion of the dedication of the new chemical laboratory at the University of Nebraska with a twofold pleasure: first, because it gave me an opportunity to publicly pay a tribute that I have long felt like paying to the purely scientific man, the man who is impelled by a force that he cannot define to continually delve into the mysteries of nature with the hope that he can uncover some hidden principle that will find application in the advancement of the affairs of men, the man who is not actuated by any hope of reward, but is simply driven by a desire to discover. Nature works in wondrous ways its ends to accomplish, and human beings from infants up are forced to do her bidding. A child *will* play and do those things essential to its development and the man especially endowed for marked accomplishment in some particular field, if he be educated, is impelled as is the child. It can be truly said that the men whose work constitutes the milestones of the history of science were inspired.

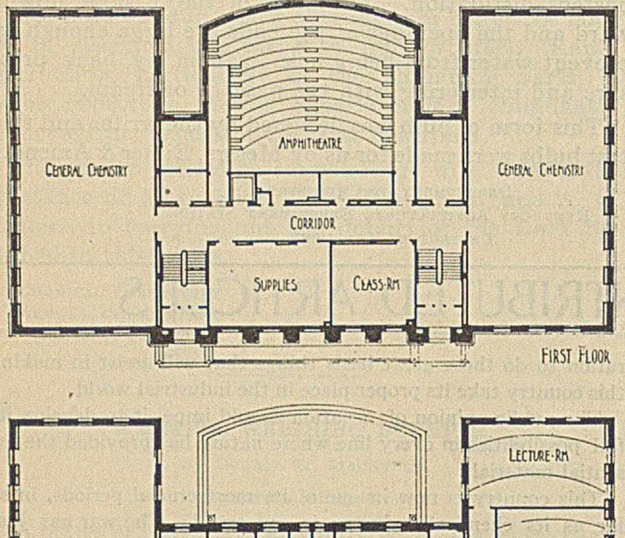
My life has been occupied in applying the principles which the scientists have discovered. As life has progressed I have become more and more impressed with a feeling that the world has not recognized as it should the pure scientist. But times are changing. The managements of our large manufacturing concerns are appreciating more and more the value of the work of the research man on specified problems, and are establishing research branches of their own. This is comforting because it shows that capital, especially large capital, is becoming more and more willing to be guided in its application of science to industry, by those who have been especially educated for such work. Germany's initial success in the chemical world was due to an early appreciation of the importance of the relation of research to practical industry. Of course, institutions such as this prepare men not only for research, but for the development and manufacture of chemical products in general. It is therefore with especial pleasure that I assist in the dedication of this, the greatest institution of its kind west of the Mississippi, in which many young men will get their training and their inspiration to do those great basis things that will assist in making this country take its proper place in the industrial world.

The public opinion of a nation should impel it to develop its full possibilities in every line where nature has provided the essential materials.

This country is now in one of its most crucial periods, in so far as its chemical industry is concerned. The war has just exposed its deficiences, but at the same time, fortunately, has shown its possibilities. The fact that over 3,600,000 tons of nitrates passed through the Panama Canal during the 15 months prior to the armistice shows in what dire distress would have been the allied nations had they not controlled the seas, and had been forced to abandon the nitrate beds of Chile, and to rely upon their ability to take nitrogen from the air for their powder supply. Not only were deficiencies in indispensable war material shown, but deficiencies in things necessary in everyday life. Under the spur of necessity, and the high prices resulting from a deficient supply, the United States and private industries plunged into chemical manufacture, and tried to meet a situation that should have been prepared for in time of peace. More than $100,000,000 were spent by the United States in nitrate plants alone, which plants had not reached the production stage when the war ceased. The production of explosives measured in dollars, under private control, increased in yearly production from 50,000,000 to 500,000,000 by April 1917, after which time the United States took control of the entire explosive manufacture. It was necessary to quadruple the chlorine supply of the nation, to plan to increase by ten times the phosphorus supply, and to make a material increase in the bromine supply, in order to meet the demands on the Chemical Warfare Service for lethal gases and smokes. The domestic production of coal-tar crudes, intermediates, and dyes, increased from $3,000,000


New Chemistry Hall, University of Nebraska

a year before the war, to $70,000,000 during the war. Drugs in some instances sold for 50 times their pre-war price. Similar increases, with great variation in prices, characterized other lines of chemical industry. Countries that had bought, prior to the war, all their chemicals from the central powers of Europe, suddenly called upon the United States for their supplies, which still further disturbed prices, and called for greater manufacturing effort.



Plan of the Three Main Floors

Our war experience not only showed that our chemical industries were not so developed, in time of peace, as to meet our war needs, but also showed that such needs can not be provided in less than two years' time. In modern war no nation could repel the attacks of a prepared nation for that length of time. Fortunately we had in this war allies who furnished us guns and shells, and kept the seas open so that we could import the material needed for our powder. While we should draw from this a never-to-be-forgotten lesson on the subject of preparedness, we can at the same time take much satisfaction from the marvelous way in which the chemists and chemical engineers of the country were meeting the situation when the war closed. One of the greatest questions now before the country is: Can the advances in chemical industry made under the stress of war for war needs, for domestic needs, and for export, be held against foreign competition?

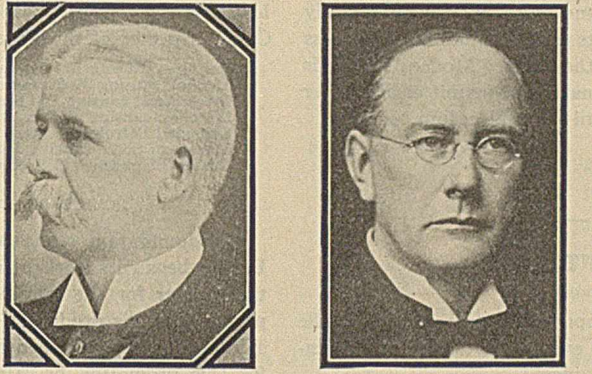
The fact that the University of Nebraska, west of the Mississippi, a section of the country handicapped by freight rates in many instances, is just completing a great laboratory to train young men for the coming struggle in chemical industry, is indicative of the determination of the nation to carry on a winning fight in that struggle. This constitutes the second great satisfaction connected with my visit here.

The work of the chemist and the chemical engineer during the war certainly shows that this country has technical ability in a marked degree. The raw materials are here, capital should have had its object lesson as to what can be done, and if there are other artificial obstacles in the way, or needed appliances not existent, the Government must assist in meeting the situation. It is the Government's business to know the needs of its people, and to see that they have an equal opportunity with their competitors in the world's trade.

Our young men who hope to succeed in chemical industry must know more than the chemistry or chemical engineering connected with their manufacturing establishment. They must know the benefits and abuses of tariffs. They must understand the relation of land and water transportation to the ultimate price of their product delivered in its market. They must be acquainted with all subsidies or other aids that their foreign competitors receive from their Governments.

As a basic proposition in this struggle, our land transportation problems must be settled on broad lines. The people of the nation are entitled to, and the development of the country depends upon, transportation at the lowest cost consistent with a fair return on the amount of money needed to build and maintain the railroad systems. Our nation has reached the stage when it must trade with other nations, must produce at a price that can compete in foreign markets, and the prime essential in this undertaking is cheap transportation, not only in gathering together the raw materials, but in delivering the finished product to its market. In the accomplishment of this delivery, the people of the United States must have their own merchant marine. I do not know how that last problem is to be solved, whether through United States ownership and operation or not, but I do know that a nation without its merchant marine is handicapped beyond hope in the race for international trade. The ships of no nation will carry freight for another nation if the merchants of the nation owning such ships can fill the demand.

Our chemical manufacturers before the war were handicapped in every direction, by land transportation, ocean transportation, and by the unfair and illegal competition of their foreign competitors, especially their German competitors. No one can grumble at a victory fairly won. Germany's early success in the chemical field was due to the appreciation on the part of her universities of the value to the industries of technical men, and especially the results following the availability of a large number of such men. The Germans appreciated the fact that if world markets were sought, transportation costs should be low. This resulted in the adoption of the higher grade products such as dyestuffs, medicines, etc., as specialties. This procedure also fitted in with the military aspirations of the nation, because many of the by-products in making dyes and medicines are used in the manufacture of explosives—all are derived from coal tar. If by competition or otherwise a nation can be prevented from making dyes and medicines, she is crippled in a military sense not only because the intermediates in dye manufacture can be used in making explosives, but because the dye processes, plants, and personnel can quickly be utilized in making explosives and other chemical substances that modern war has adopted. Germany, before the war, furnished more than $^9/_{10}$ of the dyestuffs of the world. There was, therefore, more than a desire to succeed industrially in Germany's determination to prevent by fair means or foul the development of American chemical industries. Through taking out patents in this country on processes that she never intended to put into practice here, by dumping excess production into our markets at prices below cost of manufacture by means of fake companies in this country, whenever any new chemical industry tried to establish itself, and by bribing the actual dyers in the factories, she smothered chemical industry in this land. Fortunately, Germany's methods have been exposed by our Alien Property Custodian, her patents have been sold so that all American manufacturers can use them and no unfair illegal competition will be countenanced in this country in the future. France and England have even gone so far as to place an embargo against the importation of all dyestuffs. This country must be kept industrially free in the future.



H. H. Nicholson
1882–1905

S. Avery
1905–1909

Benton Dales
1909–1918

F. W. Upson
1918–

The Department Heads

Although not a chemist, it was my fortune to have charge of the Chemical Warfare Service of the Army during this war, and I have had my first peep into the possibilities of the chemical world, and have probably appreciated, on account of my responsibilities, more than the average man, what it means for a country not to be prepared in a chemical way for war. Modern war is a war of machinery and science. Man, of course, is as vulnerable as ever, and the same sized bullet that killed him in the Civil War will kill him now, and the object of most appliances is to destroy the enemy appliances so that man can go forward.

In no line of warfare is there the same possibilities for surprise and the gaining of decisive results by a single discovery as in the field of chemistry. There is no more humane method of warfare, if the word "humane" can be applied to the taking of life, which is of course what war means, than the use of gas and other chemicals. There is so much misconception on this point that I will quote from a report on medical observations, four months after the attack, on 2000 cases of men seriously gassed in this war:

1—That gas victims, irrespective of the type of gas and severity of attack sustained, show no marked predisposition towards active pulmonary tuberculosis, or towards the reactivation of a healed or quiescent pulmonary lesion.

2—That gas victims present little evidence of material destruction of lung tissue.

3—That gas victims with emphysema findings have a more protracted convalescence than have those of the bronchitic group.

While 30 per cent of all casualties in the American troops was due to gas, only 3 or 4 per cent of these casualties died. The above casualties result when an army is supplied with gas masks and other defensive appliances. If an army has no protection, as may be the case with a new chemical substance kept secret until the war, all the men exposed will become casualties unless they run away, from which fact the reason is clear that research, both from the offensive and defensive sides of chemical warfare, should be kept up to date at all times, so that our soldiers, if forced to go to war, will not be at the mercy of a prepared adversary.

The record of the Research and Production Divisions of the Chemical Warfare Service shows what our country can do. Although the last to enter the war, and commence the development of methods of making the standard gases as well as new ones, at the end of the war the United States was manufacturing gases at rates larger than all the other Allies and Germany combined. One of our chemists, accompanying the Army into Germany for the purpose of investigating the German method of making mustard gas, ascertained at a big gas plant there that the German method for making mustard gas had been abandoned and the American method adopted. I feared, when I first heard this, that German espionage had found some American secrets, but I later learned that the knowledge was acquired through the chemical analysis of the gas in one of our unexploded shells. This analysis showed that it was not made in the German way, and indicated the American method. Germany was making this gas at about the rate of 10 tons a day. This country had actually made it at a rate of 40 tons a day, and had a plant ready to operate at a rate of 80 tons a day when the armistice came, and was prepared to more than double that rate. Our extreme unpreparedness immediately became apparent when we entered the war, and our ablest chemists and chemical engineers flocked to the colors and offered their services, and threw their hearts and souls into the undertaking. About 1000 chemists commenced on research, some of them on methods of producing in large quantities poison gases that had been made only in small quantities in the laboratory, others searching for new substances for offensive warfare, and others trying to find the best means of protecting our soldiers from gas. When all of these men, and the best chemical engineers, were welded together in one team, splendid results followed. In addition to the gases referred to above, more than 5,000,000 gas masks were made before the armistice. Every American soldier had an American-made gas mask. The search for suitable materials for the gas masks reads almost like a romance. When it was found that charcoal from coconuts and other nuts gave best protection, men were sent to the Philippines, Central and South America to procure them. One of the most satisfactory responses of the war was that of the children of the country to the call to collect peach stones. When the war closed there were 5000 tons of such seeds in one pile at our charcoal works at Long Island City. There were 12,000 women working on gas masks at our Long Island plant alone, and it required no inspection to see that they were determined that every mask that went overseas was air-tight. Nearly all of them had some relative over there. Our chemical engineers did things in bigger ways than ever before. There was built in about 8 mo. a chlorine plant with a capacity of 100 tons a day. The biggest plant in the world previously was a 60-ton plant.

All of this is in keeping with the thought that the institutions in this country develop an initiative and individuality second to no nation. But this individuality in ordinary times tends to cause our people to lose sight of the nation's needs in time of stress, and consequently never make preparation for the storm of war. We need something that will temper this individualism with an ever-present national spirit that will always have in mind the nation's advancement and safety. What can all the people do that will permanently impress them with the thought that they have a country? I know of nothing that will do it to the same extent as will universal military training, and I know of nothing which at the same time will do more to create a spirit that will solve the serious industrial questions ahead of us, all on account of the democracy that comes from the association forced by such training. This training, however, should be coupled with a system of instruction extending from the kindergarten to the university, instilling into the youth of the land the precept that a nation must be just in order to play its predestined part in the world, and must be strong and ready to exert its strength in order to do its part in maintaining fairness and justice among the peoples of the earth. Modern science is too potent in the hands of selfish nature to permit of any other course, and selfishness will last until the millennium comes.

War Department
Chemical Warfare Service, U. S. A.
Washington, D. C.

SHIPPING CONTAINERS[1]

By C. P. Beistle

The Bureau of Explosives appreciates and welcomes the opportunity to join with you this evening in discussing the important question of shipping containers.

It seems advisable to devote a little time to an explanation of the origin and present status of the efforts of the Bureau of Explosives to promote safety in the transportation of dangerous articles through improvement of shipping containers. You are familiar with the old policy of the railroads in regard to shipping containers. The Traffic Department in prescribing freight rates stated in a very general way the type of containers that would be acceptable for different classes of freight. It was not practicable to go into much detail in prescribing these containers. The absence of detailed specifications gave shippers who were anxious to economize on their transportation costs an opportunity to present their shipments and have them accepted at the freight stations, in almost any type of container that the shipper felt disposed to use. The active competition between railroads made it difficult, if not impossible, to apply restrictions whose enforcement meant the refusal of improperly packed freight. Loss and damage occurred as a natural result and the railroads bore the financial burden. What this burden amounts to at the present time is illustrated by the following statistics. The Annual Reports on the Statistics of Railways in the United States, prepared by the Interstate Commerce Commission (Division of Statistics and Accounts), show in their analysis of Operating Expenses under item "Loss and Damage, Freight," the figures given in the following table:

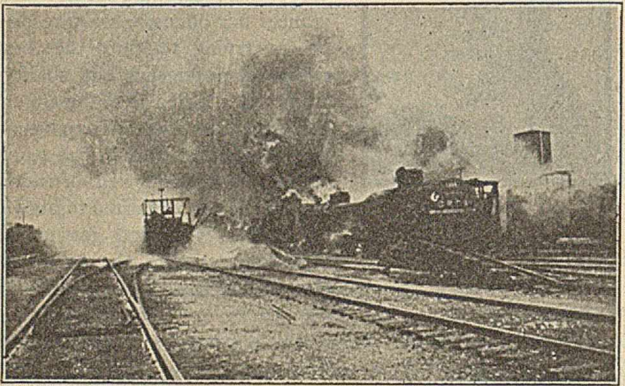


Fig. 1

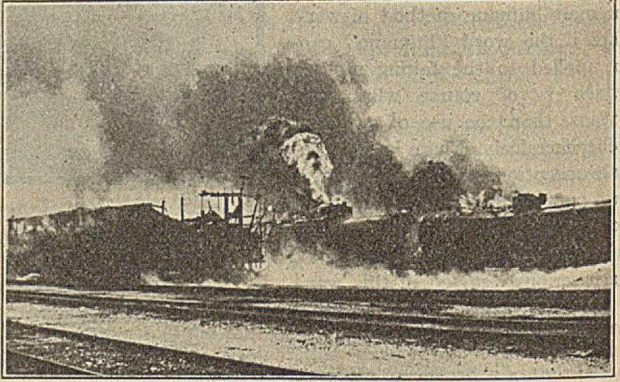


Fig. 2

Year Ending June 30	Carrier	Loss and Damage Freight	Per cent of Total Operating Expenses
1916 (latest available)	Class I, II, III[1]	$22,738,893	1.029
1915	I, II, III	29,942,828	1.461
1914	I, II	33,671,219	1.555
1913	I, II	30,885,454	1.451
1912	I, II	24,639,852	1.237

[1] Class I carriers are those having annual operating revenues above $1,000,000. In 1916 Class I carriers operated over 230,500 miles and Class II operated over 18,000 miles of railroad in the United States.

The materials classed as dangerous by the regulations of the Interstate Commerce Commission, and causing the heaviest losses during the year 1918, as shown by Annual Report of the Chief Inspector of the Bureau of Explosives, were as follows:

Gasoline, causing 101 fires and a loss of	$881,000
Alcohol, causing 39 fires and a loss of	145,000
Nitric Acid, causing 158 fires and a loss of	108,000
Matches, causing 39 fires and a loss of	51,000
Liquefied Petroleum Gas, causing 2 fires and a loss of	45,000
Nitrate of Soda, causing 5 fires and a loss of	28,000
Crude Oil, causing 11 fires and a loss of	26,000

POLICY OF BUREAU OF EXPLOSIVES

The foundation stone of this policy, established when the Bureau began its work in 1907, was to form a partnership with the shipper for the purpose of promoting safety in the transportation of his product. The principal object of this partnership was to impress upon the shipper his share of responsibility for this promotion of safety, and to give him corresponding opportunity to meet that responsibility. By this plan he had a voice in framing specifications to govern the design and construction of his shipping container, as well as the rules to govern both the carrier and the shipper in the marking, describing, and handling during transit of these shipments. On account of the greater danger involved, work was directed first toward the transportation of explosives. The containers used for this purpose were wooden boxes for high explosives and metal kegs for black powder. An exhaustive series of tests was planned and carried out at the Altoona yards of the Pennsylvania Railroad. These packages containing sand to represent the usual explosive contents were loaded in freight cars that were subjected to various degrees of rough treatment to represent the shocks liable to occur in railway operation. Special instruments were devised and constructed to furnish data concerning the stresses brought to bear upon these packages as a result of coupling shocks. When a freight car is allowed to strike at a speed of 5 miles per hr. a solid train of loaded freight cars at rest, the force tending to produce a movement of lading along the floor of the car amounts to not less than 5 lbs. for each lb. in the weight of the package. For example, 240 boxes of high explosives weighing 58 lbs. each develop under these

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[1] Address before the New York Section of the Society of Chemical Industry, May 23, 1919.

Summary[1] of Reported Accidents Involving Shipping Container Failures Causing Fires, Personal Injuries, or Property Loss, Occurring in the Transportation of Dangerous Articles Other than Explosives for a Period of 5 Years Ending Dec. 31, 1918

	Tank Cars				Metal Drums or Barrels				Carboys				Wooden Barrels & Kegs				Cylinders				Cans, Bottles, Jugs, etc., in Wooden Boxes or Barrels			
Name of Articles	No. Accidents	Persons Killed	Persons Injured	Property Loss	No. Accidents	Persons Killed	Persons Injured	Property Loss	No. Accidents	Persons Killed	Persons Injured	Property Loss	No. Accidents	Persons Killed	Persons Injured	Property Loss	No. Accidents	Persons Killed	Persons Injured	Property Loss	No. Accidents	Persons Killed	Persons Injured	Property Loss
Acetone	...	...	...	...	13	...	...	$ 1,638	1	...	...	$ 287	...	...	...	...	...	...	...	...	2	...	...	$ 36
Acid, hydrochloric	9	...	...	$ 737	...	...	...	...	674	...	1	13,007	...	...	...	...	...	...	...	...	32	...	...	168
Acid, hydrofluoric	...	...	...	...	...	...	...	...	22	...	3	271	28	...	1	$ 2,425	...	...	...	...	1	...	1	1
Acid, hydrofluosilicic	...	...	...	...	...	...	...	...	...	...	...	...	14	...	...	477	...	...	...	...	...	...	...	...
Acid, nitric	...	...	...	...	...	...	...	...	468	...	13	384,491	...	...	...	...	...	...	...	...	52	...	...	216,620
Acid, sulfuric	14	...	9	2,548	39	...	1	11,289	1016	...	30	27,261	2	...	...	13	...	...	...	...	64	...	11	1,169
Alcohol	5	...	...	32,660	3	...	...	5,670	2	...	...	33	71	...	8	162,386	...	...	...	...	47	...	...	2,558
Batteries, storage (charged with acid)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15	...	...	1,180
Benzol	9	...	...	8,029	1	...	...	38	...	...	...	...	1	...	...	4	...	...	...	...	1	...	...	1
Bromine	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	26	...	...	21,613
Carbon bisulfide	...	...	...	...	3	...	...	1,675	...	...	...	...	...	...	...	...	...	...	...	...	14	...	...	88
Cologne spirits (alcohol)	...	...	...	...	...	...	...	...	...	...	...	...	23	...	...	13,250	...	...	...	...	3	...	...	10
Electrolyte	...	...	...	...	...	...	...	...	98	...	1	2,635	...	...	...	...	...	...	...	...	3	...	...	13
Ether	...	...	...	...	5	...	...	81	...	...	...	...	...	...	...	...	...	...	...	...	7	...	...	43
Gas, compressed acetylene	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15	1	8	$15,878	...	...	...	...
Gas, compressed carbonic acid	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	181	...	7	1,074	...	...	...	...
Gasoline	76	3	16	142,705	68	...	1	5,851	...	...	...	...	5	...	3	1,246	...	...	...	...	33	...	...	207
Naphtha	6	...	...	2,514	1	...	...	1	...	...	...	...	3	...	...	1,514	...	...	...	...	...	...	...	...
Paint	...	...	...	...	4	...	...	105	...	...	...	...	20	...	...	464	...	...	...	...	31	...	...	161
Shellac, Varnish	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	34	...	...	...	...	15	...	...	57
Toluol	14	...	...	14,068	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Varnish	...	...	...	...	...	...	...	...	...	...	...	...	7	...	...	6,493	...	...	...	...	17	...	...	5,118
Totals	133	3	25	$203,261	137	0	2	$26,348	2281	0	48	$427,985	176	0	12	$188,306	196	1	15	$16,952	363	0	12	$249,043

Total No. Accidents = 3286, each involving from 1 to 150 individual containers (see nature of failures under each type of container). Total No. Persons Killed = 4 Total No. Persons Injured = 114 Total Amount of Property Loss = $1,111,895 Losses include fire, containers and contents, damages to other freight and property.	Tank car failures consist of leaking plates, seams, rivets, outlet valve, discharge pipe and outlet valve cap, not caused by collision or derailment; leaks resulting from the formation of ice in outlet valve discharge pipe or cap; leaks resulting from damage to outlet valve pipe or cap (due to collision, derailment, or rough handling).	Drum failures consist of leaking bungs, ventholes, seams, and ruptures due to corrosion; bursting due to internal pressure; rough handling.	Carboy failures consist of inefficient stoppering, insufficient cushioning, improper loading, bracing, or blocking, etc., breakage due to causes unknown, breakage due to rough handling.	Wooden barrel and keg failures consist of leaking staves, heads, bungs; bursting of heads; collapsing due to loose hoops, sprung staves, etc.; rough handling; or improper loading, blocking, or bracing.	Cylinder failures consist of broken valves, leaking valves, bursting of safety discs, explosions due to defective welding, dropping of cylinder, increase of internal pressure from exposure to direct sunlight, hot steam pipes, fire or dissociation of acetylene gas.	Failures of above-mentioned containers consist of inefficient stoppering or closure of interior packages; improper packing or cushioning; insufficient packing or cushioning, leaks due to improperly driven nails, rust spots, or defective seams (resulting from brittle or poor solder); improper loading, bracing, etc.

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[1] This summary does not include the many listed dangerous articles which have been involved in less than 10 accidents each during the past 5 years.

circumstances a tendency towards relative movement which can be stopped only by a force equal to 5 × 58 × 240, or 68,600 lbs.

After a careful study, plans for loading and bracing these explosive packages in cars were worked out in detail and published in our *B. E. Pamphlet*, No. 6A, which illustrates by drawings and photographs the best loading and bracing methods. The wooden boxes and metal kegs in use at that time for these shipments were subjected to careful test in static testing machines to develop their resistance to end and side pressures. These resistances were strengthened as much as was possible under the conditions that had to be met. As a final result of this standardization work we have been able to reduce the property loss due to the annual shipment during normal times of about 600,000,000 lbs. of explosives, to an average of about $30,000 a year. This loss during 1907, the first year, covered by statistics, amounted to $500,000. During the same year 52 people were killed and 80 injured by explosions in transit. These figures have been reduced so that it is now exceptional when a life is sacrificed by the transportation of explosives throughout the United States and Canada.

Our invitation to manufacturing shippers of dangerous articles throughout the United States to coöperate with us in this important work has met with most generous response. Where these shippers were already organized for other purposes into societies or associations, the full weight of the influence of these associations has been thrown into this work. In many cases organizations were effected where they had not previously existed, the principal object being to have representatives available to meet at any time representatives of the Bureau of Explosives, to discuss the problems requiring solution. In no case has this coöperation been more generous or effective than in the case of the Executive Committee of the Manufacturing Chemists' Association, under the chairmanship of Mr. Henry Howard, of Boston.

We have made very satisfactory progress in standardizing the shipment of explosives. The natural benefits to be expected from such standardization are referred to in the following quotation from the Annual Report of the Chief Inspector for the year 1918:

> At this time it does not seem possible that the principal events of the year 1918 can ever be approximated in our national experience. For some time to come the one event, the winning of the war, will crowd all others into the background of our mental vision. When we are able to focus our minds on other events the services rendered by our railroads will stand out in bold relief and in the foreground of this picture will appear the

successful transportation of enormous quantities of such dangerous articles as explosives, poisonous liquids and gases, gasoline, and acids.

Our military program, adopted early in 1918, called for a production in one year of about 2,000,000,000 lbs. of explosives for military use, and for the production of poisonous liquids and gases at a maximum rate of about 200 tons per day. The actual production attained under this program cannot be stated at this time, but it is known that for most of the year preceding the signing of the armistice, the monthly production of military explosives exceeded 80,000,000 lbs., or more than 2000 carloads of 40,000 lbs. each per day. These explosives moved to the loading plants where each carload of explosives produced not less than 5 carloads of explosive projectiles. Allowing 10 days for the average movement to destination, and considering less-than-carload shipments as well as carload shipments, a conservative estimate shows that the railroads of the United States during the busy months of 1918 had at all times not less than 50,000 cars in transit on government business and bearing the explosive placard. This was in addition to the average of 5,000 cars in transit to meet the normal commercial demand, and our estimate does not include the cars bearing military explosives in Canada.

FIG. 3

In meeting this abnormal demand only 11 accidents of all kinds occurred in the transportation of explosives during 1918, only 4 persons were injured, only one life was lost; and the total property loss was only $33,238. Of these results the only one chargeable to war material was the loss of one life, which occurred in Canada.

This excellent record is due, primarily, to the general use of standard packages and of standard methods of loading, blocking, and bracing the packages in cars. Such standardization is secured more readily for explosives than for many of the other classes of dangerous articles on account of the relatively small number of shippers of explosives, and their very general appreciation of the necessity for strict compliance with the regulations. The record should be an object lesson to shippers of other dangerous articles and to operating officials of railroads. These other losses can and should be reduced by the same attention to construction of containers, loading of packages, and handling of cars. The efforts of the Bureau of Explosives must be reinforced, however, by stronger measures if progress in this direction is to be accelerated.

EFFICIENCY IN SHIPPING CONTAINERS A PROBLEM IN MECHANICAL AND CHEMICAL ENGINEERING

No argument is necessary to show the absurdity of concentrating the efforts of efficiency engineers on minimizing manufacturing costs and getting maximum yields in a manufacturing plant, without utilizing the same talent in the protection of these manufactured products from loss during transportation. The problem of securing safe transportation involves numerous factors. The nature of the material to be shipped must be considered with respect to the results liable to follow from leakage from shipping containers. In some cases only the loss of the material is involved, while in others disastrous fires involving the loss of much additional property may result, either by the effect of the exposure of leaking material to air and moisture, or by ignition of inflammable material. In some cases the material shipped is liable to act chemically on the container. The nature of the material shipped and the design and construction of the container must be considered also from the standpoint of safe storage of the article, as well as safe transportation of it by rail. In many cases deterioration of containers during storage has a direct effect upon the safety of subsequent transportation of the package. The mechanical engineer who designs shipping containers must appreciate the stresses that are liable to act on his container during transit, and the loading and bracing of these containers in a freight car must be scientifically planned and executed. The amount of material packed in a container has an important influence also on the design of the container. Finally, the various factors calling for a maximum of strength and endurance must be analyzed against the permissible costs. In settling the permissible costs we must consider whether the package is designed for one journey or for continued use. In many cases the expensive package is the cheap one, the saving being due to its long life and continued service.

INTERSTATE COMMERCE COMMISSION CLASSIFICATION

Dangerous articles other than explosives are classified for transportation purposes by the Interstate Commerce Commission into Inflammable Liquids, Inflammable Solids, Oxidizing Materials, Corrosive Liquids, and Compressed Gases. Through the coöperation mentioned above, the Bureau of Explosives and the manufacturing shippers of these materials have during the last 11 or 12 years prepared transportation rules and shipping container specifications which have been adopted by the Interstate Commerce Commission, acting under legislative authority. The rules promulgated by the Commission describe the general types of shipping containers for these various classes of dangerous materials, and also the specific container and packing for many individual articles contained in these classifications. The specifications for shipping containers do not always represent ideal conditions from the safety standpoint, but as a rule they embody the best container commercially practicable and acceptable to the best class of shippers.

INFLAMMABLE LIQUIDS

The bulk of shipments of inflammable liquids are shipped in boxed cans, steel barrels or drums, or in tank cars. These liquids commonly have very slight corrosive effects on metal or other containers, and the principal requirement is to get the requisite strength in the construction of the container.

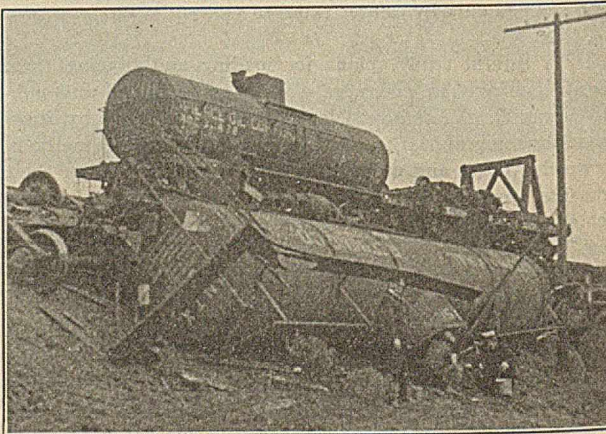

FIG. 4

The most dangerous of the inflammable liquids shipped in quantity are casinghead gasoline and liquefied petroleum gas. These liquids are produced by liquefying the condensable vapors in casinghead gas or natural gas, either by the compression or absorption process. By the compression process, especially, a considerable amount of highly volatile material is condensed or dissolved in the liquid product. Some of the more volatile portions are eliminated by means of a "weathering" process, but the final product is far more volatile and dangerous than ordinary refinery gasoline. Such liquids produce internal pressure in their shipping containers. Owing to these pressures, very slight defects in the containers may produce large leakages. It was necessary to devise a test other than the flash test to show the varying degree of hazard involved in handling condensates of this nature. As the special hazard is the high vapor pressure, the test applied to the material is simply a determination of the vapor pressure in the liquid in a closed container filled to 90 per cent capacity at temperatures of 70° and 100° F., respectively, under standard conditions. Material that gives a pressure not exceeding 10 lbs. at 100° F. may be shipped in tank cars of the ordinary type, while condensates having pressures above 10 lbs., and not exceeding 15 lbs. in the summer or 20 lbs. in the winter, require a special type of tank which was developed especially for the transportation of this commodity.

TANK CARS

The ordinary tank car was originally designed for the transportation of comparatively less volatile liquids, such as crude oil and kerosene; and later, refinery gasolines were satisfactorily shipped in these cars, as comparatively little internal pressure was developed even in hot weather. These tank cars were not designed primarily to stand internal pressures. The shells are sufficiently strong, but the dome cover is not sufficiently tight, the safety vent valves are not of satisfactory design, and the presence of a bottom outlet valve is responsible for many expensive accidents.

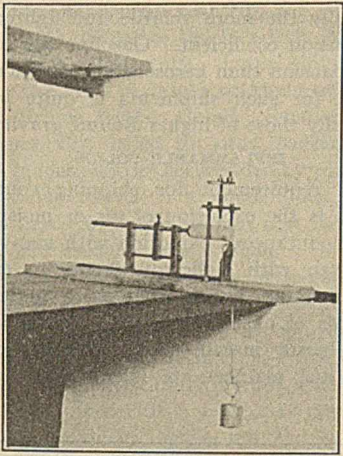

Fig. 5

The insulated tank car used for the more volatile casinghead condensates is entirely covered with an insulating layer of magnesia or cork about 2 in. thick, which is in turn covered with sheet iron. The dome cover, instead of screwing directly into the dome ring, is bolted down over the dome opening with 10 or 12 bolts around the edges of the cover. By this means direct pressure is placed on the gasket instead of a twisting motion which is obtained with the dome covers which screw into the dome ring. Further, these bolted-on covers cannot be removed until a vent is opened by which all internal pressure is relieved before the dome cover is released. The insulation around the car prevents to a surprising degree the heating of the contents of the car by the heat of the sun and the atmosphere. For this reason the vapor pressures are kept low and there is less loss by evaporation than with the ordinary tank cars.

Very serious accidents have been caused by the use of the tank cars with screw dome covers. In several instances these covers were removed while there was still high pressure in the car. As a result the cover was blown high in the air and a large volume of vapor and hundreds of gallons of liquid were forced up through the dome opening. The vapors were ignited by lights or fires several hundred feet away causing fires or explosions.

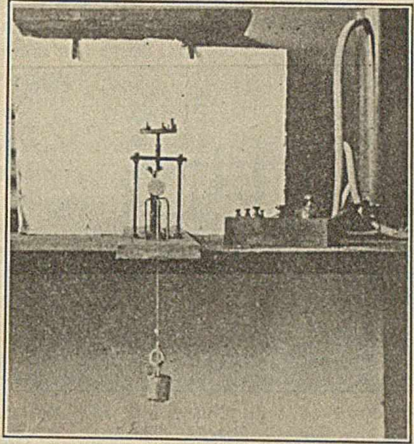

Fig. 6

Safety vent valves are necessary on the tank cars of both types, as otherwise, if the car were involved in a fire, it would most certainly explode and in that case throw burning gasoline over a wide area, causing rapid spread of fire and probable loss of life. The design of these valves is such that many permit escape of vapor at pressures far below the point at which they are set to operate. The gasoline vapors escaping under these conditions occasionally ignite from outside sources; however, the fires thus caused are comparatively small in extent as they burn only at the safety valve, and are usually extinguished without great difficulty and cause slight damage or loss. The bottom valves on tank cars used for inflammable liquids are a source of hazard, as the outside vent or boot is likely to be damaged or broken off in derailment or accidents, and at the same time the valve becomes unseated, allowing the rapid escape of the contents, which under these circumstances usually ignite almost immediately.

Gasoline frequently contains a small portion of water; this water settles to the bottom of the tank car and frequently works its way past the bottom valve into the outlet pipe. In cold weather this water will freeze. The expansion of freezing may burst the outlet pipe or unseat the valve. These conditions may be unnoticed until unloading the car is attempted or until the weather becomes warmer, when it frequently happens that a large portion of the contents escapes before the flow can be controlled. Aside from the loss of contents, severe fires and explosions have occurred from this cause. While from the standpoint of safety the bottom valves on tank cars are undesirable, it appears impracticable to eliminate them, owing to various commercial considerations.

Figs. 1 and 2 show fire in cars of gasoline owing to opening old style tank cars while there was considerable internal pressure. Figs. 3 and 4 show a tank car wreck which resulted in loss of much gasoline, but no fire. The absence of fire was due to the use of care and exceptionally good judgment in clearing up the wreck. In addition to care and judgment, good luck was present.

STEEL BARRELS AND DRUMS

The specification steel drum required for inflammable liquids serves the purpose admirably; failures in this container generally result from too long service, porous bungs, or improper gaskets. It is a fact not generally known, that ordinary cast-iron bungs in noticeable proportions are sufficiently porous or flawed to permit leakage through the metal. This is more noticeable with light and volatile liquids, such as gasoline or ether. The remedy is to use steel bungs, or to subject all cast-iron ones to severe test for porosity before use.

Difficulties with these metal drums may be divided into three classes: first, poor welding; second, closing devices; and third, corrosion and rough handling.

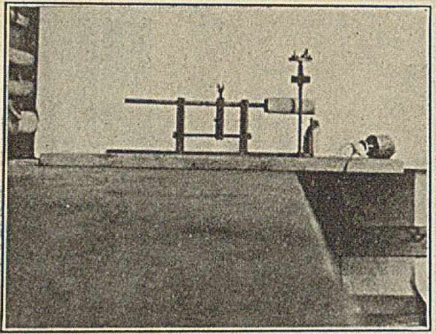

Fig. 7

Poor welding can ordinarily be controlled only by the most careful supervision of the manufacturer. An air test of 15 lbs. is prescribed for each package, but small holes may be covered with scale or closed by oxide so that leakage will develop after use. Such a test made before each shipment, especially if the package is hammered with a wooden mallet along the chime and side weld, would eliminate practically all chance of leakage due to defective welding. The apparatus and test would not be very expensive and would probably pay in the case of a large shipper, for the railroads are fast coming to the conclusion that claims on leaking packages should not be paid unless injury actually occurs in transit. A small shipper can get fair results by laying the package on its side after filling, and allowing it to remain for several hours and examining for leakage while hammering with a wooden mallet along the chime and side weld. Repairing of leaks by soldering does not pay in the long run and should not be allowed. They should be welded.

The efficiency of closing devices can be easily controlled by the purchaser, even if the manufacturer is careless. All that is necessary is a careful and intelligent inspection of packages upon receipt, and the use of a new gasket at each shipment. Bungs when screwed in about three-quarters of the distance should show a fairly close fit in the threads, otherwise they will soon strip. The thread in the bunghole should have at least 5 complete threads and that on the bung should be sufficiently long to engage in all of the 5 threads in the bunghole. Bungs should screw up to an even bearing when gaskets are removed. Gaskets should be at least $^3/_{16}$ in. thick by $^3/_8$ in. wide.

The use of a proper gasket is essential to tight closure of drums. The material from which the gaskets are made must be chosen with regard to the material to be shipped and also to the physical qualities, such as hardness, durability, and elasticity. Satisfactory gaskets may be made from numerous materials, such as hard fiber, leather, rubberized asbestos, etc. One of the principal causes of failures in gaskets is the fact that they are used too often. It would probably be a safe rule to require that no gasket should be used more than once.

WOODEN BARRELS

The transportation of dangerous articles in wooden barrels and kegs will always result in accidents as long as those packages are authorized. This is especially true in connection with the lighter of the inflammable liquids and the more dangerous inflammable solids. The troubles lie principally in the inherent liability to slow leakage of barrels of the tight variety and sifting of contents through cracks in slack barrels.

The shipment of alcohol in wooden barrels has resulted in comparatively large losses. In addition to the original weakness of the package these accidents are due to shippers using second-hand barrels without properly recoopering them, or barrels which do not actually come up to the standards prescribed. Faulty methods of loading may also contribute to the losses, since these packages are especially susceptible to damage through shock.

For new barrels the user is urged to require the manufacturer to certify to the fact that his product complies with the specifications and to mark them to show such compliance. This responsibility placed upon the manufacturer of the package will secure some improvement.

For second-hand barrels only the most careful recoopering should be allowed and care should also be taken that only those barrels actually complying with the specifications on original manufacture should be used for the dangerous articles.

The shipment of permanganate of potassium, the chlorates, and similar articles in slack barrels and kegs is also giving some trouble. If these accidents continue it will probably be necessary to limit these articles to metal containers. The present container, the slack barrel, is dangerous even after the contents are removed and some fires have been caused by their use as second-hand packages for other articles.

Failures of shipping containers for inflammable liquids have often been due to overloading the container and the expansion due to rise in temperature. To determine the proper outage it is necessary to know the coefficient of expansion of the liquid and the maximum temperature range to which it may be subjected in transit or storage. The maximum temperature to which shipments may be subjected in transit is probably about 110° F. in this section, while in the Southwest it is approximately 120° F. Generally the more volatile and lighter liquids have the higher expansion coefficient. Gasoline has a much higher coefficient of expansion than kerosene and heavier oils, and the outage sufficient for such shipments is quite inadequate for gasolines, especially those of higher Baumé gravity.

INFLAMMABLE SOLIDS

The principal requirement for shipping containers of inflammable solids is the exclusion of air or moisture. Contact with air causes spontaneous oxidation with many of these substances, and often with sufficient degree to cause ignition. The degree of activity varies with these materials and the attendant hazards of exposure to air is in proportion to this activity. Phosphorus, metallic sodium, fused sodium sulfide, cobalt resinate, and matches are included in the class of inflammable solids.

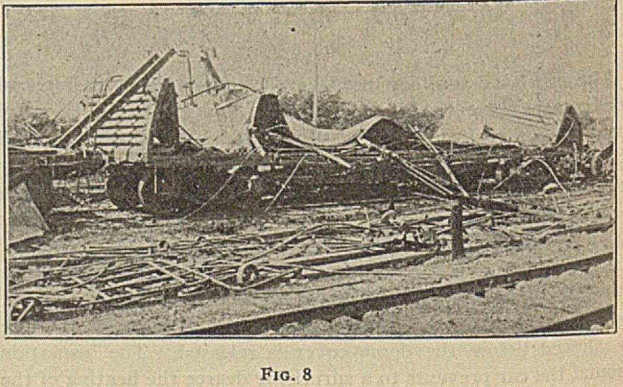

Fig. 8

The shipping containers for phosphorus commonly consits of sealed tin cans containing the phosphorus submerged in water; these cans are shipped in outside wooden boxes. This type of container has been satisfactory in direct shipment from factory to consumer. Where the material has been subjected to long storage before shipment, trouble has been caused by the slow rusting of the tin cans, allowing the escape of the water, the entrance of air, and in some cases the actual ignition of the phosphorus. It will be necessary to modify the specification of this container either by having a much heavier coating of tin on the tin can, or by requiring that the outer wooden box be provided with an hermetically sealed metallic lining. The latter will probably be the safer, as no matter how secure the single inner package is, it is liable to be burst by the freezing of the water in cold weather.

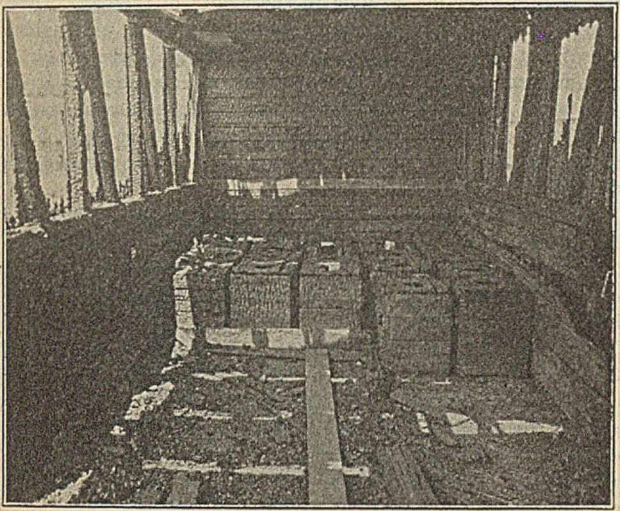

Fig. 9

Metallic sodium, while highly active, has caused very little trouble in shipments, owing to the fact that the shipping container is practically satisfactory. Large shipments are commonly made in the form of bricks or ingots which are packed in heavy steel drums tightly closed. Smaller shipments are packed in hermetically sealed tin cans, packed in boxes, also immersed in oil in glass bottles surrounded by tin cans, the entire inner package being placed in a wooden box. Carload shipments are also made with the sodium cast solid in sheet-iron drums, such as are used for caustic soda. This package, while satisfactory for inter-plant shipments in solid carloads, is not permissible in L. C. L. shipments, or for general use.

Fused sodium sulfide is required to be shipped in tight iron drums, as when in wooden barrels it is liable to spontaneous heating and ignition, particularly in hot and damp weather. The crystallized sodium sulfide is more hazardous.

Strike-anywhere matches, while not liable to ignition by exposure to air, require a tight package for the reason that if the matches are accidentally ignited in a tight package, the fire is almost immediately smothered for lack of air. The present shipping containers for matches are wooden or fiber-board boxes. These containers quite generally smother any fire started in the matches. However, if the outer package is defective or is broken by rough handling, any fire started is likely to spread throughout the package and to adjacent packages.

The ordinary strike-anywhere match is extremely sensitive to friction. It is in fact more readily ignited by friction than any commercial or military explosive. Decrease of the losses in transportation may be sought either by the use of a shipping container more nearly air-tight, such as a metal-lined wooden box, or by noticeably decreasing the sensitiveness of the matches themselves. In order to determine the relative sensitiveness of the matches a special friction test apparatus has been designed and put into use.

In this apparatus an alundum cylinder, 3 in. long and 1$^1/_8$ in. in diameter, is held in a horizontal position on a slide moving in a direction parallel to its axis. The slide and cylinder are moved forward 2 in. by a 500 g. weight after falling through a distance of 6 in. The match to be tested is held so that the match head touches the top surface of the cylinder, and the match stick is in a vertical position. The match is held in a socket which can give an adjustable pressure of from 10 to 200 g. on the match head. The test is made to determine the least pressure which will cause ignition of the match head during the 2 in. movement.

OXIDIZING MATERIALS

Materials classed as oxidizing materials for transportation purposes include sodium peroxide, barium peroxide, potassium permanganate, potassium chlorate, and others of less activity and hazard. Sodium peroxide is inherently the most hazardous of these compounds, but owing to the effectiveness of the containers—tight steel drums or tight tins packed in wooden barrels or boxes—very little difficulty has been experienced in shipments. Barium peroxide formerly caused numerous fires accompanied by heavy losses. At that time shipments were made in heavy and apparently tight wooden barrels. The barium peroxide was in the form of a fine but heavy powder. This powder in small quantities worked through the joints in the barrel, and it was found that friction of this powder between dry wooden surfaces readily produced fire. As a result of this investigation steel containers were required for shipments, and since this type of container has been used no fires have been reported in these shipments. The loss of the Steamer "*Volturno*" by fire some 6 years ago is believed to have been caused by the ignition of barium peroxide shipped in wooden barrels.

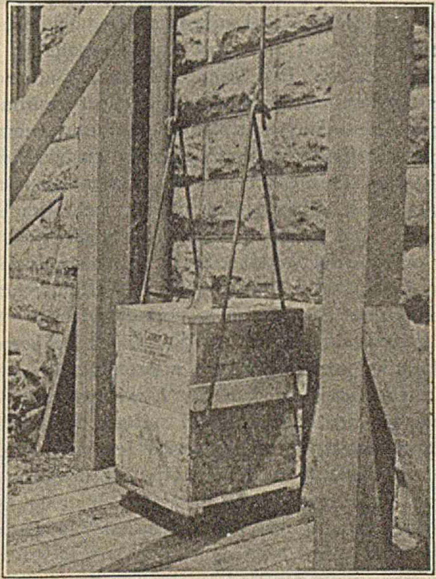

Fig. 10

Potassium permanganate and potassium chlorate are now shipped in wooden barrels or kegs. This practice is not entirely satisfactory, for there is a chance of fires being caused by friction if the contents escape from the package. Also if the chlorate gets into a fire it occasionally causes quite severe explosions. It will be recalled that there was a series of explosions of chlorate in connection with a warehouse fire in Jersey City about 18 months ago. An unexpected risk pertaining to wooden containers for chlorates has recently been noted. Fires have been caused by shipments of metal and hardware in second-hand chlorate kegs. The inner surface of these kegs was slightly crusted and impregnated with sodium chlorate. The friction of the metal pieces against the chlorate-impregnated surface started the fires. Immediate discovery and control of two fires disclosed definitely the cause. It is quite possible that other fires have been caused in this manner and that the cause was never determined.

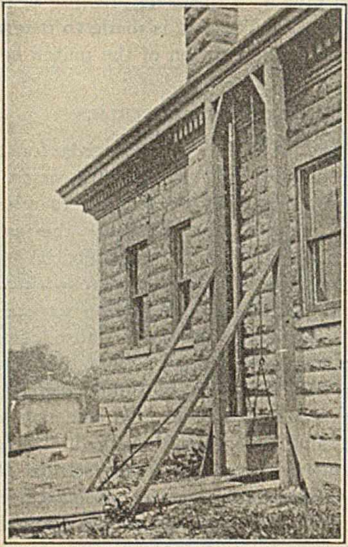

Fig. 11

CORROSIVE LIQUIDS

The shipping containers used for corrosive liquids consist principally of tank cars, steel drums, glass carboys, and glass bottles. For sulfuric acid and mixed nitrating acid the tank car is very satisfactory and the steel drum reasonably so. The glass carboy at its best is a fragile package. Sulfuric acid of 92 to 96 per cent strength has but slight effect on iron or steel, but the stronger acid, known as oleum, has a much more marked effect. This effect is not uniform over the surface, but causes irregular pitting. This effect may be due to local impurities in the metal, but it is quite pronounced in the grade of steel used in making steel drums. Owing to the proposed development of air, nitric acid plants, it is desired to ship strong nitric in tank cars with the minimum mixture of sulfuric acid which will serve to protect the steel from undue corrosion. So far as known, the least amount of sulfuric acid which has been successfully used for this purpose has been approximately 15 per cent by weight of the total mixed acid. The corrosion of the steel depends not only on the amount of sulfuric acid, but also on the amount of water in the mixture. Investigations on this subject are still incomplete. The shipment of nitric acid has been the cause of heavy losses, not only of acid but also of equipment. These shipments must necessarily be made in glass carboys.

While the glass is not affected by the acid, frequent fires have occurred owing to the breakage of the carboys. The glass carboy of the usual capacity, about 12 gal., is extremely fragile, and even with the best available packing there is considerable breakage due to the shocks caused by shifting and coupling of cars, or by train movement. The regulations require that no material, such as hay, straw, or similar combustible material should be used as packing for nitric acid carboys. The packings most used are mineral wool, and the so-called Stahl packing, which consists of four grooved, vertical wooden strips whose elasticity serves as the cushioning agent. While both of these packings are safer than hay for nitric acid carboys, nevertheless numerous fires have occurred in shipments in both types of these carboys. Figs. 8 and 9 show the result of fire in two different cars of nitric acid.

It is desirable that a carboy box for nitric acid should have a metal or other liner that will hold the acid after the carboy is broken, and not permit it to come in contact with the wooden boxes, or the wooden floor and lining of the car. As yet such a shipping container has not been developed to a commercial stage.

In the development of the carboy and its container it was necessary to determine accurately the resistance of the various combinations to severe stresses. In railroad transportation observation has shown that packages receive their greatest stresses in a direction parallel to the length of the car. These maximum stresses are due to coupling, switching, and sudden stops in train operation. The straight-sided carboy now in use is naturally more resistant to vertical stresses than to lateral ones, hence the freight car and the carboy make a combination in which the greatest stress comes on the weakest part of the carboy. As far as possible the packing serves to overcome this inherent weakness of the package.

Boxed carboys filled to the shoulder with water are tested to destruction by both vertical and lateral impact. The vertical impact is obtained by dropping the carboys on the bottom on a concrete floor. The lateral impact is obtained by suspending the carboy so as to act as the weight on a 14 ft. pendulum. The carboy strikes laterally against a vertical wall just beyond the bottom point of swing. The amount of impact is determined by the vertical component of the arc through which the carboy swings. In making this test it is necessary that the carboy be swung so that the face of the box is exactly parallel to the vertical wall, otherwise the box will not strike squarely and the test will be misleading.

Considerable difficulty has been caused at times by bursting of nitric acid carboys from internal pressure, due to expansion of the acid by heat or by decomposition of the acid by light. Experiments showed that with tightly closed bottles of nitric acid filled to 90 per cent of capacity, and exposed to direct sunlight, a pressure of 17 lbs. per sq. in. developed in 3 days. A considerably less pressure was produced by diffused daylight, and practically none in the absence of light. These tests showed the necessity of venting of nitric acid carboys, especially where ground glass stoppers were used for chemically pure acid. Work is also being carried on in the development of porous stoppers for commercial acids which will permit the escape of vapors produced in transit.

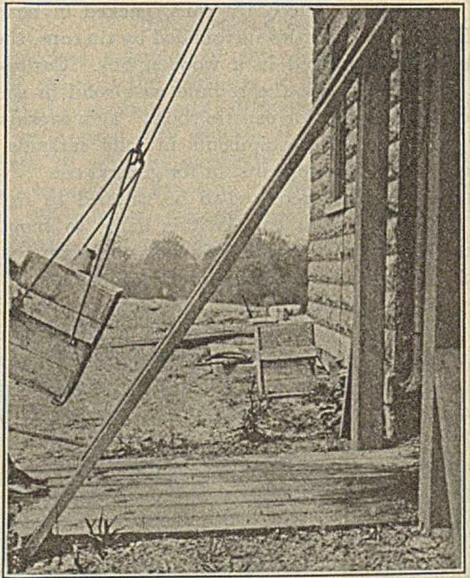

Fig. 12

Until recently carboys were commonly closed by a loosely fitting earthen stopper held more or less securely in place by clay, plaster of Paris, and burlap. These stoppers were generally in fair condition when loaded in the car, but by the vibration and shocks of transportation they worked loose and in many cases jarred completely out of the necks of the carboys. This condition caused splashing of the acid from the carboys, which in some cases caused fire or injury to employees, and always caused rapid deterioration of the carboy boxes, the car floor, and lining.

Boxed carboys for the transportation of inflammable liquids and acids are a prolific source of trouble. Probably for nitric acid it will be necessary to adopt eventually a metal-lined box to retain the acid in case of accident. For ordinary acids, however, it is believed that careful attention to the following points will largely eliminate accidents due to the package: First, cushioning; second, closing device; third, repair.

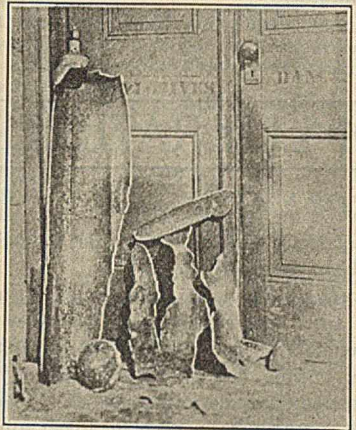

Fig. 13

Poor and insufficient cushioning cannot be cheap in the long run. It will cause accidents and it will increase repair. The cushioning material should be 1$^1/_2$ to 2 in. in thickness all around the carboy and should be carefully put in. A thin cushioning will give insufficient protection and will quickly wear through by the constant rubbing of the carboy, while one full of lumps will cause the pressures to be brought on small areas of the carboy and cause breakage. A 1 in. thickness does not give space for proper packing or sufficient cushioning.

The use of elastic wooden strips for cushioning decreases initial costs, but has not proved successful from the standpoint of safety and final costs. Great care must be taken in manufacture and assembly, the elasticity of the wood is liable to be quickly destroyed by acid or acid fumes, and finally the repair and readjustment costs are certain to be high unless efficiency is neglected. I believe that some improvement will be obtained if packages cushioned with elastic wooden strips are used only where reshipments will not occur.

The closing device appears to be simply a question of cost. If a stopper is well made, an efficient gasket applied, and a strong metal fastening used, there will be no leakage. Already the improvements along this line have been great, but there is room for more.

The lack of proper repair of packing is probably one of the greatest causes for breakage of carboys. The carboy is fundamentally an improper package and unduly subject to breakage, and when the outside box and the cushioning deteriorate, the resulting package is exceedingly inefficient. Periodical and efficient repacking should be required.

Fires have been occasionally caused by the use of organic packing, such as sawdust, around bottles and jugs of bromine. This packing was improved later by saturation of the packing with the so-called bittern water, but still fires occurred at times, and it was finally required that bromine bottles or jugs should be packed in entirely incombustible packing.

Fires resulting in shipment of phosphorus trichloride necessitated the prohibition of any organic material as packing around the bottles or of any packing which will combine in any way with the phosphorus trichloride.

MISCELLANEOUS ARTICLES IN BOXES

The shipment of miscellaneous goods packed in boxes, and including dangerous articles, has always been difficult to regulate. A small amount of dangerous articles may start just as bad a fire as a large amount.

The greatest risk is noted in the transportation of nitric acid. The present regulations require all cushioning material to be incombustible. This does not seem to be sufficient as there are frequently in the same outside container other packages containing sufficient combustible matter to cause fire when attacked by the acid. Safety suggests that nitric acid should be absolutely prohibited from being packed with other goods.

The boxes in general use for these miscellaneous goods frequently merit severe criticism. Apparently many shippers fail to realize that in marking their boxes to show compliance with a certain specification they are giving the word of their company to the effect that they actually do comply. The required marking is supplied by some of these shippers, not because the package is correct, but because the railways will not take the package without it.

The shippers should purchase their boxes under a guarantee from the manufacturer that they comply with the proper specification, and they should require him to mark the boxes to show such compliance and to stand back of this marking.

COMPRESSED GASES

The specifications for shipping containers for compressed or liquefied gases have been exceptionally successful in preventing losses and accidents. This is due to the fact that the pressure in cylinders of compressed or liquefied gases can be accurately determined and controlled. The cylinders can be made of a metal selected to have the proper chemical composition and the required tensile strength, elastic limit, and working qualities. Further, each cylinder, after being designed and made with a view to meeting these requirements, is subjected to a hydrostatic pressure test at a pressure sufficiently above any reasonable working pressure to ensure a proper factor of safety. It is required that when subjected to this pressure test, the permanent expansion must not exceed 10 per cent of the temporary expansion. A test of this nature assures that the actual bursting pressure will considerably exceed the test pressures, and at the same time the metal will not be overstrained, weakened, or hardened by the test. In the manufacture of compressed gas cylinders there is the advantage that the cylinders last for a long time, and hence the expense is distributed over a long series of shipments. Carbon dioxide cylinders have been in general use in this country for a longer period than any other type of compressed gas cylinders. Many cylinders have been in use for more than 20 years. Many of the earlier cylinders were made according to specifications which would not at present be approved, yet there have been relatively few failures. Where cylinders of this type have failed it has generally been due not so much to excess pressure, but to brittleness of the metal. In most cases the bursting of the cylinders was caused by a shock such as is produced by a cylinder falling over, or dropping from a car or wagon.

Fig. 13 shows a carbon dioxide cylinder which burst in service. This cylinder was of sufficient strength, but the metal was brittle.

Acetylene cylinders have presented a peculiarly different problem in design and construction, because of the property of acetylene which causes it under certain conditions to dissociate with explosive violence when compressed to a pressure above 2 atmospheres. It can readily be liquefied, but in this condition is almost as dangerous as nitroglycerin. Experience has shown that the only safe way to store and ship compressed acetylene is in solution in acetone, which in turn is held in a porous filling mass in a steel cylinder. Asbestos blocks or other porous materials are used for this mass. This mass must have a porosity of not greater than 80 per cent and must have no large voids in which an explosive reaction may start. The mass must be of sufficiently fine texture to be safe, and sufficiently rigid and durable to prevent sagging away from the walls of cylinder, even after long use and severe handling.

Aside from the tests of the cylinder by the usual hydrostatic tests, the filled and charged cylinders are tested as to liability to explosive dissociation of contents and bursting of the cylinders. The tests commonly applied are, first, placing charged cylinder in fire and observing whether gas escapes quietly by the safety vents or bursts cylinder; second, placing a charge of dynamite on cylinder sufficiently heavy to make deep dent in side wall, and yet not sufficient to break wall; third, burning a hole through wall of cylinder with a charge of thermit.

Shipping container specifications, as has been indicated, have been gradually developed to their present state. They are neither completed not perfected, they do not always represent the best possible container because they must be made within certain limiting costs to be available for commercial use. They represent the joint results of the experience of shippers of the commodities, manufacturers of the shipping containers, and of the carriers, plus thorough study of all the conditions. Additional specifications are being prepared from time to time as needed, and modifications and improvements are made in those previously drawn up. Further knowledge of the materials to be shipped, improvements in materials and manufacturing processes, will suggest future developments and improvements in shipping containers.

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BIBLIOGRAPHY OF HELIUM LITERATURE

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INTRODUCTION

It is particularly appropriate at this time to issue a bibliography of the scientific literature relating to helium. The development, during the war, of great fractionating plants capable of separating from natural gas a sufficient quantity of helium to supply a fleet of airships has aroused the keen interest, not only of engineers and scientists, but also of the general public in the unique properties of this gas.

The year 1918 certainly marks the beginning of a new era in the history and use of helium. Before that time only a few liters of the gas had ever been collected, and the cost per liter was enormous. The separation of millions of liters of the gas at a very moderate cost, therefore, makes the gas at once available for many purposes which formerly seemed impossible of accomplishment.

Helium has probably been the most interesting of all the elements to the theoretical scientist on account of the romantic history of its discovery, its occurrence in a remarkable condition of solid solution in many minerals, its formation as a product of the disintegration of the radioactive elements, its liquefaction after a decade of unsuccessful attempts by some of the world's greatest experimenters, the attainment by its use of temperatures below those at which the resistances of pure metals vanish, its many unique physical properties, and the many important theoretical conclusions which have been drawn from its behavior.

All of these points of interest have been the subjects of very thorough investigation. The important developments of the future will probably be along the line of the applications of helium, many of which have already been suggested; but in order to make the most of these possible applications it is necessary to know the properties on which they are based. It is as a guide to these properties that, it is hoped, this bibliography will find its chief usefulness.

This bibliography was first prepared at the beginning of the development of helium for balloon gas purposes and was intended as an aid in that enterprise. It has since been brought up to a later date and is thought to include practically everything of scientific value published up to January 1, 1919, except reviews and other articles containing no original work, which were published in inaccessible foreign journals, when the same material was available in English or American publications. Such articles have been purposely omitted.

The arrangement of material under each subhead has, in general, been such that closely related articles occur together in their chronological order. The bibliography is thus, in effect, a brief outline history of the subject. An exception to this arrangement is made in the case of articles on the occurrence of helium, which have been arranged alphabetically according to the author's names. This was done because the papers by different authors are usually but slightly related to each other, and the chronological development seems of less importance than the bringing together of the papers, often numerous, of each author.

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I—DISCOVERY

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BUREAU OF STANDARDS
WASHINGTON, D. C.

FOREIGN INDUSTRIAL NEWS

By A. McMILLAN, 24 Westend Park St., Glasgow, Scotland

DETERMINATION OF ACETONE, ALCOHOL, AND BENZENE

A method for the determination of small quantities of acetone, alcohol, and benzene in the air was described by S. Elliot and J. Dalton at a meeting of the Society of Public Analysts in London. A measured quantity of the air is drawn through suitable apparatus, the vapors being absorbed as follows: The acetone in alkaline iodine solution, the excess of iodine being estimated by thiosulfate; the alcohol in dilute chromic acid solution, and after oxidation to acetic acid, the excess of chromic acid is estimated by iodine; the benzene in a mixture of concentrated sulfuric and fuming nitric acids, which convert the benzene into dinitrobenzene, and this is extracted and estimated by stannous chloride solution.

GERMAN POTASH FOR ALLIES

According to a Berlin telegram quoted by Reuter's correspondent in Denmark, an agreement was signed recently for the delivery of potash in England. It is not impossible that there will be a further agreement for the delivery of potash to America. England is to get 30,000 tons, the proceeds of which will be credited to the German government in payment for food supplies. Of this amount 10,000 tons will be forwarded *via* Hamburg or Bremen and 20,000 tons *via* Rotterdam.

HYDRAULIC MAINS OF REËNFORCED CONCRETE

A communication to the *Société Technique du Gaz* by Mr. Martineau describes the successful result which followed the emergency measure of constructing ten hydraulic mains in reënforced concrete undertaken as the only possible course during the war in consequence of the high price of cast iron, and the delay in getting such work completed. The metallic reënforcement consists of a network of $^1/_4$-in. round iron wire formed in squares 4 in. × 4 in. The concrete walls had a thickness of 2$^3/_8$ in. The walls of the main rest on I iron running the length of the retort bench. The valve of the tar outlet is let into the cement. A rebate along the upper part of the main receives the cover, formed of a slab of cement, into which are set the inspection and cleaning boxes. Before being taken into use all the interior surface of the main, as also the lower side of the cover, were given three coats of hot tar. This was done to close up the capillary passages in the cement and thus prevent any action of ammonia on the metallic part, the continuous flow of the tar during the working maintaining this protective coating. The main was brought into use without any mishap in the way of expansion or leakage. Test pieces of cement placed in it at the time of starting operations and 6 months afterwards showed no signs of any action on the cement by the gas liquor. The ten mains were constructed in 6 weeks and the cost of each ($200) was much less than the quotation ($500) for the work in cast iron at the prices ruling.

ELECTRIC STEEL-HARDENING FURNACE

A Wild-Barfield electric steel-hardening furnace which has been supplied to the metallurgical department of Sheffield University by Automatic and Electric Furnaces (Limited) of 6, Old Queen Street, Westminster, measures 8 in. by 15 in. over all and has a heating chamber 4 in. in bore by 13 in. in depth. The power consumption (200 volts alternating current) is 1,400 watts at full load and the maximum temperature attainable is 850° C. The furnace has an output of 10 lbs. of tools per hr., the maximum weight of article it can take being 2 lbs. and the maximum length 8 in. An electrically-heated quenching and tempering bath, taking 600 watts, measures 12 in. by 15 in. over all. The inner pot is 8 in. in bore and 13 in. in depth, and can take articles up to 4 lbs. in weight and 10 in. in length. The maximum temperature that can be reached is 350° to 400° C.

PLATINUM

Following upon some prospecting work undertaken at the initiative of the Spanish government after three years research in various directions, it has been found that platinum exists in Serrana de Rhonda to an extent of 2 to 3 g. per meter. Serrana forms a chain of volcanic mountains extending over a distance of 1400 sq. km., hence the beds surpass the platinum found in the Ural mountains, where the beds cover an area of only 50 sq. km. It may also be mentioned, says *Engineering*, 127 (1919), 303, that the deposits in the Urals never yielded more than $^1/_4$ g. per meter and, in addition, the beds there are getting exhausted.

EDIBLE OIL REFINING

A new industry, says the *Chem. Trade J.*, 64 (1919), 258, has been started at Sunderland, England, by the opening of an edible oil refinery. The new venture is an attempt to capture a highly profitable trade formerly enjoyed by Germany and has already despatched its first consignment in the form of salad oil to margarine works. The present output of refined oils is about 50 tons which will be increased on the introduction of new machinery at an early date. Not the least important branch in the undertaking is the department for dealing with the residue which finds a ready sale in the soap-making industry.

LINSEED OIL SUPPLY

Business men in England in the oil trade are puzzled to account for the shortage in linseed oil which first made itself felt before Easter. Three causes, according to the *Liverpool Daily Post*, are suggested for the shortage. One is that the government is holding up supplies in order to compel the trade to use up the surplus linseed oil fatty acids of which there are large stocks in hand. Another cause given is that holders are refraining from selling in the expectation of firmer prices, while a third suggestion is that the government had temporarily oversold to the continent which has long been hungry for linseed oil. There is a temptation to do this since the price for export is $375 per ton as against $290 for home consumption. It is at present not possible to say what is the correct cause.

GERMAN SOAP AND ALLIED INDUSTRIES

Quoting from a German contemporary, *Chem. Trade J.*, 64 (1919), 367, discusses Germany's after-war prospects of obtaining oil and fats with special reference to the soap and margarine industries. The German stearin, soap, and candle industries were on a large scale before the war. About 250,000 tons of fat were used for soap-making and from 6,000 to 8,000 tons for candles. There were 34 large, 85 medium, and 549 small soap factories with a total capital of $75,000,000. Not more than 18,000 tons of fat per annum were available during the war for soap-making. Of the 120 margarine factories previously existing and producing 250,000 tons, only 24 are now working. Before the war, Germany's consumption of oils and fats was estimated at 1,900,000 tons, comprising 600.000 tons of vegetable oils and fats, and 1,300,000 tons animal fats. 1,500,000 tons were used for food and 400,000 tons for industrial and technical purposes. Only about 20,000 tons of oils and fats were obtained from home-grown oilseeds and the balance of 580,000 tons were milled in Germany from 1,700,000 tons of imported oilseeds and nuts. A considerable amount of oil was, of course, exported. Germany views with concern the enormous extension of the oil-milling industry in other countries, especially in England and America, and feels that her chances of competing on equal grounds for the world's supplies of oilseeds and nuts are remote as many of her large mills have had to close down. Bone fat extraction was increased but most of this fat is unedible. The article discusses the merits of crushing oilseeds or expressing as compared with benzine extraction. The latter gives a higher yield of oil but necessitates, as a rule, more refining than when the oil is cold-expressed.

SILICA FROM RICE HUSKS

Some experiments have recently been carried out in Burmah, says *Engineer*, 127 (1919), 403, with a view to utilizing the silica content of rice-husks, in the manufacture of glass. On burning the husk about 18 per cent of white ash is obtained and, although this ash contains small quantities of iron, it has been proved suitable for the manufacture of glass having a pale green or yellow color. In burning the husks, sufficient heat is generated to carry out the various processes.

OXYGEN IN SODIUM PEROXIDE

The methods generally available for the estimation of oxygen in sodium peroxide, depending on the liberation of hydrogen peroxide by water and titration with permanganate and on the treatment with potassium iodide and bicarbonate with titration of iodine with sodium arsenite, are said to give low results, while the method of measuring the oxygen liberated by water in the presence of cobalt nitrate gives high results. The following methods described by J. Milbauer in *Prakt. Chem.* are said to give accurate results. (1) Water (100 cc.) is mixed with concentrated sulfuric acid (5 cc.) and chemically pure boric acid (5 g.), sodium peroxide (0.5 g.) is added gradually to the mixture, which is shaken briskly, and the liberated hydrogen peroxide is treated with permanganate. The low results given by the older method are attributed to the catalytic decomposition of a portion of the hydrogen peroxide by the manganese sulfate formed during the titrations. (2) Sodium peroxide is introduced gradually into a solution of potassium iodide (2 g.) in dilute sulfuric acid, 1 in 20 (200 cc.), and the iodine then titrated with standard thiosulfate. The results agree with the first method. (3) Sodium peroxide (0.2 to 0.3 g.) is mixed with about 10 cc. copper sulfate solution (0.05 per cent) in a small flask connected with a nitrometer, the flask shaken and decomposition is complete in a minute. The oxygen is then measured. The gas evolved contains 0.32 per cent carbon dioxide and 0.08 per cent hydrogen. With cobalt nitrate as catalyst the results are invariably high. The author considers that this may indicate the presence of an oxide higher than the peroxide. The action of the atmosphere on sodium peroxide has also been investigated. Moisture appears to be more active than carbon dioxide in causing decomposition.

MAGNESIUM AND ITS ALLOYS

A very interesting account of the production of magnesium and its uses as an alloying agent is given in a somewhat long article published in *Engineer*, 127 (1919), 402. Before the war, it would seem that Germany was the sole producer of magnesium on a commercial scale, but factories have now been set up in Canada, the United States, France, and England. The technical difficulties involved in the manufacture, which were considerable, have been mastered and many new processes have been introduced which reduced the cost of production and lead to wider uses of the metal. The usual methods of extraction are (1) action of sodium on fused magnesium chloride, (2) electrolysis of a fused double chloride. The magnesium chloride was formerly obtained exclusively from Stassfurt, Germany, but it is now recovered as a by-product at various salt works. Among the new methods of manufacture is the reduction by carbon which yields a black powder at a very low cost. Another method giving an alloy of magnesium and aluminum directly consists in electrolyzing a fused bath of magnesium chloride and fluoride. The anode is carbon; the cathode consists of aluminum so that the magnesium formed at the cathode forms an alloy which can be used as stock in making up alloys of any desired composition. The chief advantages of magnesium alloys are their lightness, strength, and toughness, and their ability to resist shock and vibrations, very important properties when used in aircraft construction. Alloys of magnesium and aluminum containing 5 to 30 per cent magnesium have approximately the same mechanical properties as brass and are used for making screws, nuts, wire, tubes, and sheets. The hardness increases with magnesium content. With 70 per cent magnesium, the alloy is as hard as mild steel. The tensile strength of alloys containing 2 to 10 per cent magnesium is considerably improved by quenching from about 500° C. It would seem that the cheapness of production will have a large influence in the wide introduction of alloys of magnesium and aluminum.

REFRIGERATION

Mr. B. Rothwell, describing the Seay ammonia absorption refrigerating plant at a meeting of the Liverpool Enginering Society, said that this plant has been proved capable of making 25 tons of ice per ton of coal burned, with an estimated evaporation of 9 lbs. of steam per pound of coal. In this system of refrigeration, the absorbing medium used is ammonium nitrate, normally a crystalline salt. In absorbing ammonia it changes to a sticky viscous liquid form. It is stated that 3 lbs. of this salt absorbs 1 lb. of pure ammonia. Thus in the absorber the salt takes up ammonia gas as it comes from a refrigerator or ice-making tank at low pressure and temperature, the crystalline changing into the thick liquid form. In the generator this liquid is treated again by steam coils until the ammonia is driven off and passes into an ammonia condenser of an ordinary type, the salt reverting to its solid form in the process. In connection with the generator, it is claimed that much economy in heating is obtained over what can be secured in the older water and ammonia absorption plant. This is because the change of state of the salt from liquid to solid liberates its latent heat of liquefaction which goes towards the heat required for vaporizing the ammonia and thus, of the approximately 520 B. t. u. required to vaporize each pound of ammonia, only about 200 B. t. u. have to be provided by steam heating coils.

PROTECTION OF IRON FROM RUST

A method of protecting iron from rust for which very durable results are claimed has recently been described by Prof. Barff and is referred to in the *Schweizer Elektrotech. Ztg.* The iron is treated at red heat with superheated steam, thus receiving a superficial coating of black iron oxide that offers complete protection against rust. The coating is of a very hard nature and adheres firmly. In some circumstances the coating formed will resist the action of emery paper for a considerable time while if the temperature is raised to 650° C. and the time of treatment to 6 or 7 hrs. it wil resist the action of a file. Exposure in the open air to rain or moisture for 6 wks. did not produce any appearance of rust.

SUBSTITUTE FOR LUBRICANTS

Electrician, 81 (1919), 986, quoting from the *Weser Zeitung*, reports that a new undertaking—the Potash Mineral Fat Undertaking—with headquarters at Essen is being founded. It is proposed to manufacture a heavy lubricant for traction cars and carts, etc., by the treatment of potash, other essential ingredients being obtained as by-products from coal. It is surely one of the most curious anomalies of the past few years that the exigencies of war should have led to the development of coarse lubricants from potash, a material which outside Germany has been very scarce and whose manufacture has called forth great expenditure of effort and ingenuity.

LUBRICANTS FOR LOCOMOTIVES

According to a report by Mr. Esser, of Luxemburg, published in *Glaser's Annalen*, a mixture of mineral oil and tar oil has given satisfaction as a lubricant for high-speed traction machinery and carriages while tar oil alone is only serviceable for low speeds. It is not claimed that this mixture comes up to the quality of the best lubricants available for such purposes in peace time. The parts should not be mixed in the cold lest heavy hydrocarbons of the anthracene series be deposited which would bind the parts. When the tar is mixed hot a sediment is at first formed but there is said to be no further trouble. For the summer service 80 parts tar may be mixed with 20 parts mineral oil; for winter months the two constituents should be used in equal proportions, and in very cold days up to 15 per cent of petroleum should further be added to keep the lubricant limpid.

QUEENSLAND COPPER

There is abundance of copper, says *Engineering*, in Queensland. It is hard to say where copper cannot be found in more or less large deposits, and all the copper deposits are not worked and the bulk of the yearly output has been derived from a few favored mines, which always contain gold and silver in considerable quantities. The celebrated Mont Morgan mine is a proof of this but the extensive district of Cloncurry produces more than half of the output of copper for the whole state. Several years ago it was confidently stated that the production of copper would be vastly increased as would also the output of other valuable metals in the north by the construction of certain railways. These railways are now completed and afford connection between the distant mines and the eastern seaports. The vast copper-mining district of Cloncurry has an area equal to that of Tasmania.

SALVING FRENCH HOSEPIPE

An interesting side line of war salvage is being carried on at Hayes, Middlesex, England, where some hundreds of miles of trench hosepipe are being disintegrated and the various products recovered for sale. This type of hose contains a large amount of iron wire and canvas impregnated with a small proportion of rubber. A special machine has been designed for treating the hose, and the stripped wire is stated to be worth about $60 a ton at present prices. The rubber is being reclaimed, and the canvas ultimately finds an application as cellulose. The work is being done on a part of the premises of a detinning works, where considerable quantities of scrap tin are now being treated by the electrolytic process with satisfactory results. Tin metal of a particularly high standard of purity containing as much as 99.8 per cent of pure tin is being obtained from the scrap.

ROSELLA FIBER

The British Commissioner at Asuncion states, according to *Paper Maker*, 57 (1919), 426, that conditions of labor in Paraguay will not admit of the rosella fiber (*Hibiscus sapdarifa*) competing with jute, but it is expected that it might be used locally as a substitute. There are six other fibers that are promising, one of which is the "natural wool." This fiber, sometimes called "vegetable wool," is obtained from the leaf of the common palm which grows wild in profusion in Paraguay, but as in the case of the kernels from the same palm, it may be doubted if the fiber can be obtained in sufficient quantities upon a commercial basis. The removal of the fiber from the plant is exceedingly simple. The plant is left to soak in water for four days and the fiber comes off as a glove. The pulp of the plant serves for paper making. The paper factory at Buenos Aires has given an order for the pulp, which cannot be fulfilled owing to the bulky nature of the cargo which makes the freight prohibitive.

POROSITY IN BRICKS

Some figures bearing on the effect of porosity on the heat-conducting properties of bricks were given in a recent paper to the English Ceramic Society by Dr. J. W. Mellor. He found by calculation that with pores 0.1 cm. across at a temperature of 1400° C. the amount of heat carried across the air space per second was equal to the amount carried through the solid. With smaller pores the same would be the case at higher temperatures and with larger pores at a lower temperature. Thus, for pores 0.01 cm. across the temperature would be 3000° C., and for pores 0.5 cm. the temperature would be only about 730° C. The latter would be rather large pores, but pores of 0.01 cm. would scarcely give a porous structure. In the calculations the conductivity of air and possible changes in conductivity due to increases of temperature were not taken into account and convection by current of air was also ignored.

SCIENTIFIC SOCIETIES

INTERALLIED CHEMICAL CONFERENCE IN PARIS

On the initiative of the Société de Chimie Industrielle, an interallied meeting of delegates of chemical societies has just been held in Paris.

Representatives of the Société Chimique de France, the oldest of all French chemical societies, the Société de Chimie Industrielle, the Association des Chimistes de Sucrerie et Distillerie, the Société de Chimie Physique, the Société de Chimie Biologique, the Société des Experts Chimistes, and the Association des Chimistes de l'Industrie Textile made up the French delegation.

Belgium was represented by Mr. Chavanne, president of the Société Chimique de Belgique; the United States by Mr. Wigglesworth, president of the American delegation, Dr. F. G. Cottrell, delegate from the National Research Council and from the American Electrochemical Society, Lt. Col. Bartow of the American Institute of Chemical Engineers, Messrs. John Pennie and Charles MacDowell, delegates to the Peace Conference, Lt. Col. Zanetti, Lt. Col. Norris, Maj. Colin MacKall, Lt. Sidney Kirkpatrick, Lt. Commander Donald Riley, delegates from the American Chemical Society; the United Kingdom of Great Britain and Ireland by Sir William Pope, president of the British Federal Council and former president of the Chemical Society, Prof. Henry Louis, president of the Society of Chemical Industry, Mr. Chapmann, former president of the Society of Public Analysts, Mr. Reed, former president of the Society of Chemical Industry, and Messrs. Stephen Miall and Edwin Thompson; Italy by Prof. Emmanuel Paterno, vice president of the Italian Senate and president of the Italian Chemical Society, Messrs. Guiseppe Paterno, Umberto Pomilio, and Francesco Giordani, delegates of the Société Chimica Italiana, and Messrs. Parodi Delfini and Eugenio Barbier of the Société du Chimica Industriale.

The delegates held several private conferences These conferences, presided over by Prof. Charles Moureu, a member of the Institute and president of the Fédération Française des Associations de Chimie, prepared a plan for an interallied confederation, the object of which is an intimate coöperation between France, England, Belgium, the United States, and Italy.

There existed before the war an International Chemical Council which included representatives of the Central Empires. It has just been dissolved. The Interallied Confederation will take its place. German science will continue to function, but the barbarous aid which it gave to the enemy armies during the war is sufficient to debar it forever from a confederation where science is to serve the progress of humanity.

The Conference outlined the relations that should exist between the different chemical associations of the allied countries and allowed also the chemical societies of neutral countries an equal right to take part in the Confederation. At the close of the discussions an Interallied Council was constituted. Each nation represented appointed two delegates to take part in it. This Council, which meets in London, July 15 to 18, 1919, is composed as follows:

Belgium—Messrs. Chavanne and Crismer

United States—Dr. Cottrell and Lt. Col. Zanetti

France—Messrs. Moureu and Paul Kestner

United Kingdom of Great Britain and Ireland—Sir William Pope and Mr. Henry Louis

Italy—Senator Paterno and Mr. Parodi Delfini

General Secretary—Mr. Jean Gerard, 49 Rue des Mathurins, Paris, France

During the public meetings held April 14 and 15, many communications of great interest were presented. Professor Louis, president of the Society of Chemical Industry, addressed the audience on the processes of the concentration of iron minerals by magnetic separation. It is not necessary to point out the importance of this problem when one remembers that France will soon become one of the first iron producers of the world.

Dr. Cottrell described the developments in the United States toward procuring the helium desired for filling balloons and dirigibles. Although this problem is not now of such immediate interest, it illustrates one of the most interesting instances of progress in chemistry during the war, a result which will supply in industrial quantity a gas which before has been only a laboratory curiosity.

Professor Moureu, the first to show the existence of helium resources in France, and Mr. George Claude, inventor of the Claude process for the liquefaction of air, made a few remarks with the object of drawing the attention of the scientific world to the possible consequences of this discovery as much from a theoretical as from a practical view.

The meeting closed with a communication from Mr. MacDowell on the potash industry in the United States. This industry, originating with war needs, is now flourishing. It furnishes to agriculture a part of the necessary potash required in America. However, the production is still insufficient, and Mr. MacDowell made a request for the surplus Alsatian potash to replace in the United States the German potash from Stassfurt.

At the April 15th meeting, one of the American delegates to the Peace Conference, Mr. John C. Pennie, discussed patent legislation in the United States. This legislation, the result of an idea inscribed in the fundamental constitution of the United States, is carried out in an extremely liberal spirit as compared to that existing in European countries.

Mr. Barbet suggested the creation of an interallied patent, and the meeting closed with an extremely interesting communication by Mr. Otlet, Directeur de l'Office International de Bibliographie, on the organization of international publications and the function of the chemical associations.

Two of the most important industrial establishments in France, the Kuhlmann Company and Solvay & Company, invited the members to luncheon. The luncheons were served at the Laurent Restaurant, presided over by Mr. Donat Agache, representing the Kuhlmann Company, and at the Marguery Restaurant presided over by Mr. Talvard, director of the Solvay Company.

A farewell banquet brought the members together at the Palais d'Orsay. The members of the Conference were present, together with many influential men of the scientific and industrial chemical world. The banquet was presided over by Mr. Loucheur, Ministre de la Reconstitution Industrielle, assisted by Mr. Boret, Ministre de l'Agriculture et du Ravitaillement.

At the guest table there were present: Lord Moulton, Sir William Pope, Prof. Henry Louis, Mr. Levinstein, Mr. Wigglesworth, Maj. Frederick Keyes, Mr. John C. Pennie, Professor Chavanne, Prof. Emmanuel Paterno, Prof. Moureu, Mr. Paul Kestner, president of the Société de Chimie Industrielle, Messrs. Haller, Le Chatelier, and Adolphe Carnot, members of l'Institute, Mr. Cahill, Commercial Attaché to the English Embassy, Mr. Poulenc, president of the Société Chimique de France, Mr. Duchemin, president of the Syndicat Général des Produits Chimique, Mr. Renard, Deputy and former Minister, Mr. Gaston Menier, Senator, Mr. Fleurent, Directeur de l'Office des Produits Chimiques et Pharmaceutiques au Ministère du Commerce, Mr. Roux, Directeur des Service Scientifiques au Ministère de l'Agriculture, Mr. Lheure, Directeur Général du Service des Poudres, Mr. Behal, member of l'Académie de

Médecine, and Mr. Dordes, Directeur des Services Scientifiques au Ministère des Finances.

By the generosity of the Compagnie des Produits Chimiques d'Alais et de la Camargue, the Société de Chimie Industrielle was enabled to invite to the banquet the many representatives of the Chemical War Service, including Belgian, American, English, Italian, and French, and to thus pay respect to the very important coöperation carried on during the war by the allied chemists. After a concert given by the band of the Republican Guard, Mr. Kestner gave a brief history of the Society of Chemical Industry, of which Mr. Henry Louis is president. It was founded 37 years ago, has 14 sections and 5,000 members. It is a fine example. If we wish to develop economically, to supply our needs, to become exporters, these are examples of combination which we should follow. Then speaking of the ruined industries:

> If you come to see our ruins, our destroyed factories, our tools mutilated or stolen, our soil rendered barren, the horrible sight will remain forever with you to confirm the necessity of complete reparation.

Prof. Henry Louis then spoke as follows:

> There is no doubt that we have carried off a complete and glorious victory on the field of battle, serving with true and loyal means against the ignoble arms that the enemy has employed; in the same manner, we will win a victory not less pronounced in the economic war for which our enemy has long since been prepared, and all her industrial preparations will be destroyed by our allied technic as surely as her military preparations were crushed by the heroism of our soldiers.

During the course of a talk by Sir William Pope, the following words were much applauded:

> I would like to express to you the pleasure with which we have seen the return to France of the right bank of the Rhine which gives back to her the raw materials indispensable for her industrial rebirth.

At these declarations the authorized representatives of the United States, Italy, and Belgium were unanimous in their enthusiasm.

And Mr. Loucheur, having the final word, said with charming simplicity and good humor that after having held chemistry in abomination—it had hindered him in entering Polytechnique—he had recognized its power and had determined to learn it. He stated that with aviation and the tanks it had won the final victory for us and that it enjoys the preference for its effort at coöperation. The effort must be effective, for Germany has not diminished her chemical industry; on the contrary, she has developed it considerably. She is a very formidable adversary whom we are going to meet in the economic struggles of tomorrow. In order to conquer her on this ground we must treat chemists as they deserve, encourage them, and stimulate their willingness, for, as an English proverb says, "Where there's a will, there's a way."

Before separating, the members of the Interallied Conference visited the devastated region of Chauny on Wednesday, April 16.

They were received by Mr. Gerard, President du Conseil d'Administration de la Société de St. Gobain, and observed the methods adopted by the Germans in their efforts to completely crush this industrial city where no battle took place.

Very much impressed by the visit to this place of destruction, the members of the Conference separated at the end of the journey.

The next Conference will be held in London in July.

AMERICAN CHEMICAL SOCIETY DYE SECTION

The initial meeting of the newly organized Dye Section of the American Chemical Society will be held at Philadelphia, beginning Wednesday, September 3, 1919, under the chairmanship of Dr. C. L. Reese. Everyone interested in the chemistry of dyes is invited to be present.

The Secretary of the Section asks all workers in the field of dyes to present the results of their scientific work at this and following meetings of the Dye Section. To this end the Secretary of the Section requests any one who has ready for publication any work on the chemistry of dyes to communicate with him at once, giving subject and time necessary for presentation.

Any information on the chemistry or engineering of the manufacture of dyes would be particularly pertinent to the present conditions of the dye industry in the United States. It is to be hoped that all engaged in the dye industry will realize the mutual help that will result from a liberal presentation of their discoveries and experiences.

Full details as to exact place of meeting and list of papers will be in the final program of the September meeting of the American Chemical Society. This program will be mailed to those requesting it by either Dr. C. L. Parsons, Box 1505, Washington, D. C., or the undersigned.

R. Norris Shreve, *Secretary*

43 Fifth Ave., New York City
June 11, 1919

NATIONAL RESEARCH FELLOWSHIPS IN CHEMISTRY

The National Research Council has made the following appointments to National Research Fellowships in Chemistry:

F. R. Bichowsky, of Washington, D. C., A.B. (Pomona, '12), Ph.D. (California, '16), physical chemist at the Geophysical Laboratory of the Carnegie Institute of Washington since 1916, who plans to conduct researches at the University of California.

Emmett K. Carver, of New York City, A.B. (Harvard, '14), Ph.D. (Harvard, '17), formerly assistant to the director of the Wolcott Gibbs Memorial Laboratory at Harvard and recently Captain, Chemical Warfare Service, U. S. A.

W. H. Rodebush, Ph.D. (California, '17), research chemist for the United States Industrial Alcohol Company of Baltimore, who will conduct researches at the University of California on specific heats and other properties of substances at low temperatures.

Warren C. Vosburgh, of New York City, B.S. (Union College, '14), A.M. (Union College, '16), Ph.D. (Columbia University, '19), research assistant to the professor of chemistry at Columbia University for the past six months.

George Scatchard, of New York City, A.B. (Amherst College, '13), Ph.D. (Columbia University, '17), formerly research assistant to the professor of chemistry at Columbia University and instructor in organic chemistry, and recently First Lieutenant, Sanitary Corps, U. S. A.

FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES, CHICAGO, ILLINOIS, WEEK OF SEPTEMBER 22 TO 27, 1919

The week of September 22, 1919, when the greatest exposition of the chemical industries in the world holds forth in the Coliseum and First Regiment Armory, will be one of convocation of many societies in Chicago with the Exposition.

The American Institute of Mining Engineers will occupy the stage for the first part of the week, the American Ceramic Society meets on Wednesday, September 24, the American Electrochemical Society on Thursday, Friday, and Saturday, September 25, 26, and 27. The dates of the Technical Association of Pulp and Paper Industry were not announced at the time of going to press.

Among the interesting features of the Exposition program will be a symposium upon "Safety in the Plant and Mine" with speakers of authority in this work under the chairmanship of M. L. Leopold, safety engineer of the U. S. Bureau of Mines, and in the evening after this meeting—which will occupy an entire afternoon—there will be shown a series of motion pictures which are now being made in industrial plants all over the country under the supervision of government agents, of safety work in plant, field, and mine.

Even in motion pictures, as in all important improvements in plant machinery and products, the Exposition is outstanding as the place of introduction to the public of the newest and most recent developments. Each improvement of the projectoscope in motion picture projection has been reserved for first public demonstration at the Exposition which again this year will have the latest developments in this field of endeavor.

There have been many developments in the way of new exhibits that are engaged for the Exposition: of these, it is not circumspect to list them all, but mention may be made of the group of electric furnace exhibits which will be there, and in operation. These will give men of science, probably for the first time, an opportunity to see and compare the various designs and judge them for the different lines of work to which they are applicable.

A glance at the roster of exhibitors causes one to look forward with interest to the opening of the Exposition and its exhibits.

A BUILDING FOR THE AMERICAN CHEMICAL SOCIETY

Editor of the Journal of Industrial and Engineering Chemistry:

At the recent Council Meeting of the SOCIETY held in Buffalo, a brief reference was made to the growing need for a building to serve as the permanent administrative headquarters of the SOCIETY and to provide accommodations for the editing of *Chemical Abstracts*, the compilation of compendia of chemical literature, and possibly other activities of the SOCIETY.

There were far too many matters requiring the immediate attention of the Council to permit discussion of this proposal and it was simply mentioned in order that the officers of the SOCIETY might keep it in mind for future careful consideration. The purpose of the present note is to bring the matter to the attention of a larger number of our members in the hope that the advantages of a building for the SOCIETY may become more generally recognized.

The arguments in favor of a permanent home address of the AMERICAN CHEMICAL SOCIETY as compared with a post office box number for the Secretary's office need hardly be mentioned. The determining consideration, so far, has undoubtedly been the question of cost. While we were a struggling young SOCIETY, it certainly would have been unwise to divert funds so urgently needed for our publications to providing a home office for the SOCIETY. We have, undoubtedly, been exceptionally fortunate so far, in not having to pay rent for offices; and, although there appears to be no immediate apprehension that this subsidy to the SOCIETY will be terminated, nevertheless, it should not be counted on indefinitely. It is conceivable that even in spite of the great contributions American chemists have recently made to the Government's conduct of the war, a question may sooner or later be raised in regard to the propriety of the continued use of government offices for the business of our SOCIETY. Furthermore, in the case of *Chemical Abstracts* we cannot be sure that the present institution will continue to furnish free quarters and we may have difficulty in finding free accommodations elsewhere.

Even though the apprehensions expressed above may be ill founded, a very real argument in favor of having our own home lies in the possibility of a more economical and efficient organization of our activities. The advantages in this respect appear to have been realized by organization similar to ours both here and abroad. As examples, may be mentioned the engineering societies of the United States, the American Medical Association, and the English and German chemical societies. The building of the German Chemical Society in Berlin contains in addition to the administrative headquarters, the editorial office of *Chemische Zentralblatt, Berichte, Beilstein,* and *Landolt-Börnstein*, as well as a library and large lecture hall.

There is little doubt that the work involved in the compilation of physical-chemical constants and data of inorganic and organic chemistry can be most economically done in connection with the search of the literature required for our *Chemical Abstracts*. The intimate coördination of these projects, and provision for their permanent organization and continued expansion, is perhaps the strongest argument for a building for our SOCIETY.

The possibilities of utilizing such a building for many other purposes in connection with the advancement of chemistry in America are unlimited. A bureau of chemical intelligence, as recently suggested by Dr. A. M. Patterson,[1] would naturally find its logical place in such a building. Many other projects will quickly suggest themselves, such as: (1) The collection of very rare journals and other publications abstracted in *Chemical Abstracts*, but usually not available in libraries; (2) the collection of relics and data of historical interest to chemistry in America; (3) a repository for rarer compounds, dyes, and other chemical products; (4) a section devoted to patents; (5) possibly a bureau of employment.

If such a building, devoted to the needs of American chemists, were located in Washington, it would, in addition to eliciting the pride of our own members, be an object of interest to many of the visitors who annually come to the nation's capital. Can we overestimate the value of such a building to us when we consider what we might gain thereby in the way of publicity and the general public's knowledge of and interest in our activities?

There is hardly a doubt that if a suitable building were presented to the AMERICAN CHEMICAL SOCIETY, it would be accepted and used to great advantage by several branches of our organization. If this is granted, the question arises whether the matter is not of enough importance for us to exert ourselves actively to secure a building. The point then is, how great an effort would be required, that is, how costly a building is needed? On the basis of conditions as they exist in Washington it would appear that an initial outlay of about $25,000 would secure a building which would serve our purpose for some years at least. This would mean the purchase of a centrally located building which could be remodeled for our use and enlarged from time to time as required, or eventually replaced by an entirely new and commodious structure. Taking this estimate as a minimum, the upper limits of the undertaking would be governed only by the amount of money which could be collected for the purpose.

The question of securing the relatively small sum suggested should certainly not be a serious matter. There is little doubt that many of our members would be willing to contribute to this object and funds from public-spirited individuals outside the SOCIETY might also be expected. Whatever amount is thus secured and invested in a building becomes a part of the permanent assets of the SOCIETY which constitute the surest possible provision for the future.

ATHERTON SEIDELL
President, Chemical Society of Washington

WASHINGTON, D. C.
May 15, 1919

THE CANADIAN INSTITUTE OF CHEMISTRY

The Chemists' Organization Committee, appointed at the convention of Canadian Chemists held in Ottawa, May 1918, submitted to the second convention held at Montreal, May 16 and 17, 1919, a report, the main recommendations of which were, briefly, as follows: The task of organizing chemists in Canada should be carried out by an entirely new and separate organization, to be known as the Canadian Institute of Chemistry, the membership to consist of Fellows and Associates. The qualifications for the Fellowship should be: (1) Graduation at a

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[1] THIS JOURNAL, **11** (1919), 487.

university after a four-year course with chemistry as chief subject; or (2) graduation at a university after a three-year course with chemistry as main subject, followed either by a further year's university training in chemistry, or by two years' experience in an approved laboratory; or (3) five years' active experience—with a responsible position—in either pure or applied chemistry, and the passing of an examination before a board appointed by the Institute. This examination may be waived in the case of chemists already practicing at the date of incorporation of the Institute. The minimum age of Fellows is to be 25 years; below that age the same qualifications are to apply for the Associateship. An Associate is to become Fellow on reaching 25 years of age on the recommendation of five Fellows, provided he has practiced chemistry for at least two years. All candidates must satisfy the examiners that they have had a good general education.

The objects of the new organization are to raise the status of the profession and so attract the best intellects; to have available an organization that can be consulted by the government in times of crisis; to protect the public; and to assist chemists by establishing registration and employment bureaus, a library, and centers for social and scientific intercourse.

The results of elections at a meeting held on May 21 were:

President: Prof. J. Watson Bain, of the University of Toronto.

Vice Presidents: Dr. George Baril, Laval University, Montreal; Dr. A. McGill, Chief Analyst, Department of Trade and Commerce, Ottawa; Dr. R. D. MacLaurin, University of Saskatchewan, Saskatoon, Sask.

Secretary-Treasurer: Harold J. Roast, F. I. C., Montreal.

Executive Members: Prof. E. G. R. Ardagh, University of Toronto; Dr. J. S. Bates, Kenogami, P. Q.; Dr. T. E. Bigelow, Mount Allison University, Sackville, N. B.; S. J. Cook, Department of Trade and Commerce, Ottawa; J. A. Dawson, Department of Trade and Commerce, Vancouver; I. Grageroff, Montreal, Que.; Dr. L. F. Goodwin, Queen's University, Kingston; Prof. A. Lehman, University of Alberta, Edmonton; Prof. E. MacKay, Dalhousie University, Halifax, N. S.; Prof. M. A. Parker, University of Manitoba, Winnipeg.

It was decided that the fees for Fellows in the Institute should be an entrance fee of $10.00 and an annual fee of $5.00. For Associates, the entrance fee will be made $5.00 and the annual fee $2.50. The secretary announced the first subscription to the Foundation Fund of the Institute, namely, a check for five hundred ($500) dollars from the James Robertson Co., Ltd., Montreal.

The office of The Canadian Institute of Chemistry is in the Kingdom Building, Beaver Hall Hill, Montreal, Quebec.

MEETINGS OF THE EXECUTIVE COMMITTEE OF THE DIVISION OF CHEMISTRY AND CHEMICAL TECHNOLOGY, NATIONAL RESEARCH COUNCIL

At the meeting held in Washington on April 21, 1919, there were present Messrs. Alsberg, Bancroft, Lamb and Washburn.

It was voted that a special committee on the chemistry of colloids be appointed to undertake the following specific projects:

(1) To arrange a series of lectures on different aspects of colloid chemistry by competent specialists and to make public the fact that such lectures have been arranged for and can be given at any institution or before a meeting of any interested body which will make the necessary financial arrangements with the committee.

(2) To secure the preparation and publication of a textbook and laboratory manual on colloid chemistry suitable for use in university courses in this field, both books to be prepared under the auspices of the committee and subject to the criticism of its full membership and any other experts whom the committee may desire to consult.

(3) To make a research census of investigations and investigators in the field of colloid chemistry.

The committee on colloid chemistry selected is made up as follows:

H. N. Holmes, Oberlin College, Oberlin, Ohio, *Chairman*
Jerome Alexander, 59th St. & 11th Ave., New York, N. Y.
W. D. Bancroft, National Research Council, Washington, D. C.
G. H. A. Clowes, Eli Lilly Co., Indianapolis, Ind.
W. A. Patrick, Johns Hopkins University, Baltimore, Md.
J. A. Wilson, 203 Juneau Ave., Milwaukee, Wis.

The following questionnaire relating to the economic and educational conditions affecting opportunities for research in universities was approved:

ECONOMIC AND EDUCATIONAL CONDITIONS AFFECTING OPPORTUNITIES FOR RESEARCH IN UNIVERSITIES

The Division of Chemistry and Chemical Technology of the National Research Council is making a study of the research conditions in the departments of chemistry in the universities of the country in so far as these conditions are affected by the economic status of the members of the staff and the time available for carrying on research. Each member of the staff above the rank of assistant is requested to supply the Division with the information requested below. All such information will be treated as confidential and to this end it is requested that the name of the professor or instructor not appear upon this blank, but be placed upon the back of the inclosed return envelope in order that the completeness of the replies may be checked.

Age
Married
Number of dependents
University title
Degrees received, with dates
University salary
About how many hours per week (averaged throughout the school year) are you required to spend in
  (*a*) The class room (lectures, quizzes, etc.)
  (*b*) Laboratory teaching, exclusive of research courses
  (*c*) Preparation for (*a*) and (*b*)
  (*d*) Other university duties
  (*e*) Outside work to supplement income
Do you find it difficult to conduct research because of lack of equipment?
Does your institution (*a*) encourage, (*b*) discourage, or (*c*) adopt an indifferent attitude toward the prosecution of research by its professors?
Name and address of institution

A letter from Edward F. Harrison, of Philadelphia, with reference to a proposed chemo-mechanical method for extracting organic matter from sewage was presented, and it was recommended that Mr. G. C. Whipple, sanitary engineer, be consulted with regard to what action, if any, the Council might take with reference thereto.

A letter from Mr. H. J. Wheeler, chairman of the former Committee on the Chemistry of Soils and Fertilizers, recommending the continuation of such a committee, was presented, but no action was taken.

A letter from Dr. Charles E. Munroe, chairman of the Committee on Explosives Investigations, relating to the appointment of a committee to arrange for a series of coöperative investigations dealing with the specific heats of explosive materials, was presented.

It was voted that a committee of three members, to consist of the chairman of the Division, the chairman of the Explosives Investigations Committee, and one additional member (to be selected by them) of recognized standing as an expert in calorimetry, be appointed.

It was voted, however, to suggest to that committee the advisability of arranging to have the desired investigations all done, if possible, by one person, for example, as a master's thesis, instead of distributing the work among a larger number of less qualified students.

A letter from Dr. Edwin A. Hill, of the United States Patent Office, dealing with the status of the card index of chemical literature and making certain recommendations concerning the desirability of expanding it into a Bureau of Chemical Intelligence, was presented, and it was voted to transmit this letter to the Research Information Service for consideration and report.

A revised statement of the recommendations of the Division with respect to the formation of an International Chemical Council was presented and approved. The recommendations in their final approved form are as follows:

1—That an International Chemical Council be constituted; and that, if possible, arrangements be made for transferring the funds originally given to the International Association of Chemical Societies to this International Chemical Council.

2—That the object of the International Chemical Council be to initiate and promote international coöperation in chemistry; for example, by arranging:

(a) For international coöperation in the preparation and publication of chemical literature.

(b) For the appointment of international commissions to deal with special chemical questions of standardization (such as atomic weights, nomenclature, etc.).

(c) For international coöperation in the prosecution of special research projects.

(d) For the calling of international chemical conferences for various purposes; and also for the organization of an International Chemical Congress with meetings at stated intervals, and including all of the scientific and technological branches of chemistry.

3—That the International Chemical Council be constituted of delegates representing the leading chemical societies and other chemical research organizations of the several allied and neutral countries, these delegates to be selected as described in Paragraph 5.

4—That the International Chemical Council be affiliated with the International Research Council; and that the National Research Council of each country or its National Academy when no Research Council has been created, act as the intermediary in communications between the International Chemical Council and the chemical organizations of that country, and arrange for the proper representation of those organizations in accordance with Paragraph 5.

5—That the delegates from each country shall in general be chosen by the major chemical societies in that country, but that the number and distribution of such delegates and their voting strength within the delegation be determined initially by the National Research Council of that country, with the understanding that in countries where a National Research Council shall not have been organized the National Academy itself shall fulfill this function until the National Research Council is organized.

6—That upon all questions voted upon by the International Chemical Council the number of votes cast by the various countries shall be determined by their population as follows:

Countries of less than 5 million inhabitants have 1 vote
Countries between 5 and 10 million inhabitants have 2 votes
Countries between 10 and 15 million inhabitants have 3 votes
Countries between 15 and 20 million inhabitants have 4 votes
Countries over 20 million inhabitants have 5 votes

The inhabitants of colonies and possessions are included in the population of the country to which they belong, according to the indications of its government. Each self-governing dominion has the same number of votes as an independent country according to the above scale.

7—That the International Chemical Council, as soon as it shall be organized, shall elect an executive committee of seven members, which shall exercise such functions as may be assigned to it by the Council. The executive committee shall appoint an executive secretary, who shall have charge of correspondence and of the central office of the Council.

8—That until the International Chemical Council shall be organized and its executive committee appointed, the Committee on International Coöperation in Chemistry appointed by the Paris Conference shall act as a provisional executive committee for purposes of organization. Its membership shall, however, be increased by the addition of four members representing industrial chemistry, to be appointed, respectively, by the Royal Society of London, the Academie des Sciences de France, the Academia dei Lincei, and the National Research Council of the United States. This committee shall elect a chairman and a secretary, but the latter need not be a member of the committee.

A detailed statement of the resolutions adopted by the Council of the AMERICAN CHEMICAL SOCIETY at the Buffalo meeting, with reference to the publication of chemical compendia and critical tables of physical and chemical constants [THIS JOURNAL, 11 (1919), 415] was presented.

It was voted that in the opinion of the Division the plan proposed in those resolutions should be amended so as to strike out the one-year limitation on the terms of office of the trustees and committees provided for therein, it being the opinion of the Division that all such appointments should be made for an indefinite period, the understanding being that the appointees would in so far as possible continue until the completion of the work undertaken. (See minutes of meeting of April 29, 1919.)

Messrs. Bancroft and Washburn were appointed a committee to act for the Division on all questions relating to the organization of the machinery for inaugurating the proposed compilation and publication of critical tables of physical and chemical constants.

A verbal suggestion from Dr. Munroe, concerning the advisability of creating a committee to look into the question of the use of explosives as fertilizing materials, was presented, and Dr. Alsberg was appointed a special committee to look into the matter and make recommendations at the next meeting of the Executive Committee.

....

At the meeting on April 29, 1919, there were present Messrs. Alsberg, Bancroft, Lamb, Stieglitz and Washburn, and by invitation, Messrs. Hillebrand, Parsons, and Moore, members of the Division, and Livingston, liaison member from the Division of Biology and Agriculture.

The appointment of Dr. W. P. White as a member of the Committee on Specific Heats of Explosive Materials was approved.

It was voted that the action taken at the previous meeting regarding the term of appointment of trustees and committees in connection with the preparation of chemical compendia and critical tables be amended to read as follows:

That in the opinion of the Division the committee of seven charged with the scientific control of the undertaking should be appointed for such terms as the appointing powers shall decide.

It was voted that the Committee on Scientific Control of the Tables on Physical and Chemical Constants be requested to take up at an early date the question of what particular physical properties of organic compounds are of most importance to the organic chemists, with the idea that standard methods for determining such properties might be worked out with the coöperation of the Bureau of Standards and such methods published and be made generally available for the use of organic chemists.

A letter from Dr. Marie, editor of the Annual Tables of Physical and Chemical Constants, addressed to Dr. Stieglitz and recommending that the International Commission in charge of those tables should take up at once the matter of preparing a set of critically digested tables, was presented, together with Dr. Stieglitz' reply thereto. Dr. Stieglitz' reply was to the effect that in his opinion the International Commission in charge of the Annual Tables was not in a position to handle such an undertaking under present conditions for a variety of reasons which he mentioned, and that such tables could better be prepared by this country in accordance with the program adopted by the AMERICAN CHEMICAL SOCIETY.

The Division voted concurrence in the views expressed by Dr. Stieglitz in his reply to Dr. Marie.

The Division approved the addition of the American Society of Biological Chemists to the list of societies which elect delegates to the International Chemical Council, this Society to elect one such delegate.

Dr. Parsons requested that members of the Division send to him suggestions regarding the personnel of the two control committees to be charged with the preparation of the series of technological and scientific monographs, to be published by the AMERICAN CHEMICAL SOCIETY, and also suggestions as to subjects for such monographs and suitable persons to undertake their preparation. He also informed the Division that the AMERICAN CHEMICAL SOCIETY had named E. G. Love and C. L. Parsons as trustees in charge of the monograph series, and Julius Stieglitz as trustee for the "Table."

A letter from Dr. C. E. Munroe, chairman of the Explosives Investigations Committee, concerning the investigation of explosives as fertilizer materials, was presented, and after extended discussion it was voted that Dr. B. E. Livingston be requested to present the matter to the Division of Biology and Agriculture for consideration and report, with the understanding that if that Division should decide that a committee to deal with the matter ought to be appointed, the Division of Chemistry and Chemical Technology would concur therein and would act with the Division of Biology and Agriculture in the formation of a joint committee.

Dr. Alsberg was appointed by the Division as its liaison member with the Division of Biology and Agriculture.

The proposed questionnaire with regard to economic and educational conditions affecting opportunities for research in universities was amended to include a question to the following effect:

> Do you desire to have brought to your attention, from time to time, research problems which need investigating and which would make suitable thesis subjects for advanced students? If so, state field of chemistry preferred.

....

At the meeting on May 15, 1919, those present were Messrs. Alsberg, Bancroft, Lamb, Washburn and Leuschner, liaison member from the Division of Physical Sciences.

It was voted, first, that the Division recommend the appointment of Lt. Col. A. B. Lamb, C. W. S., Dr. F. G. Cottrell, Chief Metallurgist, Bureau of Mines, and Lt. Col. J. E. Zanetti, C. W. S. as three of the American delegates to the meeting of the International Chemical Council to be held in London next July; second, that the chairman of the Division be named as alternate for Mr. Lamb in case he should be unable to go; third, that the chairman of the Division be instructed to ascertain the names of prominent American chemists who may possibly plan to be in Europe at the time of the July meeting of the International Chemical Council and to arrange, if possible, to secure the attendance of such men at the meeting of the Council as additional American delegates.

It was voted that the name of Professor Gellert Alleman, Swarthmore College, Swarthmore, Pa., be placed before the chairman of the National Research Council as nominee of this Division for appointment by the Council as one of the three trustees in charge of the series of monographs to be published by the AMERICAN CHEMICAL SOCIETY.

It was voted that the names of Dr. Arthur L. Day, Geophysical Laboratory, Washington, D. C., and Mr. Elihu Thomson, Lynn, Mass., be transmitted to the Division of Physical Sciences with the recommendation that it concur in the nomination of one of these gentlemen as chairman of the Board of Trustees in charge of the business control of the critical volumes on physical and chemical constants, the appointment of this position to be made by the chairman of the National Research Council.

It was voted that a Committee on Sewage Disposal be formed to undertake the following projects:

1—To prepare a research survey of the field with special reference to possible methods of sewage disposal which will recover the valuable oils, fats, and fertilizer constituents of the sewage; this survey to include statistical data and a discussion of the economic aspects of the subject as well as the scientific ones.

2—To outline a series of basic research problems necessary to the further extension of our knowledge of the possibilities of recovering and utilizing the valuable constituents of sewage.

3—To ascertain what researches are already in progress in the country in connection with this problem and, if it seems desirable, to prepare a list of sewage experiment stations or similar organizations whose equipment and staffs may possibly be utilized in connection with any project of coöperative research which it seems wise to undertake.

4—To prepare general plans and estimates of cost of establishing a sewage experiment station to study new methods of treating sewage for the recovery of its valuable constituents and to work in close coöperation with investigators now engaged or who in the future may be interested in undertaking physical, chemical, or biochemical investigations on various aspects of the problems which present themselves.

5—To investigate particularly the Rice process and the Miles process of sewage treatment and to make recommendations to the Division as to what action, if any, the Council might take with reference to research or development in connection with one or both of these processes.

It was voted that the Committee on Sewage Disposal be constituted with the following personnel:

PROF. G. C. WHIPPLE, Professor of sanitary engineering, Harvard University, *Chairman*
MAJ. C. G. HYDE, Surgeon General's Office, War Department, Washington, D. C. (professor of sanitary engineering, University of California)
LT. COL. EDWARD BARTOW, Sanitary Corps, U. S. A., A. E. F., Water Analysis Laboratory, U. S. A. P. O. No. 702(?) (Chief of the Illinois State Water Survey and professor of sanitary chemistry, University of Illinois)
LT. COL. W. D. BANCROFT, C. W. S., American University Experiment Station, Washington, D. C. (Chairman, Division of Chemistry and Chemical Technology, National Research Council, representing colloid chemistry)
PROF. E. B. PHELPS, Cr. Dr. Charles North, 30 Church St., New York City
MR. MARTIN H. ITTNER, 105 Hudson St., Jersey City, N. J., an organic chemist, who is a specialist in the chemistry of oils and fats
DR. W. W. GARNER, Physiologist, Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C., expert on the chemistry and use of organic fertilizer materials

The Committee on the Chemistry of Colloids was authorized to proceed with the preparation and publication of a suggestive bibliography of literature on colloids of a brief and elementary nature to serve as a guide to chemists wishing to take up the study of this subject.

The title of the Committee on Specific Heats of Explosive Materials, authorized at the meeting of April 21, was changed to the Committee on the Thermal Properties of Explosive Materials.

The following personnel was approved for the Committee on Synthetic Drugs:

JULIUS STIEGLITZ, University of Chicago, Chicago, Ill., *Chairman*
MOSES GOMBERG, University of Michigan, Ann Arbor, Mich.
G. W. MCCOY, Director of Hygienic Lab., United States Public Health Service, Washington, D. C.
FRANCIS M. PHELPS, Pacific Building, Washington, D. C.
W. A. PUCKNER, Chief, American Medical Association Chemical Laboratory, Chicago, Ill.
EDWARD S. ROGERS, People's Gas Building, Chicago, Ill.

The following extracts from the minutes of the meeting of the Division of Physical Sciences on May 1 were brought to the attention of the Committee:

> *Moved:* That the Division of Physical Sciences approve in principle the plan for the publication of critical tables of physical and chemical constants, as outlined in the "Report by the Committee on Publication of Compendia of Chemical Literature, etc.," and that the acting chairman be authorized to appoint two members to represent the Division of Physical Sciences on the Committee to be formed in accordance with the following motion passed at the meeting of the Executive Board of the Council, April 15:
>
> *Moved:* That a copy of the Report on Publication of Compendia of Chemical Literature, etc., be sent to the members of the Executive Board prior to the next meeting, and that a committee consisting of two members of the Division of Chemistry and Chemical Technology, two members of the Division of Physical Sciences, one member from the Bureau of Standards, and one member from the Smithsonian Institution, be appointed to report on the proposed project at the next meeting of the Executive Board. Adopted.

In response to a request of the Chemical Division for the appointment of a liaison officer to act with them, the following motion was made:

Moved: That the appointment of a liaison officer from this Division to act with the Chemical Division be referred to the Executive Committee with power. *Adopted.*

Moved: That the Division does not concur in the method proposed by the Division of Chemistry for making a research survey. *Adopted.*

Moved: That the Division on Educational Relations be requested to coöperate with the Executive Committee of this Division and that of Chemistry and Chemical Technology in formulating proper plans whereby a research survey might be made and report back to the Division. *Adopted.*

SCIENTIFIC SECTION AMERICAN PHARMACEUTICAL ASSOCIATION

During the annual convention of the A. Ph. A. to be held in New York the week beginning August 25, 1919, the Scientific Section will hold meetings on Thursday and Friday, August 28 and 29. Those desiring to read papers before this section should submit them to the Secretary, Dr. A. G. Du Mez, Hygienic Laboratory, U. S. P. H. S., Washington, D. C., not later than August 10, 1919.

CALENDAR OF MEETINGS

Society of Chemical Industry—Annual Meeting, London, July 15 to 18, 1919.

American Chemical Society—Fifty-eighth (Annual) Meeting, Philadelphia, Pa., September 2 to 6, 1919.

American Institute of Mining and Metallurgical Engineers—Chicago, Ill., September 22 to 26, 1919.

National Exposition of Chemical Industries (Fifth)—Coliseum, Chicago, Ill., September 22 to 27, 1919.

American Electrochemical Society—Fall Meeting, Chicago, Ill., September 23 to 25, 1919.

NOTES AND CORRESPONDENCE

SHALL WE HAVE ANNUAL PATENT RENEWAL FEES?

Editor of the Journal of Industrial and Engineering Chemistry:

Our patent system is founded on the constitutional provision that "The Congress shall have power * * * * to promote the progress of science and useful arts, by securing for limited times to authors and inventors, the exclusive right to their respective writings and discoveries. * * * * *" Note the "promote the progress." It seems to me only fair to assume, therefore, that Congress is *not* to grant these exclusive rights if by so doing "progress of science and useful arts" is avoidably or needlessly obstructed or impeded.

In the following a partial remedy is suggested for the cure of such cases where there is avoidable obstruction or impediment to such progress through the grant of such exclusive rights.

Fundamentally, our patent system is the most generous and liberal patent system in the world and more patents have been taken out in this country than anywhere else. Nevertheless, I think this very generosity and liberality has in some substantial respects seriously disadvantaged us. I believe that can be cured without diminishing the generosity and liberality of the system as a whole.

Because I was then personally satisfactorily convinced that many of our patents avoidably and needlessly obstructed progress, I stated in a paper read before the New York Section of the AMERICAN CHEMICAL SOCIETY, ten years ago, on January 8, 1909 (see *Electrochemical and Metallurgical Industry*, Feb. 1909, p. 78), "that an inventor who allows his patent to lie idle transgresses the spirit underlying the patent system. He is reserving to himself a field of endeavor which he has agreed to exploit and is not exploiting and by his reservation he prevents its exploitation by others and thus retards progress.

"A partial remedy for this might be a low annual tax, say $15 or $25 or some other sum, not high enough to stand in the way of any inventions giving any reasonable promise of remuneration, yet high enough to make it appear unprofitable to retain reservation in fields which they are either unwilling, unable, or incompetent to develop."

Revenue was and is only an incidental result of that suggestion; its sole purpose is to correct that abuse and the income is wholly secondary and for my purposes entirely beside the point.

The discussion that followed will long be a most vivid recollection for me. Everybody (so it seemed) jumped on me and so hard that I thought I hadn't a friend in the room.

Among the things that convinced me then that I was right in the above suggestion was the large number of forfeitures for non-payment of renewal fees or taxes regularly published in England and in Germany and also that about three-fourths of a long string of British patents cited as anticipatory references in the recent patent litigation had turned out to be so "valuable" that their owners (and among them Henry Deacon) had forfeited them rather than pay $25 for the fifth year of the monopoly grant.

The reasons advanced by those who ten years ago opposed this suggestion were, on the one hand, that the poor inventor would be discriminated against and invention by him discouraged, and on the other hand, rich corporations would not be deterred by any such fees.

It must be remembered that the United States is the only major country that does *not* have an annual fee system; that in and of itself does not by any means make the tax system right. But there is an obvious discrimination against United States inventors through the absence of such a fee system in this country because, when a German inventor forfeits his German patent, he thereby throws that field open to development and exploitation by Germans in Germany but because he does not also and at the same time relinquish his corresponding rights in the United States we are barred by our own laws and by our own acts from enjoying a liberty of action and a freedom of motion that the Germans enjoy. A dead German patent, therefore, still lives and rules in the United States.

Supposing we had had in force the following fee system modeled after that of England, Germany, and other European countries:

First year, to and including the seventh year, no fee

8th year	$10	13th year	$ 60
9th year	$20	14th year	$ 70
10th year	$30	15th year	$ 80
11th year	$40	16th year	$ 90
12th year	$50	17th year	$100
	TOTAL, $550		

How many of the 1200 Bayer patents recently sold by our Alien Property Custodian would have been in force at the time of sale? To keep them alive for their full statutory term would have cost $660,000, or an average of $66,000 per year. It is unreasonable to assume that there are no "dead horses" among 1200 patents and no one wants to pay for a "dead horse" although no one, in such a case, would mind having him so long as he costs nothing.

In order to present an idea of how the German tax system operates in Germany on German patents in Class 12: chemical processes and apparatus; Class 22: dyes, varnishes, lacquers, paints and adhesives; and Class 23: oils and fats collectively, consider the following table constructed for me from official German documents:

	Total No. of Patents Granted during Each Year from 1900 to 1914 in These Classes	Total No. of Patents Still in Force on March 1, 1915 in These Classes	Percentage of Patents Still in Force on March 1, 1915
1914	852	852	100% (1st yr.)
1913	870	811	93% (2nd yr.)
1912	863	684	79% (3rd yr.)
1911	656	504	77% (4th yr.)
1910	702	351	50% (5th yr.)
1909	567	286	50% (6th yr.)
1908	620	253	41% (7th yr.)
1907	621	237	38% (8th yr.)
1906	542	233	43% (9th yr.)
1905	545	124	23% (10th yr.)
1904	420	80	19% (11th yr.)
1903	518	85	16% (12th yr.)
1902	685	80	12% (13th yr.)
1901	627	37	6% (14th yr.)
1900	417	1	0.5% (15th yr.)
TOTAL	9505	4619	49%

Life of grant of German patent, 14 years.
Average effective life of German patent less than 7 years.

Invention and "the progress of science and useful arts" may very well have been impeded rather than promoted thereby in Germany; and that, even though the exact contrary has been very strenuously maintained in this country and in the very recent past for the German patent system by some who, by no stretch of imagination, could be termed, that present-day *rara avis*, "Germany's friend."

To get at material capable of answering that question would call for determination of ownership of each of the 9505 German patents in the preceding table and that would be a long, tedious, and expensive job. In order to get a complete picture the same operations should be gone through for Austria, England, France, Italy, Japan, Switzerland, and any other relevant countries. Then we might have material for an answer to the question so far as the chemical and allied industries are concerned. Then the whole job would have to be gone over again for the other industries. Rather a tall order!

For seven of the leading chemical countries the following table of renewal fees has been compiled from Fairweather's "Foreign and Colonial Patents" published in 1910. In this the Austrian crown, the French and Swiss francs, and the Italian lire have been taken at 20 cents each, the German mark at 25 cents, the English pound at $5, and the Japanese yen at 50 cents.

	Austria	England	France	Germany	Italy	Japan	Switzerland
1	..	..	..	.....	$ 8	....	..
2	$ 10	..	$ 20	$ 12.50	8	....	$ 6
3	12	..	20	25.00	8	....	8
4	16	..	20	37.50	13	$ 5.00	10
5	20	$ 25	20	50.00	13	5.00	12
6	24	30	20	62.50	13	5.00	14
7	32	35	20	75.00	18	7.50	16
8	40	40	20	87.50	18	7.50	18
9	48	45	20	100.00	18	7.50	20
10	56	50	20	112.50	23	10.00	22
11	72	55	20	125.00	23	10.00	24
12	88	60	20	137.50	23	10.00	26
13	104	65	20	150.00	28	12.50	28
14	120	70	20	162.50	28	12.50	30
15	136	..	20	175.00	28	12.50	32
	$778	$475	$280	$1312.50	$270	$105.00	$266

The above suggestion of a total fee of $550 may appear high and reduction to one-half or to $275 by starting from a $5 fee and an increase of $5 may seem desirable.

Men for whose sound judgment I have very willingly great respect tell me that for the United States to adopt a fee system like the one above outlined would stifle invention and impede progress. Men for whose sound judgment I am bound to have equal respect tell me the exact opposite! Which group is right? I am free to confess I am more than ever convinced that the second group is.

To be sure, the Committee on Patent and Related Legislation of the AMERICAN CHEMICAL SOCIETY, of which I happen to be a member, might go ahead and examine the question thoroughly. But, as above shown, that is a colossal job if it is to be well done and will run into money quite handsomely. This is, therefore, a question on which the membership should express itself because there are so many angles to it that no one man or any small group of men can reasonably hope to tackle them conclusively.

I am of the opinion that such a tax system would effectively remove much of the grip which foreign—and especially German—inventors have on our domestic industry and would also relieve use of the congestion due to patents to our own citizens which are not exploited, or serve no useful purpose, and to some extent, at any rate, of that class of domestic patentees designated, more or less unjustly perhaps, as patent sharks, trailers, or pirates. In other words, the dead wood would be cleared out. Therefore, I express the hope that our members will seriously look into this matter from all angles and particularly those that affect themselves, by conference with counsel, executive, operating, financial and sales officers, if need be; in order that this may grow into a tangible result I suggest that at the Philadelphia meeting next September our Industrial Division devote a part of its program to a constructive, systematic discussion and exploration of this subject to the end that our Committee on Patents may be in a position intelligently to deal with the question and for the greatest benefit to the greatest number. Here is surely a case where in a multitude of counsel lies wisdom.

There is little likelihood that any legislation creating such a tax system (if that is to be done) could be of much effect until after the eighth year of its existence because it would not apply to issued patents or to the pending patent applications; such legislation could only affect applications filed when and after it became effective.

BERNHARD C. HESSE

25 BROAD STREET
NEW YORK CITY, N. Y.
June 4, 1919

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Editor of the Journal of Industrial and Engineering Chemistry:

Upon reading Dr. Hesse's communication, I am convinced that a discussion on the patent question at the September meeting of the SOCIETY would be both profitable and timely. A symposium is therefore being arranged for that meeting when the Pharmaceutical Division and the newly formed Dye Division will unite with the Division of Industrial Chemists and Chemical Engineers, it being thought that the members of these three divisions will be particularly interested in this matter. This symposium will be under the direction of the Patent and Related Legislation Committee with Mr. Edwin J. Prindle as presiding officer.

Having the active coöperation of these three Divisions, every phase of the subject should be considered and some definite conclusions reached. It is hoped, therefore, that papers may be prepared covering the various points of view, and that the members of the SOCIETY will come with the anticipation of actively participating in the discussion.

HARLAN S. MINER
Chairman, Division of Industrial
Chemists and Chemical Engineers

GLOUCESTER CITY, N. J.
June 13, 1919

SCIENTIFIC AND TECHNICAL EMPLOYEES OF THE GOVERNMENT ORGANIZE

On Thursday, May 8, 1919, the scientific and technical employees of the Government met in a mass meeting at the New National Museum, pursuant to a call sent out by a committee representative of governmental activities. The question of an organization of scientific and technical workers which has been widely discussed during the last year was brought acutely to the fore by the work of the Joint Congressional Reclassification Commission, as the Commission wishes to deal with the employees only through an organization and not as individuals. The purpose of this meeting was to determine whether the scientific and technical workers in the federal employ wish to organize, and if so, what sort of organization they desire. Three plans were submitted which were as follows: Plan No. 1, To work through existing scientific organizations; Plan No. 2, To form an independent organization of employees doing scientific or technical work; Plan No. 3, To form a scientific or technical branch of the Federal Employees' Union. The auditorium of the Museum was well filled. Dr. Rodney H. True, of the Bureau of Plant Industry, presided. After a rather full discussion of the merits of the several plans submitted, it was finally decided by a vote of 185 to 132 to adopt Plan No. 3. The determining factor in this action seemed to be the practical one of adopting the plan most likely to yield the results desired. The temporary committee appointed at the meeting of May 8, with Dr. True as chairman, has been actively at work on drawing up plans for the permanent organization.

The point of view of the organizers is as broad as can be desired by those most independently inclined. Their purpose is purely a constructive one, being directed by the facts that properly conducted scientific research has to have sufficient appropriations to insure satisfactory progress, and that affiliating with numerous and well-organized bodies which are in close touch with voters enables scientific workers to approach the appropriating powers (congressmen) through their most powerful argument, namely, their constituency. Activities will also be directed to securing for us greater freedom and improved status, reasonable salaries, effective coöperation, and better public recognition of the aims and purposes of research. Aside from these matters of direct and vital necessity are those broader questions of presenting scientific and technological ideals before the public by other means than through the exigencies of warfare.

THE BLOEDE AND THE HOFFMANN SCHOLARSHIPS OF THE CHEMISTS' CLUB

The announcement is made by the Scholarships Committee of the Chemists' Club of New York, that the Bloede and the Hoffmann Scholarships will be awarded for the academic year 1919–1920. These scholarships were founded by Dr. Victor G. Bloede, of Baltimore, and Mr. Wm. F. Hoffmann, of Newark, with the object of giving financial assistance to deserving young men, to obtain an education in the field of industrial or chemical engineering.

These scholarships will be open to properly qualified applicants without restriction as to residence, and may be effective at any institution in the United States, which may be designated or approved by the Scholarships Committee.

Applicants must, as a minimum qualification, have completed a satisfactory high school training involving substantial work in elementary chemistry, physics, and mathematics, and present a certificate showing that they have passed the entrance examination requirements of the College Entrance Examination Board or its equivalent. Preference will be given to young men who have supplemented these minimum qualifications with additional academic work, especially in subjects which will form a suitable groundwork for the more advanced study of applied chemistry and chemical engineering.

All applications should be in the hands of the Scholarships Committee of the Chemists' Club, 52 East 41st Street, New York City, on or before July 15, 1919.

TECHNOLOGICAL FELLOWSHIPS IN SWEDEN

The American-Scandinavian Foundation announces that ten fellowships have been established, of the value of $1,000 per year each, to be awarded technically trained young men, between twenty and thirty years of age, who will study in technical institutions in Sweden. The subjects are those in which Sweden offers unusual advantages: four fellowships in physics and chemistry, two in hydroelectric engineering, two in metallurgy, and two in forestry and lumbering. Further information and application forms may be obtained from the Secretary of the Foundation, Henry Goddard Leach, 25 West 45th Street, New York City.

A GRANT FOR RESEARCH

The American Pharmaceutical Association has available a sum amounting to about $240 which will be expended during 1919-1920 for encouragement of research. This amount, either in full or in fractions, will be awarded in such manner as will, in the judgment of the A. Ph. A. Research Committee, produce the greatest good to American pharmaceutical research.

Investigators desiring financial aid in their work will communicate, before August 1, 1919, with H. V. Arny, chairman A. Ph. A. Research Committee, 155 West 68th Street, New York City, giving their past record and outlining the particular line of work for which the grant is desired.

The committee will give each application its careful attention and will make recommendations to the American Pharmaceutical Association at its meeting in New York, August 25 to 29, 1919, when the award or awards will be made.

MOTION PICTURES IN THE TRAINING OF THE CHEMIST

Editor of the Journal of Industrial and Engineering Chemistry:

The results of the correspondence of the chairman of the committee of the Society on the Relation of Industries and Universities with the chief chemists of the leading commercial organizations of the United States[1] show such a startling unanimity of opinion regarding the inability of the student to apply his knowledge to the commercial phases of chemistry, that a statement of a method by which it is believed this deficiency in the training of the chemist will be overcome seems opportune at this time.

To quote Dr. Ellery, "Every practical working chemist knows that educational institutions can give only to a very limited extent practice in actual chemical processes that are commercial. Most laboratories in our educational institutions cannot equip themselves with what might be called industrial chemical apparatus, and even if they could, it is to be questioned whether the result of the use of such apparatus in a school laboratory would give the practical ideas which employers want * * * * every teacher realizes the deficiency and deplores it all the more because he knows that he is quite unable to correct it."

But is he unable to correct it? Has he forgotten the educational value of motion pictures? Can it not be seen that the adequate and logical presentation of our chemical industries through the medium of the motion picture would be of inestimable value to the educator as well as the manufacturer. This is not a new idea. It is not an experiment, for many of our leading manufacturers have already taken films for the education of their own employees. Can they not go a step further and educate their future employees by the same method?

It is proposed by the committee that an effort be made to consult with the industries that may be located within *convenient* reach of the educational institutions, in order to persuade the managers of the industries and the authorities of the schools to enter into an arrangement by which chemistry students may get actual industrial experience during their years of training. But what of our institutions which are not so conveniently located? Are they to be entirely neglected? Our schools are not and cannot be situated near industrial centers and even

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[1] This Journal, **11** (1919), 375.

in the case of those so fortunately situated it is not always the wish of the student to specialize in any particular industry during his period of training, and it is admittedly poor educational practice to have him do so.

Factory inspection trips form a part of the curriculum of some of our larger institutions. These are helpful as far as they go, but it is evident that they must be hurried and superficial at best. Very often the student is led through in a desultory manner and the entire continuity of the particular process viewed is lost, with the inevitable result—confusion. He gets a somewhat hazy idea of the magnitude of the process but the details are lost and he has no means of retracing his steps to view them again, so that even this method is open to considerable criticism and also it is adaptable only to the privileged few, those who are conveniently situated. Many manufacturers are unwilling to grant this privilege, for the reasons that the running of their plants is disorganized on the days these visits take place and they do not want the responsibility for any accident that may happen to a careless visitor. In a large number of cases these privileges have actually been withdrawn.

It seems, then, that the logical solution of this problem lies in the motion picture. If the student cannot go to the plant, bring the plant to the student. It is within the reach of all and for the use of all. The smaller school will be benefited as well as the larger one. There will be no privileged few. The industries of California will be shown to Maine and those of Maine to California. The entire scope of the chemical industry will then be shown. There need be no specialization on the part of the student during his course of training. There will be no lost motion, no hurried steps, or superficial observation. The student can study the processes at his leisure and in direct conjunction with his theoretical work. The manufacturer need be troubled only once and then by one person only instead of a group, and in place of advertising his wares to a limited few he has his products shown throughout the country to those who are most vitally interested in seeing and using them. At the same time he is educating his future employees and is directly serving and helping to build up the entire chemical industry, which we know has now become a permanent institution in this country, unfettered by any German myth.

Now what essentials must the film possess in order to be of value in a technical institution?

The films must be specially prepared for the purpose, and with a full recognition of educational requirements. They must comply with the fundamental requirements that, where industrial operations are shown, the whole of the process shall be displayed in a manner that will make clear to the student the exact nature of the technical operation.

The pictures must be supplemented by a technical description given by a person expert in the subject that is being illustrated. They must be shown under conditions that will allow of the film being stopped when required, so that where the subject calls for a fuller explanation this can be given.

The view must have a serious scientific or technical interest. A film which has been prepared solely to entertain or amuse would be quite unsuitable for use in a technical institution.

How may these requirements be met? How may these essentials be fulfilled in every detail?

Realizing the importance of the situation and sensing the profound duty which lies before it, the Community Motion Picture Bureau, the largest company in America dealing exclusively with educational motion pictures, is now proceeding to fulfil the necessary requirements. It has on its staff men who are particularly expert in each field of endeavor, educational and industrial. This makes the proper planning, producing, and presentation of each picture an assured fact. No picture will be considered complete until it has received the unqualified approval of the representative of each industry shown, thereby guaranteeing an accurate, logical, and truthful portrayal of that industry in every respect. In addition to the regular titles each picture will be accompanied by a booklet containing a short description or scenario explaining the processes chemically and mechanically, so that the educator may thoroughly familiarize himself with the subject that is to be viewed.

That the exact nature of the technical operations may be adequately shown, all important features of the process and such views as do not permit of direct photography will be presented diagrammatically, that is, by means of animated drawings. It can readily be seen how important this feature is to the student. He will be able to see what transpires inside of the vessel as well as outside, and the exact operation of any particular apparatus or mechanism can be shown in principle as well as in detail. There can be no doubt regarding the immense advantage of this method of presentation over factory inspection trips or the casual perusal of trade catalogues and blueprints. The machine works before one's eyes and one sees why and how it works.

There are projection machines now available which meet all the necessary requirements for the schools and lecture tables. The film can be stopped, making each individual picture a lantern slide, while the instructor explains any point that may appear to be hazy to the student, and if for any reason a point has been missed by the student, the machine can be automatically reversed and any part of the film run over again. The cost of these machines is easily within reach of even the smallest of schools.

Thus all the conditions have been met and it only remains for the manufacturer to do his part. What greater service can he perform for the advancement of the chemical industry in America than this one, and at the same time derive that type of advertising which is of greatest advantage to himself? But, it has been asked, "What of the manufacturer with the secret process? Will he permit that to be shown?" Many of the so-called "secrets" are not secrets at all. They are secrets merely in the imagination. And those that are truly considered secrets or "stocks in trade" usually consist of minor operating details, the showing of which could very easily be omitted without destroying the fundamental ideas or the continuity of the process. There can be no disclosures of plant secrets for, as stated before, each picture and also the scenario is to be approved by the manufacturer himself before it is released to the outside world.

The Bureau is establishing a complete library of motion pictures embodying all of the fundamental chemical industries of America and will distribute them in such a way that they may be available to every school in the country according to its individual requirements. With the aid of the industries a comprehensive library will be completed by next fall for the opening session of the schools.

That this project is a sound one, and one that will supply a crying need, was manifested by the universal acclaim with which it was received by both educators and industrial managers at the recent Victory Meeting of the AMERICAN CHEMICAL SOCIETY at Buffalo. The chemical industry of America must remain a permanent institution, but its permanence is entirely dependent upon the proper education of its chemists. The success of American enterprise is due to its superior educational methods. Shall we not be superior in motion picture education also?

ARTHUR C. NEISH
Associate Professor of Chemistry, Columbia University
OSCAR BYRON
Chemical Engineer, Columbia '14

46 WEST 24TH STREET
NEW YORK CITY
May 2, 1919

LIBRARIANS FOR SPECIAL LIBRARIES

Editor of the Journal of Industrial and Engineering Chemistry:

In reply to Mr. Smith's letter published in your June issue, I might suggest that the extent to which women have been employed as librarians of industrial and business libraries is a direct result of a special need for persons trained and experienced in library science, indexing, cataloging, and filing. Whether or not it is more important for the librarian of an industrial library to be trained in the science of his own library or in library science is still a much-disputed question, but since so large a part of the work of any industrial library has to do with library methods, there can be no doubt but that library training is essential for an efficiently organized library of any kind.

The ideal condition, of course, would be a training and experience both in library methods, and in the special science with which the library deals. It is usually impossible, however, to persuade a chemist, mechanical engineer, or accountant to enter library work, where the range of salaries is lower, and the possibilities much less than in his own special line of work, and yet where he is expected to be experienced both in library work and in some other science.

Whenever an industrial company desires a chemist, mechanical engineer, or accountant, they quite logically secure a person educated or trained in chemistry, engineering, or accountancy. Why, therefore, should there not be in charge of the library a person who is primarily library trained? Most trained librarians are now college graduates, who either have specialized in library economy or have supplemented their college degree by two years' graduate work in a library school.

Arthur D. Little, Inc.,
Cambridge, Mass., June 6, 1919

E. D. Greenman

CHEMICAL WARFARE SERVICE EMPLOYMENT SECTION

The Employment Section of the Chemical Warfare Service, Seventh and B Streets, N. W., Washington, D. C., at the present time has more applications from colleges for men to teach chemistry commencing next fall than it is able to supply.

The Section also has on its lists a number of excellent scholarships and fellowships available in ten or twelve colleges where men can take up work for the master's and doctor's degrees. In some instances, the holder of the fellowship is required to teach a few hours a week.

WORKS AND LABORATORY ACCIDENTS

EXPLOSION IN THE DYE PLANT OF THE CALIFORNIA INK COMPANY

Drug and Chemical Markets for April 16 reported that an explosion in the dye plant of the California Ink Company, Berkeley, Cal., had caused damage amounting to more than $25,000. The following account of the accident was sent in response to our request for such information as might prove of interest to other workers in this field.—[Editor.]

Editor of the Journal of Industrial and Engineering Chemistry:

The explosion that occurred was caused by a weakness in the metal forming the bottom of a steel autoclave 36 in. in diameter and about 9 ft. long, having a cast steel top that is very heavy, almost 3 in. thick. When the bottom let go it went up straight in the air just like a skyrocket, probably 75 to 100 ft. high, broke through the joists of the second story which were 6 by 10 in., went on up through the roof, which was of galvanized iron and heavy rafters, turned a somersault, and came down in another building through the roof and landed in the second story, some 50 ft. away. It naturally wrecked everything within a radius of some 35 to 40 ft. from the original position.

The most fortunate thing was that everybody was safely out of range of the explosion and no one was seriously hurt. Some of our men were considerably overcome and shocked from the gases. They were quickly revived and we are thankful to say that no one was injured permanently.

We feel quite confident that by having the autoclave built properly, with a new shell and a new one-half inch bottom, the holes properly drilled instead of punched, a repetition of this can be readily avoided.

The last pressure that anyone noticed on the pressure gauge was 125 lbs., which is our working pressure. We intend to subject both our autoclaves to hydrostatic pressure of about 25 per cent more than the working pressure, at least once a week, in order to discover any possible weakness, as we do not want a repetition of this kind of excitement with its possibility of resulting very seriously to some of our employees.

West Berkeley, Cal.
April 24, 1919

L. H. Lewars

CHEMICAL FIRE HAZARDS

Editor of the Journal of Industrial and Engineering Chemistry:

The report on a fire in a cotton bleach and dye works has come to our attention and owing to the nature of the fire we believe that the following brief description of it may be of interest to readers of the *Journal of Industrial and Engineering Chemistry.*

A barrel of sulfur black dye was stored in the drug room of the plant. At midnight a watchman detected a slight odor given off by the material in this barrel and found that the dyestuff was smoldering. The watchman summoned assistance and the barrel of material was removed to the yard and damage to the building was prevented. The manufacturers of the dye are understood to have replaced the material free of charge and to have stated that the trouble was due to the dye containing too much sulfur.

While the pure dyes of this character may be free from danger, it would seem that irregularities in the manufacture are likely to lead to trouble and that material of this sort should be so stored that large values of other materials are not exposed to the hazard, and the danger of a fire spreading from it should be avoided. The use of metal barrels for this material appears to be advisable.

The writer is not sufficiently informed as to the nature of this material to feel sure of the exact cause of fires of this sort and would be interested in an explanation of the chemical actions involved.

Boston, Mass.
May 3, 1919

W. D. Milne
Superintendent of Surveys

$100,000 FIRE

Editor of the Journal of Industrial and Engineering Chemistry:

On March 22, a disastrous fire occurred in the establishment of A. Daigger & Co., Laboratory Supplies and Chemicals, 54 West Kinzie Street, Chicago, Ill. The second, third, and fourth floors of the building were almost completely destroyed and the loss has been estimated at about $100,000.

It has been impossible to determine exactly the cause of the conflagration, but it was apparently due to crossed wires or faulty insulation in connection with an electric elevator.

The building has been rebuilt and the stock replenished, so that business has just about returned to a normal basis.

A. Daigger and Company
Chicago, Ill.
May 5, 1919

R. J. Quinn

WASHINGTON LETTER

By PAUL WOOTON, Union Trust Building, Washington, D. C.

Substantial governmental aid for the domestic potash industry cannot be regarded as promising. Tungsten and magnesite have a better chance to secure some tariff aid. Optical glass and chemical glassware and porcelain are practically certain of removal from the free list, but a reduction from the amount of duty asked may be expected. The dyestuffs industry will be maintained but much difficulty is certain in the devising of the method by which protection will be afforded.

These are deductions by disinterested persons who have analyzed the attitude of the Ways and Means Committee of the House of Representatives, as displayed since the opening of the tariff hearings.

Under existing conditions, the Republicans are very anxious not to run to extremes of protection. The Democrats, pledged in advance by the President, are going to coöperate in safeguarding the industries which grew up during the war. With the Congress in Republican hands, but with nothing like enough votes to pass a tariff measure over the President's veto, results of an intermediate character may be expected. Both Republicans and Democrats are showing the keenest interest in competitive conditions among domestic producers and manufacturers. It is safe to predict that the domestic industries will have to prove beyond doubt that *bona fide* competition exists.

The licensing plan for potash, which found favor with the Senate Committee on Mines and Mining at the last session of Congress, has not appealed to either the Republican or the Democratic members of the Ways and Means Committee. It is regarded as being impracticable of administration and as possessing few advantages over a tariff. The domestic producers admitted before the committee that they prefer a tariff, but had put forward the licensing plan on the theory that it would be more acceptable to the Democratic administration. Some are convinced that the low-cost producers of potash in the United States will be able to compete without a tariff. The advisability of trying to maintain the high-cost producers is doubted very generally in Congress, especially in face of the desirability of absorbing as much as possible of the German product. The very potent influence of the farmer is being exerted against any material increase of prices over the cost of the duty-free importations.

On the other hand, the producers made a good case in showing the strides which have been taken during the war. The committee evidently was convinced that new attainments are within reach, but some members think they will be reached, duty or no duty, and few are willing to take any step which will aid materially to the cost of fertilizer.

Dr. E. C. Sullivan, of the Corning Glassware Works at Corning, N. Y., was one of the witnesses called in connection with the chemical glassware hearing. He pointed out the superiority of the American product, showing that it will stand five or six times the drop of German glassware, and has a greater resistance to solvent action. His concern, as was the case with practically all those who testified, was more with Japanese than with German competition. Increasing costs in Germany, particularly in the wage which doubtless will have to be paid in the future, led practically every witness to regard Japan as a much more formidable competitor. It was pointed out by Dr. Sullivan and others that the Japanese competition is an actuality. Glassware made in Japan already is on the American market in large volume.

Frank J. Sheridan, of the Tariff Commission, discussed wages of the Japanese workmen and while he did not deny that their year contains 283 working days and the average daily period of work is $11^{1}/_{2}$ hours, he called attention to the fact that our speed and capacity of manufacture are so great that the difference in wages is reduced considerably. He pointed out that chemical and scientific glassware making is a key industry, in that it supplies the research departments of many industries.

Wm. P. Clarke, of Toledo, president of the American Flint Glassworkers' Union, emphasized the danger from Japanese competition. He said a 60 per cent duty would remedy but would not entirely meet the situation.

Dr. Charles L. Parsons, the secretary of the AMERICAN CHEMICAL SOCIETY, told the committee that educational institutions will gain in the long run by sacrificing the advantages they have enjoyed in securing chemical glassware free of duty. He declared that he regards the chemical glassware industry as essential to the chemical independence of the country. He said that the American manufacturers are making the best glassware in the world and that there should be a tariff to protect the industry. He expressed the belief that glassware never again will be obtained as cheaply as before the war, because the price of labor is greater and the value of the dollar is less. He predicted, however, that prices will fall somewhat from the present level.

Warren S. Hood, of the Vineland Scientific Glass Company, said that a duty always will be necessary to safeguard the industry and does not think that an embargo for five years will be sufficient to enable the American Industry to compete unaided with foreign producers.

F. F. Shetterly, of the Corning Glass Works, declared that a 45 per cent duty would be inadequate to protect the industry.

Dr. Charles H. Herty, the editor of the *Journal of Industrial and Engineering Chemistry*, in his statement to the committee, emphasized the fact that we know now what it means to be dependent on other countries and realize the need of a self-contained chemical industry in the United States. He said that he regards as vicious the law which gives educational institutions the duty-free privilege in scientific supplies. He called particular attention to the influence on the American student working continually over apparatus marked "Becker---Made In Germany." He suggested to the committee that it would be better to make the duty on scientific supplies a little too high rather than a little too low. "My doctrine is," he said, "economic independence for America so far as the chemical industry can make it."

H. S. Coors appeared in behalf of manufacturers of chemical and scientific porcelain. The annual consumption of these products, he said, is around $500,000.

Walter R. Eimer, representing dealers and makers of scientific apparatus, said the duty should be at least 60 per cent. He said opinion has changed since the Tariff Commission hearing, at which manufacturers said they would be satisfied with 45 per cent duty.

Col. H. K. Rutherford, of the Bureau of Ordnance, told of the difficulties the Army had in securing the $30,000,000 worth of fire control apparatus, which was bought during the war. He recommended a tariff and declared there is real competition among domestic manufacturers. Col. M. A. Reasoner, who bought $3,000,000 worth of scientific supplies for the Government during the war, urged a duty which would allow the continuance of the home industry.

Chester G. Fisher, of the Scientific Materials Company of Pittsburgh, pointed out that the scientific instrument industry is classed as a "master key" industry in England. He said that 90 per cent of the total cost of scientific instruments is represented by the labor. He left with the committee a copy of the Scientific Material Bluebook calling attention to the fact that in its 700 pages may be found the greatest reason why the industry should be protected, since the book contains practically every scientific instrument used—all made in America.

Harvey N. Ott asked that an addition be made to the bill so as to cover half-finished products or instruments, as he fears chicanery on the part of Germany or Austria. C. H. Stoelting, of Chicago, told of many unsuccessful attempts to compete in the manufacture of instruments without protection.

The United States Tariff Commission is furnishing the Committee on Ways and Means with special reports on the commodity under consideration. Extracts from the report on optical glass and chemical glassware are as follows:

> The advantages possessed by Germany and other countries are such that this new American industry is unequal to successful competition with the countries named on the basis of continued free importation of the foreign product.
>
> It was not until after five years of scientific research and experiment that the Jena works, of Germany, developed 28 new kinds of optical glass. This firm had the advantage of 25 years' experience in producing optical glass and in this field was practically without a competitor. It is not reasonable to expect that American manufacturers and scientists could, in less than three years, attain the required standards of knowledge and efficiency to meet the demands of domestic consumption and the inroads of foreign competition.
>
> During the war the optical industries of Germany, France, and England have been driven to a high state of industrial activity and the scientific precision essential in the production of perfect optical glass. Under the Tariff Act of 1913 optical glass is admitted free of duty into the United

States. The new American industry under such conditions is unequal to the task of engaging in successful competition with the output of the highly developed industry and the experienced scientists and manufacturers of the countries named.

Many of our most important industries requiring research work—the testing of processes and the analyses of their materials and products—are dependent upon chemical and scientific glassware for their successful continuance. Laboratory tests and analyses by means of this ware are essential in the chemical control of such varied industries as iron and steel, raw and refined sugar, packing-house products, fertilizers, rubber manufacture, Portland cement, soap, oil refining, waterworks, textiles, and in chemical plants in the manufacture of explosives, dyes, soda, and other products.

With regard to dyes and related coal-tar chemicals, the Tariff Commission's report to the committee contains the following:

> Several different methods of rendering aid and protection have been proposed, and the degree to which Congress may see fit to use the tariff will doubtless depend in large measure on whether or not the other methods are adopted and successfully administered. The more important of the proposals that have been made include (1) direct financial aid by the Government, (2) the limitation of imports through the control of patents, (3) the exclusion of foreign products except under license, (4) a revision upward of the present tariff rates, and (5) the prevention of unfair competition on the part of foreigners in the domestic market.
>
> Having said that the present rates of the tariff would probably suffice to maintain important branches of the industry, and that every increase in these rates would insure the safety of additional branches, we are finally faced with the question: What rate of duty would protect all branches that now show any growth and will guarantee the development of those that are missing? To this the Tariff Commission is bound to answer that this end apparently cannot be accomplished by any rate of duty familiar in American tariff legislation. This conclusion is inevitable when a comparison is made of what is known of domestic costs with the pre-war prices of German dyes or even with the very recent prices at which those dyes were offered in exchange for food. Many of those interested in the industry naturally wish to see the rates pitched very high. The advocates of such rates, however, overlook the effect of such a policy on other industries. If the manufacturers of textiles, leather goods, and many other commodities cannot procure, or can procure, only at an exorbitant price, the dyes which they need, not only will they be rendered unable to compete in international trade, but also they will find themselves at a serious disadvantage in the domestic market.
>
> A law that would be effective against German dumping of dyestuffs will be difficult to draw, for the usual test of dumping can hardly be applied. A comparison of their export with their domestic prices will have little meaning, because both are fixed by a monopoly and may be adjusted at will, and because private contract prices may easily be made to vary widely from published quotations. A comparison of prices with costs would be still more futile, for the obvious reason that their costs are known only to themselves, and there is little likelihood of their being disclosed.
>
> For the prevention of dumping in the case of dyestuffs it is well worth considering whether the United States might not adopt to advantage a practice not uncommon in other countries of fixing a minimum valuation for the assessment of duties, regardless of what the market price may be or what the invoice price may show.

The Eli Lilly Company, drug and pharmaceutical manufacturers, Indianapolis, has agreed to issuance of an order by the Federal Trade Commission requiring it to relinquish all attempts to influence its 248 selected wholesale distributing druggists throughout the United States to maintain standard resale prices fixed by the Lilly Company on Lilly products.

The text of the order against the concern which has total annual gross sales of several million dollars, follows:

> Now, therefore, it is ordered that respondent, The Eli Lilly and Company, and its officers, directors, agents, servants, and employees, cease and desist from directly or indirectly recommending, requiring, or by any means whatsoever bringing about the resale by its wholesale distributors of the drugs, pharmaceuticals, and similar products manufactured by it according to any system of prices fixed or established by respondent, and more particularly by any or all of the following means:
>
> 1—Entering into contracts, agreements, or understandings with such distributors to the effect that such distributors in reselling such products will adhere to any system of resale prices fixed or established by respondent.
>
> 2—Securing from such distributors contracts, agreements, or understandings that they will adhere to any such system of resale prices.
>
> 3—Refusing to sell to any such distributors because of their failure to adhere to any such system of resale prices.
>
> 4—Discriminating in prices against such distributors because of their failure to adhere to any such system of resale prices.
>
> 5—Discriminating in prices in favor of such distributors because of their adherence to any such system of resale prices.
>
> 6—Carrying out or causing others to carry out a price maintenance policy by any other means.
>
> *Provided*, that nothing herein contained shall prohibit respondent from issuing price lists or printed prices in its advertising matter, or upon containers, of its said products, so long as respondent shall refrain from directly or indirectly recommending, requiring, or by any means whatsoever bringing about the resale of such products at such resale prices.

INDUSTRIAL NOTES

The Industrial Bill passed this session by the British Columbia legislature provides for a new Department of Industries whose powers will be: to provide for industrial research, to acquire and utilize existent knowledge in arts and manufactures, to carry out an economic survey of natural resources, to furnish advice regarding industrial problems, to publish technical, scientific and statistical information, and generally promote the economic development of the province.

The Virginia-Carolina Chemical Company will begin at once the construction of a $200,000 fertilizer plant at Jacksonville, Fla., which will care for the company's business in Florida, as well as that in the Latin-American countries.

The Armour Fertilizing Works, the third largest manufacturers of fertilizers in the United States, has purchased all of the interests of Howard F. Chappell and the United States Smelting, Refining & Mining Company in the Mineral Products Corporation, for $1,000,000. The plant produces potash from alunite.

The British Photographic Research Association plans to carry out a program of research work. This body was formed in May of last year, under the government scheme of financial aid through the Department of Scientific and Industrial Research, to carry out research work in photography, photochemistry, and other related subjects. Dr. R. E. Slade has been appointed director of research, and temporary laboratories have been obtained at University College, London. Professor J. J. Thomson, O. M., P. R. S., is president of the Association, and the leading firms of photographic chemical manufactures are represented on the council.

The trade-mark "Pebeco," together with such German interests as may exist in a contract between Lehn & Fink, of New York, and P. Beiersdorf & Co., of Hamburg, Germany, was sold to Lehn & Fink on April 22 at the office of the Alien Property Custodian, for $1,000,000.

Exports of dyes during the month of February totaled over $2,000,000, according to statistics from the Department of Commerce. Exports of aniline dyes totaled $1,231,355; those of logwood extracts, $170,237; and all other dyes, $617,050. During the month, our imports of dyes amounted to a little more than $500,000.

The American Chamber of Commerce in London, numbering over 800 of the principal Anglo-American interests, is now forming a chemical and drug section. American concerns of good standing who wish to be represented in the chamber can get full particulars, application forms, etc., through the Keene Company, 335 Broadway, New York.

The Bureau of Standards has just issued Technologic Paper No. 125, entitled "The Viscosity of Gasoline." The instruments ordinarily employed for finding the viscosity of lubricating oils are not suitable for gasoline, but it was found that the Ubbelohde viscosimeter, designed primarily for use with kerosene, served to determine the viscosity of gasoline accurately enough for commercial purposes. The usual method of estimating the volatility of gasoline from the specific gravity is a rough approximation, and the volatility depends somewhat on the viscosity. Those interested may obtain a copy by addressing a request to the Bureau.

A paper mill, with a daily capacity of 165 tons, is being erected at Olaa (Hawaii) for the manufacture of all kinds of paper. This production will utilize only one-tenth of the available supplies of bagasse of the sugar factories of Olaa. The mill has been planned with a view to being gradually expanded, so as to ultimately utilize all the available supplies of bagasse, should the venture prove successful, in which case the output could reach 165 tons a day, and even more, should the factories in the other islands follow this good example. The mill cannot start for another year, as the required machinery could not be obtained during the war.

List of Applications Made to the Federal Trade Commission for Licenses Under Enemy-Controlled Patents Pursuant to the "Trading with the Enemy" Act

Year	Pat. No.	Patentee	Assignee	Patent	Applicant
1903	748,375	Hepp and Hartmann	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Blue anthraquinone dye and process of making	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1904	778,036	Hepp and Uhlenhuth	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Anthraquinone dye and process of making	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1907	871,507	Homolka and Erba	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Anthrachrysone derivatives	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1909	943,717	Uhlenhuth	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Brown anthraquinone dye and process of making	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1910	975,863	Hepp and Hartmann	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Anthraquinone derivatives and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	989,602	Henle	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Manufacture of amino-aryl-acidyl-amino-anthraquinone and their acidyl derivatives	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	998,772	Hessenland	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Blue dyestuff and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	999,785	Hessenland	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dyestuff	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	1,002,270	Hessenland	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dyestuff of the anthraquinone series and process	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	1,007,104	Hessenland	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dyestuff of the anthraquinone series and process	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1912	1,023,847	Hessenland	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Alizarin-red vat dyestuff and process of	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1912	1,025,174	Welde and Homolka	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Blue vat dyestuff and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1912	1,025,195	Kränzlein	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Salmon-colored vat dyestuff and process	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1912	1,028,139	Schmidt	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Manufacture of azo dyestuff of the anthraquinone series and process	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1912	1,038,003	Schmidt and Kränzlein	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Pure anthraquinonylurea chloride and process	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1912	1,046,498	Schmidt and Kränzlein	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Halogenized condensation product of the anthracene series and process of making	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1912	1,047,940	Hessenland	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dyestuffs of the anthraquinone series and process of making	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,052,480	Hepp, Uhlenhuth and Roemer	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Dyestuffs of the anthraquinone series and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,052,520	Schmidt	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Condensation products of the anthracene series and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1915	1,123,390	Schirmacher and Voss	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dyestuffs and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1915	1,138,670	Kränzlein, Hagenbach and Giloy	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Arylaminoanthraquinone dyestuffs and process	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1915	1,139,540	Kränzlein	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Arylaminoanthraquinone dyestuffs	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1910	961,047	Ullman	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Anthraquinone acridones	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	993,915	Ullman	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Halogenized carboxylic acid of the phenylaminoanthraquinone series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	993,992	Herzberg and Bruck	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Vat dye of the anthraquinone series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	996,485	Herzberg and Bruck	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Sulfurized vat dye of the anthraquinone series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	1,001,325	Ullmann	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Product of the anthraquinone series and process	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	1,008,906	Herzberg and Bruck	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Vat dyes of the anthraquinone series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,078,505	Herzberg and Hoppe	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Blue dyes of the anthraquinone series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	1,008,908	Herzberg and Bruck	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Vat dyes of the anthraquinone series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,050,829	Herzberg and Bruck	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Anthraquinone vat dye	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1915	1,131,516	Herzberg and Hoppe	Actien-Gesellschaft für Anilin Fabrikation, Berlin, Germany	Greenish blue dyes of the anthraquinone series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	999,045	Laska	Chemische Fabrik Griesheim-Elektron, Frankfort-on-the-Main, Germany	Manufacture of brown sulfurized vat dyestuffs	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	999,680	Singer	Chemische Fabrik Griesheim-Elektron, Frankfort-on-the-Main, Germany	Vat dyestuffs of the anthracene series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1912	1,016,638	Laska	Chemische Fabrik Griesheim-Elektron, Frankfort-on-the-Main, Germany	Vat dye and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1912	1,028,521	Zitscher and Rath	Chemische Fabrik Griesheim-Elektron, Frankfort-on-the-Main, Germany	Anthracene derivatives and process of making	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1912	1,042,931	Laska, Zitscher and Rath	Chemische Fabrik Griesheim-Elektron, Frankfort-on-the-Main, Germany	Vat dyestuffs of the anthracene series and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City

List of Applications Made to the Federal Trade Commission for Licenses Under Enemy-Controlled Patents Pursuant to the "Trading with the Enemy" Act (*Concluded*)

Year	Pat. No.	Patentee	Assignee	Patent	Applicant
1912	1,044,933	Singer	Chemische Fabrik Griesheim-Elektron, Frankfort-on-the-Main, Germany	Process of making vat dyes of the anthracene series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,066,777	Zitscher and Rath	Chemische Fabrik Griesheim-Elektron, Frankfort-on-the-Main, Germany	Process of making nitro-amino derivatives of the anthraquinone series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,070,196	Singer	Chemische Fabrik Griesheim-Elektron, Frankfort-on-the-Main, Germany	Vat dyes and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,079,568	Laska and Rath	Chemische Fabrik Griesheim-Elektron, Frankfort-on-the-Main, Germany	Vat dyestuff	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1915	1,162,496	Laska and Rath	Chemische Fabrik Griesheim-Elektron, Frankfort-on-the-Main, Germany	Vat dyes of the anthraquinone series and process	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1906	826,509	Jljinsky	R. Wedekind & Co.	Alizarin sulfo-acid and process	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1906	826,510	Jljinsky	R. Wedekind & Co.	Anthraflavin disulfonic acid and process	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1907	847,078	Jljinsky	R. Wedekind & Co.	Production of organic sulfonic acid	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1907	851,423	Jljinsky	R. Wedekind & Co.	Anthrachinone disulfonic acid	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	996,487	Jljinsky	R. Wedekind & Co.	Process of making acid dyes of the anthracene series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1914	1,087,293	Jljinsky	R. Wedekind & Co.	Process of making acid dyes of the anthracene series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1918	1,261,394	Jljinsky	R. Wedekind & Co.	Vat dyestuffs and process for their formation	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1910	965,804	Franke	R. Wedekind & Co.	Alizarin preparation and process	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1911	999,439	Karl Elbel and Edward Wray, Biebrich, Germany	Kalle & Company, Aktiengesellschaft, Biebrich, Germany	Vat-dyeing coloring matter	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1907	867,305	Karl Schirmacher and Bernhard Deicke, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dyestuff	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1912	1,025,174	Robert Welde, Höchst-on-the-Main, and Benno Homolka, Frankfort-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Blue vat dyestuffs and process of making same	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1909	916,029	Albrecht Schmidt and Ernst Bryk, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Red-violet dye and process of making same	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1908	892,897	Karl Schirmacher and Hermann Landers, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Red vat dye	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1910	968,697	Albrecht Schmidt, Ernst Bryk, and Robert Voss, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Vat dye and process of making same	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1912	1,025,138	Erwin Hoffa, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Violet-blue vat dyestuffs	Consolidated Color & Chemical Co., 122 Hudson Street, New York City
1908	876,679	Bally & Wolff	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Nitrobenzanthrone compounds and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1908	893,384	Schlegel	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Dyeing	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,062,975	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Coloring-matter of the anthraquinone series	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,062,988	Muller and Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone dyes	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,066,987	Bohn and Nawiasky	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Gray-to-black shades on vegetable fiber and process of producing them	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,067,046	Luttringhaus and Braren	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone acridones	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,077,115	Bally	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Green anthraquinone dyes and process of making	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1913	1,083,051	Boner	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Producing anthraquinone compounds	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1914	1,089,221	Isler	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone coloring-matters and process of making them	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1914	1,090,123	Bohn and Immerheiser	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Chromium compounds of oxyanthraquinone sulfonic acids and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1914	1,090,636	Luttringhaus, Lohse and Sapper	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Brown vat dye	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1914	1,095,780	Bally and Wolff	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Reddish brown vat dyes	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1914	1,106,970	Reinking and Stiegelmann	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Compounds of leuco vat dyes with aralkyl compounds and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1916	1,207,981	Neresheimer	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone dyes and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1916	1,207,982	Neresheimer	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone dyes and process of making same	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1917	1,216,921	Bally and Wolff	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Yellow-brown vat dye	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City
1917	1,238,932	Nawiasky	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone compounds	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City

According to *Commerce Reports* there is immediate need of approximately 12,000 tons of chemical fertilizers in the Canary Islands for the restoration of the banana plantations, which form the principal industry of the archipelago. The amount and kinds of fertilizers needed are: Sulfate of ammonia, 3,500 tons (24 to 25 per cent); superphosphate of lime, 3,500 tons (36 to 38 per cent); dried blood, 1,500 tons; and potash, 3,500 tons (97 to 98 per cent). The leading fruit houses are making every effort to obtain these fertilizers and are prepared to pay cash f. o. b. in any American port where they can be delivered, or even to arrange for the shipment thereof in case such a plan should be preferred by the seller.

A large deposit of silica sand has been located near Monroe, La., convenient to railway, water and gas. It is estimated that the pit contains about 18,000,000 yards of sand, gravel, and road-building material underlaid by a very large strata of silica or glass sand.

A topographic and geodetic survey of Pennsylvania for the location of chemical deposits is proposed in a bill introduced into the state senate. The essential provisions of the bill are: "The survey shall disclose such chemical analysis and location of ores, coals, oils, clays, soils, fertilizing and other useful minerals, and of waters as shall be necessary to afford the agricultural, mining, metallurgical, and other interests of the state a clear insight into the character of its resources."

The Aluminum Potash Company has filed articles of incorporation at Salt Lake City. Its capitalization is $3,000,000, with 10,000 shares of $100, 7 per cent preferred stock and 20,000 shares of common stock. The company was formed to take over potash and other mineral deposits in Piute County, Utah, near the town of Belknap.

Mr. B. E. Reuter and Mr. J. E. Wrenn, who were, respectively, chief and assistant chief of the Fats and Oils Division of the Food Administration during the war, have organized a corporation called the Fats and Oils Service Company with main offices in New York City and branch offices in Atlanta, Chicago, and San Francisco. This company aims to give to the fats and oils and allied industries information and service such as was given under the Food Administration and also has inaugurated a brokerage and commission department.

With more than 1,250,000 tons of reserve stock of sulfur above ground at the large plants in Louisiana and Texas, there is a growing belief in the trade and among technical and chemical experts that the domestic sulfur producers will invade the sulfuric acid field in competition against pyrites. The Texas Gulf Sulfur Company, since starting operations about the middle of March, has placed in production additional wells, and the present output is reported as 1,000 to 1,500 tons of sulfur per day.

A number of new uses for woodpulp have been developed during the war, many of them through the efforts of the Forest Products Laboratory of the United States Forest Service. One of the more important of these uses was in the manufacture of propulsive explosives which, incidentally, developed the fact that woodpulp was suitable for a number of other commodities. When a shortage of cotton from which to make explosives was threatened before the signing of the armistice, the laboratory entered a practically new field of investigation—studying the practicability of using woodpulp as a source of explosives. Methods for the production of acid sulfite and sulfate pulp suitable for nitrating were developed, and tests at a government arsenal proved conclusively their suitability for nitration purposes. These results have other applications, particularly in the manufacture of lacquers and pyroxylin products, and the laboratory is continuing its work along these lines.

The potash producers of the United States intend to make an aggressive fight, as soon as Congress meets, to secure some sort of protection for their industry, in which $50,000,000 has been invested since the beginning of the war. There has been too little organization behind the efforts in this direction in the past, but the recently organized United States Potash Producers' Association represents the entire industry, including not only the Nebraska and California producers, but also the sugar company producers, the producers of first sorts potash from wood ashes, and all other potash producers in this country. The association has opened an office in Washington in charge of Mr. Frederick W. Brown, executive secretary, and will urge upon Congress the necessity of licensing the importation of foreign potash.

The Davis Manufacturing Co., Jellico, Tenn., manufacturers of chemicals, have completed negotiations for the leasing of a building at Knoxville, Tenn., comprising approximately 45,000 sq. ft. floor area, and will install new machinery for the manufacture of its specialties.

Fritzsche Bros., New York, dealers in and importers of essential oils, aromatic chemical preparations, essences, and fine drugs, have incorporated with $1,000,000 capital under the laws of the state of New York.

The California Potash Co., Sacramento, Cal., is conducting extensive experiments in the pine woods near Alta, Cal., with the view of extracting creosote and tar products from mountain pine.

The Heyden Chemical Co. of America has been incorporated by Allan F. Ryan, broker, 111 Broadway, who bought the stock of the Heyden Chemical Works from the Alien Property Custodian. The company is incorporated for $2,500,000, active capital, under the laws of New York State and is distinct from the Heyden Chemical Works which was incorporated on November 2, 1900, under the laws of New Jersey.

The McKenna Corporation of 49 Wall Street, New York, was the successful bidder for the 8,000 shares of the capital stock of Merck & Company, which were sold at auction by the Alien Property Custodian for $3,750,000, on May 9, at the offices of the company, 45 Park Place, New York. The sale of the stock must be confirmed by a committee from the Custodian's office, which must be satisfied that the purchasers are American citizens. The 8,000 German-owned shares of the Merck stock represent the greater portion of the total outstanding stock of the company, 10,000 shares all told. George Merck, president of the American company, is the owner of the other two thousand shares. Merck & Company was incorporated under the laws of New York State in 1908, being recapitalized in 1917. Prior to the outbreak of the war the annual business of the company averaged between $3,000,000 and $4,000,000 a year. In 1915 the earnings increased to $6,913,637 and for the first 8 months of 1918 reached $8,030,474. The 8,000 shares of stock which were sold, were delivered to the Alien Property Custodian voluntarily by George Merck in order that the disposal of them by the Government might be facilitated. Mr. Merck also furnished a full statement of the business relations between himself and E. Merck, of Darmstadt, Germany, who furnished credit amounting to $800,000 prior to the time of the incorporation of Merck & Company in the United States in 1908.

The American stockholders of the Roessler and Hasslacher Chemical Company and its allied concerns have filed ten equity suits in the United States District Courts of New York, Buffalo, and Newark against Francis P. Garvan, Enemy Alien Property Custodian, and the Columbia Trust Company, the present holders of the stock. The purpose is to prevent the Alien Property Custodian from gaining control of the company, which is one of the largest in the country. In these suits the stockholders seek to enjoin Mr. Garvan from exercising control over 80 shares of stock of the Perth Amboy Chemical Works, 240 shares of the Niagara Electrochemical Company, and 3,800 shares of the Roessler & Hasslacher Company, for which the custodian made a demand on April 1 last, claiming their sale to American stockholders in February 1917 was not *bona fide*, but that the stock was still being held for the Deutsche Gold and Silver Scheide Anstalt of Frankfort.

The United States Civil Service Commission announces the following competitive examinations: Catalytical chemist (male), $3,000 to $4,000 a year; Assistant Catalytical Chemist (male), $2,000 to $3,000 a year; Junior Catalytical Chemist (male), $1,600 to $2,000 a year. These three positions are for vacancies in the Ordnance Office and in the Ordnance Department at Large, War Department. There is also an examination for assistant in charge of soil chemical investigations (male), at $3,500 a year or lower or higher salaries, for a vacancy in the Bureau of Soils, Department of Agriculture, Washington, D. C., and an examination for an assistant petroleum chemist (male) at $1,620 to $1,920 a year, for a vacancy in the Bureau of Mines, Department of the Interior, for duty at Pittsburgh, Pa. Applicants should at once apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C., or at the branch offices in the principal cities in the United States.

The foreign trade committee of the Chemical Alliance, Inc., has submitted a report recommending the organization of a $15,000,000 chemical corporation under the Webb-Pomerene law. The capital will be divided into $10,000,000 common stock and $5,000,000 preferred shares. The common stock is to be subscribed by manufacturers participating fully in the plan, and the preferred stock will be offered to manufacturers who desire to coöperate but wish to maintain their individual organizations. Participation will be on the basis of average annual sales of each chemical handled by each manufacturer, and profits will be distributed in the same proportion as dividends on the common stock.

A new hat dye, known as the "Hat-Brite-Dye," is now being advertised by the Sherwin-Williams Company, who have hitherto been famous for their paints.

The United States has always been dependent mainly on foreign sources for its antimony supplies, China and Japan being the principal contributors, although Mexico and Bolivia have also furnished significant amounts, according to a review of the antimony situation, by the U. S. Geological Survey. This dependence is a reflection of the higher wage scale in this country as compared with that of certain foreign countries, particularly China; it is due, also, to the comparative poverty of the United States in antimony resources, although little information of a quantitative nature has been collected concerning these resources, and they may possibly be greater than has generally been assumed.

The United States formerly produced monazite from the important deposits in North and South Carolina, but since 1910 there has been practically no production, due chiefly to the fact that the mineral from the extensive seacoast deposits of Brazil could be obtained at a lower price. Monazite, vastly the most abundant of the cerium-bearing minerals, is an anhydrous phosphate of cerium, lanthanum, praseodymium, and neodymium, with variable quantities of thoria and silica, and frequently small amounts of erbium and ytterbium. It is a radioactive mineral, its activity being due to its content of mesothorium and radium. Deposits of monazite are also known in other states, especially in Idaho and Florida, and in Colorado, Georgia, and Virginia. A part of the production of monazite from the Carolinas was used in this country in the manufacture of thorium nitrate and a part was exported to Germany.

The National Reduction Company is building a large rosin and turpentine plant at Calvert, Ala.

The Supreme Court of the United States has entered a unanimous decree in the action of the Federal Trade Commission against Colgate & Company, sustaining the soap company, declaring that in refusing to sell its product to certain objectionable distributers it has done nothing contrary to the Sherman anti-trust law, and dismissing the Federal Trade Commission's complaint.

Alien Property Custodian Garvan has sold at auction $1,375^1/_2$ shares of common and 137 shares of preferred stock of the Jarecki Chemical Co., Cincinnati, O., to the Isaac Winkler & Brother Company for $150,000.

The War Trade Board announces that on and after July 1, 1919, nitrate of soda and nitrate of potash will be permitted to be imported into the United States without restriction under a general import license when coming from countries with which general trade is authorized.

Fluorspar properties in Kentucky will be developed by the Cumberland River Spar Mining Co., of Fulton, Ky., incorporated with $250,000 capital by William H. Spradlin, W. M. Nalling, and C. E. Kaiser.

The British Dyestuffs Corporation, Ltd., has been registered with a capital of £6,000,000, in £1 shares, to take over the businesses of British Dyes, Ltd., and Levenstein, Ltd., to carry into effect agreements between those companies and the president of the Board of Trade (on behalf of the government) and to carry on the business of manufacturers of and dealers in dyes, dyestuffs, chemicals, drugs, paints, varnishes, colors, etc. One of the articles provides that the company shall supply products at reasonable prices. The first directors are Mr. H. Levenstein, Sir Harry D. McGowan, Mr. G. P. Norton, and Mr. J. Turner, and two government directors to be appointed by the Board of Trade.

The Utah Sulfur Corporation, operating at Morrissey, Beaver County, Utah, plans the immediate construction of furnaces to cost about $180,000, for the subliming of sulfur, according to a recent announcement by Michael P. Morrissey, president and general manager.

The United States Geological Survey has completed tests of lignite mined near Ione, Cal., and has reported that the best deposits yield 62 gal. of oil per ton, and at least 18 lbs. of ammonium sulfate. This lignite is remarkably "fat," containing 31 per cent of volatile matter and 16 per cent of fixed carbon.

What is probably the first research laboratory to be put in by any department store in the United States has been installed recently by the Bannon Brothers Co., St. Paul, Minn. This laboratory, completely equipped, actually makes practical and chemical tests of the textiles, food products, linoleums, and other goods carried by the store. The research laboratory consists of a glass-inclosed room, fitted with the usual chemical laboratory equipment and, in addition, special equipment for the testing of textiles and other products. The staff includes a trained chemist and two assistants, who make analyses of goods. Both microscopical and chemical tests are made. A test is made of every article advertised so that it can be truthfully presented as "pure silk" or "89 per cent wool," with the backing of an actual test in the store's own laboratory.

The National Aniline & Chemical Company, Inc., have opened a branch office in Akron, Ohio, at the People's Saving & Trust Building, in order to give better service to the mid-western trade, and especially the rubber industry.

The Office of Drug and Oil Plant Investigations, Bureau of Plant Industry, in connection with its projects of oil-yielding crops and waste utilization, is installing a laboratory at Arlington to study the technology of fats and vegetable oils.

PERSONAL NOTES

The death of Boverton Redwood, F.R.S.E., one of the world's foremost authorities in the petroleum industry, occurred on June 6, 1919. Mr. Redwood was well known in this country in petroleum, chemical, and engineering circles, having been a frequent visitor here, in his professional capacity, to the oil fields. He was a consultant of high standing on petroleum questions and on other chemical lines. He was the author of many important papers and books upon petroleum and allied subjects, a member of the Society of Chemical Industry, the Institute of Mining Engineers, the American Chemical Society, a Fellow of the Royal Society of Edinburgh and the Royal Geographical Society, and honorary member of the American Philosophical Society and other scientific societies.

The Franklin Institute at Philadelphia has presented the Franklin Medal to Sir James Dewar, the distinguished English chemist.

Mr. M. B. Long, of the gas laboratory of the Bureau of Standards, has resigned in order to accept a position in the research laboratory of the Western Electric Company, New York City.

Professor F. Soddy, F.R.S., of the University of Aberdeen, has been elected to the second chair of chemistry recently established in the University of Oxford.

Col. William H. Walker has received his discharge from the Army and has returned to his home at Bridgeton, Me. His position as commanding officer of Edgewood Arsenal has been taken by Lt. Col. Amos A. Fries, Corps of Engineers (C. W. S.), U. S. A., who as Brigadier General, National Army, A. E. F., commanded the C. W. S. forces in France throughout the war.

Col. George A. Burrell, Col. F. M. Dorsey, and Col. William H. Walker have been awarded the Distinguished Service Medal by the War Department in recognition of their services during the war as members of the Chemical Warfare Service.

Dr. H. L. Walster, assistant professor of soils, College of Agriculture, University of Wisconsin, resigned that position recently to accept work as station agronomist and chairman of the department of agronomy of the North Dakota Agricultural College, Fargo, N. D.

The British Iron and Steel Institute has announced that it will confer the Bessemer Medal for 1919 on Dr. F. Giolitti, Director General of the Ansaldo Steel Works, Genoa, Italy. Dr. Giolitti is a member of the American Electrochemical Society.

Col. G. A. Burrell, president of the Island Refining Company, 62 Cedar Street, New York City, has been given the degree of doctor of science by Wesleyan University, Middletown, Conn. Last year his alma mater, Ohio State University, gave him the honorary degree of chemical engineer.

Mr. Milo R. Daughters, formerly connected with Mellon Institute, is now with the Dominion Canners Laboratory, Brighton, Canada.

Mr. Benjamin Markus recently resigned his position of research chemist with the Aetna Chemical Company to go into the consulting and manufacturing business with Mr. O. S. Tischler, also formerly connected with the Aetna Chemical Company.

Mr. Howard H. Johnson since his recent discharge from the Army has been working in the laboratory of the Ismert-Hincke Milling Co., Topeka, Kan.

Messrs. G. C. Bacon, G. C. Given, R. G. Gutelius, U. J. Lebourveau, G. C. Robinson, A. M. Taylor, and W. C. Wilson have been transferred from the Experimental Laboratories of the Atlas Powder Company, Tamaqua, Pa., to Stamford, Conn., where they form the personnel of a new Atlas Powder Company Experimental Laboratory.

Mr. E. R. Lederer, formerly superintendent of the Petroleum Refining Company of Texas, is at the present time general superintendent of the Home Oil Refining Company of Texas with headquarters at Fort Worth, Texas.

Mr. O. B. Zimmerman, following his discharge from the Army, returned to his former place of employment, the International Harvester Company of America, Chicago, Ill., where he is advisory engineer to the sales department.

Drs. E. T. Allen and E. G. Zies, of the Geophysical Laboratory, Washington, D. C., are members of the expedition of the National Geographic Society to Mt. Katmai, Alaska, and will study the physical chemistry of the fumerols of that volcanic district.

Mr. G. H. Cartledge, who was associated with Col. G. A. Burrell in consulting work at Pittsburgh, is now chief chemist of the Island Refining Corp., Jones' Point, N. Y. Associated with Mr. Cartledge, as chief of development operations, is Mr. H. E. Bruce.

Dr. E. R. Stein has been discharged from the U. S. Army, where he was engaged in experimental work in the Chemical Warfare Service, Hanlon Field, France, and has accepted a position as research chemist at Shawinigan Laboratories, Ltd., Shawinigan Falls, Quebec, Canada.

Mr. L. A. Dubbs has resigned his position as chemist with the Universal Oil Products Company, Independence, Kan., and has become connected with the Pacific Potash-Alum-Sulfur Co., Los Angeles, Cal.

Mr. F. W. Mohlman, formerly chemist for the Connecticut State Department of Health in charge of the laboratory for the investigation of stream pollution and sewage disposal, is now chief chemist in charge of the laboratory of the Chicago Sanitary District, Chicago, Ill.

Mr. George H. Ellinwood, formerly chief chemist for the Boston Belting Corporation, Boston, Mass., recently entered the employ of the Federal Rubber Company, Cudahy, Wis., as technical superintendent.

Mr. D. B. Dow, who recently returned from overseas duty and who was later discharged from the service, has accepted a position with the Bureau of Mines, at the Petroleum Experiment Station, Bartlesville, Oklahoma.

Mr. J. S. Staudt, formerly with the M. W. Kellogg Company, Air Nitrate Plant No. 2, Muscle Shoals, Ala., is now with the staff of supervising engineers, in connection with the construction of the Government Infantry School of Arms, at Columbus, Ga.

Mr. Esmond R. Long is now an instructor in the department of pathology, University of Chicago, Chicago, Illinois, having been formerly on the staff of the Saranac Laboratory for the study of tuberculosis.

Mr. A. Lusskin, formerly on the chemical engineering staff (operating) of the Air Nitrates Corporation at the plant at Muscle Shoals, Ala., is now research chemist with the International Oxygen Company, Newark, N. J.

Dr. Horatio Wales, Jr., formerly chemist for the Evans Engineering Corporation, Old Bridge, N. J., is now chemical assistant to Mr. F. W. Hochstetter of the Recording and Computing Machines Company, Dayton, Ohio.

Mr. Charles V. Bacon, recently discharged from the service, while still holding a civil appointment as chief of the Research Section of the Engineering and Standardization Branch of the General Staff of the War Gas Investigations is also carrying on his work as chemical engineer, at 3 Park Row, New York City.

Mr. W. Faitoute Munn, formerly chemist in charge at the Baker & Adamson Works of the General Chemical Company, Easton, Pa., has accepted the position as chief chemist for the Brewster Film Corporation, East Orange, New Jersey.

Mr. J. Egbert Bishop, chemist, met his death recently while inspecting a 4.7 howitzer shell at the Piccatinny Arsenal, Dover, N. J.

Mr. A. G. Greenamyer has accepted the position of metallurgist with the Donner Steel Company after serving as chief chemist and metallurgist with the Pittsburgh Crucible Steel Company, Pittsburgh, Pa.

Mr. Kenneth E. Bell, formerly 2nd Lieutenant in the Chemical Warfare Service at Edgewood Headquarters, is now working in the research laboratory of applied chemistry at the Massachusetts Institute of Technology under Doctors W. K. Lewis and R. E. Wilson.

Mr. Arnold H. Smith has resigned his position as assistant chemist in the Bureau of Standards, Washington, D. C., and has accepted a position in the research laboratory of the Goodyear Tire and Rubber Company, Akron, Ohio.

Mr. Robert F. Reed has resigned his position with the Ault & Wiborg Co. of Cincinnati, Ohio, as superintendent of their dye works at Norwood, Ohio, to accept a position with E. I. du Pont de Nemours & Co. in connection with the dye works at Deepwater Point, N. J.

Mr. T. Linsey Crossley, who has been associated for a number of years with Dr. J. T. Donald of Montreal and who established the Toronto laboratory of J. T. Donald and Co., consulting chemists, has taken over the Toronto office and laboratory of that firm at 43 Scott Street, and will there carry on the business of consulting chemist and chemical engineer.

Mr. George G. Wunder has resigned his position with the Rock Island Arsenal Laboratory to accept a position as assistant chief chemist of the A. O. Smith Corporation at Milwaukee, Wis.

Dr. Charles C. Scalione, formerly Lieutenant in the Research Division of the Chemical Warfare Service, has been appointed catalytical chemist of the Nitrates Division of the Ordnance Department and is now stationed at the Fixed Nitrogen Research Laboratory, American University, Washington, D. C.

Dr. Samuel C. Prescott, of the Massachusetts Institute of Technology, formerly Major in the Sanitary Corps, U. S. A., has been appointed expert in charge of dehydration investigations in the Bureau of Chemistry, Department of Agriculture, and will continue the investigations on this subject carried on during the war under the direction of the War Department.

Mr. J. P. Bonardi, assistant chemist, U. S. Bureau of Mines, who has been at the Seattle Station experimenting on flotation problems with W. H. Coghill, has returned to his assignment at the Golden, Col., Station.

Mr. Herbert Fleck has been appointed chief chemist, Crucible Steel Co., Pittsburgh, Pa., succeeding his brother, Mr. E. M. Fleck.

Mr. J. W. Howard has finished serving in the Ordnance Department of the Army and has resumed the practice of his profession as consulting engineer on roads and pavements with testing laboratory in Newark, N. J., and office in New York City.

Dr. R. F. Bacon, director of the Mellon Institute, is chairman of the committee of the American Institute of Chemical Engineers which is coöperating with the Government in the disposition of chemical plants and surplus stocks of chemicals and apparatus.

Mr. E. H. Claussen, recently discharged from military service, is with the Mine & Smelter Supply Co., 42 Broadway, New York City.

Mr. Thomas E. Fisher has resigned from the Wharton Steel Company and has become connected with the Traylor Engineering & Manufacturing Co., Allentown, Pa.

Mr. R. W. Hovey, of the Forest Products Laboratories of Canada, has resigned to accept a position with the Abitibi Power and Paper Co., Iroquois Falls, Ont.

Mr. Stuart B. Marshall, consulting engineer and metallurgist, has established his headquarters at Chevy Chase, Washington, D. C. He also retains his Roanoke, Va., address.

Capt. Edward Steidle has recently returned from Europe to resume his work with the Carnegie Institute of Technology, Pittsburgh, Pa. He will devote his time to the development of a mining department which will be in close contact with the industry.

Mr. Albert W. Davison, recently discharged from the Chemical Warfare Service, and formerly assistant professor in physical and electrochemistry at the University of Cincinnati, is now manager of the Virginia Haloid Company, Low Moor, Va.

Mr. Arthur D. Camp has been transferred from the Cleveland factory of the National Carbon Company to the American Ever-Ready Company, Long Island City, N. Y., where he has established a laboratory and general technical department.

Mr. James K. Plummer, formerly at Raleigh, associated with the North Carolina Experiment Station, has joined the staff of the Hercules Powder Company.

Mr. Eugene Waugh, president of the Waugh Chemical Corporation, 2 Rector Street, New York, died recently at New Rochelle, following an operation for stomach trouble. He was born in Jersey City in 1857. Mr. Waugh was with the General Chemical Company for fifteen years.

Mr. H. L. Marsh has resigned his position as works director and superintendent of the E. Virgil Neal Chemical Works, Long Island City, N. Y., to enter into manufacturing and consulting work on his own account. At present Mr. Marsh is president of the Norfolk Chemical Company, Inc., a newly formed corporation about to undertake the manufacture of a few special pharmaceutical chemicals and in addition he is director of the Marsh & Marshall Laboratories, consulting, research, and analytical chemists.

Mr. Samuel W. Epstein, formerly in charge of the Rubber Laboratory in Akron, Ohio, a branch of the Bureau of Standards in Washington, D. C., was recently called to Washington to take charge of rubber chemistry at that Bureau.

Mr. George H. Kimber, who was with the National Aniline & Chemical Company prior to his enlistment in the Air Service, U. S. A., has now been discharged from the latter and is with the United States Color & Chemical Co., at Ashland, Mass.

Mr. B. V. Reeves, who was discharged from the Army last March after serving at the United States Chemical Plant, Saltville, Va., as superintendent of the retort department, with rank of 1st Lieutenant, Ordnance Corps, is now employed by the Farnam Cheshire Lime Co., Farnams, Mass., as chemical engineer.

Mr. Emory F. Almy, formerly serving as chemist at Fort Omaha at the hydrogen plant, and later transferred to the Chemical Warfare Service at Cleveland, is now chief chemist of the Lawrenceville, Pa., plant of the Nestle Food Company.

Dr. Samuel Avery, who served as Major in the Chemical Warfare Service during the war, has returned to the University of Nebraska.

Capt. O. L. Barneby, formerly commanding officer of the Defense Department, Development Division of the Chemical Warfare Service, at Nela Park, Cleveland, is now at the Nizor Laboratory of the Crouse Tremaine Co., Cleveland, Ohio.

Mr. G. O. Kildow, recently discharged from the Chemical Warfare Service, has been awarded a fellowship established by the Northwest Magnesite Company.

Dr. Benton Dales, formerly professor and head of the department of chemistry at the University of Nebraska, is now research chemist for the B. F. Goodrich Rubber Co., at Akron, Ohio.

Mr. R. P. Anderson has returned from overseas to his former position with the United Natural Gas Co., Oil City, Pa.

Mr. C. J. Engelder, who has been a lieutenant in the nitrate division of the Ordnance Department, carrying on research in connection with the operation of the United States Nitrate Plant No. 1, Sheffield, Ala., is now with William J. Knox, of New York City.

Mr. Byron S. Proper, who has been in the service for over a year, conducting water analysis for the Army in France, is now chief chemist and technical representative for the H. Reeve Angel & Co., Inc., New York City.

Mr. Archibald M. Erskine, formerly with the Chemical Warfare Service, Washington, D. C., is now with the du Pont Company at the Eastern Laboratory, Gibbstown, N. J.

Mr. Ismond E. Knapp, formerly chemical engineer and consulting chemist with the Technical Service Corporation, is now with du Pont Company at the Jackson Laboratory, Wilmington, Del.

Mr. Reginald H. Eagles, recently discharged from the Chemical Warfare Service, is now chemical engineer with the Dorr Company of New York City.

Mr. Clark M. Dennis, formerly with the Barrett Company, is at present with John E. Teeple, Ph.D., of New York City, as consulting and engineering chemist.

Mr. T. L. Nelson is now with the National Carbon Company, at Niagara Falls, N. Y., having formerly been with the Ansco Co., at Binghamton.

Lt. Lee F. Supple, of the Sanitary Corps, at present stationed at the Embarkation Hospital, Camp Stuart, Newport News, has been appointed assistant professor of organic chemistry at Lewis Institute, Chicago, and will take up his new duties at the beginning of the summer term.

Mr. R. W. Millar has been discharged from the First Gas Regiment, U. S. A., and has returned to the University of Illinois to do graduate work.

Dr. A. S. Loevenhart, formerly chief of the Pharmacological Section, Research Division, Chemical Warfare Service, is again at his post as professor of pharmacology and toxicology, University of Wisconsin, Madison, Wis.

The honorary degree of doctor of science was conferred upon Dr. Raymond Foss Bacon, Director of the Mellon Institute of Industrial Research, on the occasion of the annual commencement of DePauw University, Greencastle, Ind., on June 11, 1919.

The election of the following officers for the ensuing year was recently announced at the annual meeting of the Manufacturing Chemists' Association in New York City: *President*, Thomas S. Grasselli; *Vice Presidents*, William Hamlin Childs and H. H. F. Handy; *Treasurer*, C. Wilbur Miller; and *Secretary*, Arthur H. Weed. The new executive committee consists of Henry Howard, *Chairman*, E. R. Grasselli, D. W. Jayne, Lancaster Morgan, J. D. Penrock, Chas. L. Reese, and A. C. Rosengarten.

Dr. Arthur W. Dox, after nineteen months' military service as Captain in the Sanitary Corps, has returned to his former position as chief of the chemistry section of the Iowa Agricultural Experiment Station.

Mr. Martin Kilpatrick, Jr., of the division of inorganic chemistry, the College of the City of New York, has accepted a position as assistant professor of chemistry at Vassar College.

Mr. W. E. Gouwens, who served in the Sanitary Corps, U. S. A., having been stationed at the Embarkation Depot at Newport News, Va., has returned to his position as curator of the Kent Chemical Laboratory, University of Chicago.

Mr. Wilbur F. Brown, formerly of Ball Brothers Glass Company at Muncie, Ind., has recently accepted a position in the laboratory of the Libby Owens Glass Company, at Kanawha Falls, W. Va.

Mr. John C. Jopling, formerly of Princeton, Ind., is now located at Barberton, Ohio, with the Diamond Match Company, and is developing some special machinery and processes which are used in the manufacture of a special match.

On the occasion of the annual commencement of the University of Pittsburgh on June 13, the honorary degree of doctor of engineering was conferred upon Mr. Van H. Manning, Director of the United States Bureau of Mines, in recognition of his noteworthy accomplishments in the investigation of problems of mineral technology. The University also conferred the honorary degree of doctor of chemistry upon Dr. Willis R. Whitney, Director of the Research Laboratory of the General Electric Company, Schenectady, N. Y., because of the valuable service which he rendered to the Government as a member of the Naval Consulting Board. These honorary degrees were given upon the recommendation of the Mellon Institute of Industrial Research, an integral part of the University of Pittsburgh.

Mr. Joseph E. Plumstead, until recently chief chemist and assistant superintendent for the Kingsport Pulp Corporation, of Kingsport, Tenn., has returned to the Celluloid Company, Newark, N. J., where he was at one time employed, to take charge of the production end of developed processes and to work on process development.

Mr. Felix Kremp, formerly with the Electric Reduction Company, Washington, Pa., is now connected with the Atlas Crucible Steel Company, as assistant metallurgist, Dunkirk, N. Y.

Dr. H. J. Broderson, formerly an instructor in industrial chemistry at the University of Illinois, is now with the Standard Oil Company located at Indiana.

Mr. E. L. Priest, formerly doing prescription and laboratory work in Joliet, Ill., is now with the William S. Merrell Chemical Company of Cincinnati, Ohio, doing pharmaceutical chemistry in their specialty department.

Lt. H. P. Gurney has been discharged from the Chemical Warfare Service, Gas Defense Division, and has returned to the Boston Belting Corporation to take charge of their technical division.

Miss Mildred E. Hinds, formerly assistant chemist, has been appointed chief chemist of the Food and Drugs Department of the state of Tennessee to succeed Mr. H. L. Walter, former chief chemist, who has resigned to take up work in Idaho.

Miss Helen Updegraff, formerly assistant research chemist of the Delaware College Agricultural Experiment Station, is now in charge of the chemical work at Columbia Hospital, Milwaukee, Wisconsin.

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.

INTERNAL REVENUE COMMISSIONER

Manual for Oil and Gas Industry under Revenue Act of 1918. 136 pp.

NATIONAL MUSEUM

Heretofore Undescribed Meteoric Stone from Kansas City, Missouri. B. P. Merrill. Reprint No. 2259.

BUREAU OF CONSTRUCTION AND REPAIR

Gas Masks. Instructions for use of Navy gas masks, mark 2, head canister type. 13 pp.

Rivets. Specifications for riveting and reference data for use therewith. 69 pp.

NATIONAL ACADEMY OF SCIENCES

Report of National Academy of Sciences, Year 1918. 154 pp. Paper, 10 cents. Same as Senate Document 388.

DEPARTMENT OF LABOR WORKING CONDITIONS SERVICE

Investigation into Dermatic Effect and Infective Character of Lubricating Compound. F. E. Deeds. 8 pp.

BUREAU OF EDUCATION

Statistics of State Universities and State Colleges, Year Ended June 30, 1918. Bulletin 51. 15 pp. Paper, 5 cents.

Commercial Education. F. V. Thompson. Bulletin 18. 11 pp. Paper, 5 cents.

Engineering Education. F. L. Bishop. Bulletin 19. 8 pp. Paper, 5 cents.

Advanced Educational Work within Government Bureau. P. G. Agnew. Higher Educational Circular 14. 7 pp. Issued February 1919.

FUEL ADMINISTRATION

Standardization of Petroleum Specifications Committee. Oil Division Bulletin 1. 11 pp. Reprint with slight changes of report for 1918.

PUBLIC HEALTH SERVICE

Biochemical Studies of the Saliva in Pellagra. M. X. Sullivan and K. K. Jones. Public Health Reports. May 16, 1919. 12 pp.

Determination and Distribution of Arsenic in Certain Body Fluids after the Injection of Arsenobenzol, Salvarsan, and Neosalvarsan. C. N. Myers. Public Health Reports. May 2, 1919. 10 pp.

GEOLOGICAL SURVEY

Cadmium in 1918. C. E. Siebenthal. Separate from Mineral Resources of the United States, 1918, Part I. 12 pp. Issued May 8, 1919.

The market for metallic cadmium was not good in the first half of 1918, and considerable stocks accumulated, amounting to 161,000 lbs. on August 31. Production was somewhat curtailed before August but more sharply curtailed after that time. The output during the first eight months of the year was 118,700 lbs. of metallic cadmium and 36,500 lbs. of cadmium sulfide, but for the last four months it was only 8,464 lbs. of metallic cadmium and 15,202 lbs. of cadmium sulfide.

There are several cadmium minerals, but none of them occur in profitable quantities as ores. The cadmium of commerce is derived from zinc minerals and ores, in almost all of which it occurs in minute quantity, the ratio being about 1 of cadmium to 200 of zinc. Cadmium behaves metallurgically almost the same as zinc and hence constitutes a fraction of 1 per cent of almost all spelter. The sources of cadmium that have been utilized are zinc ores treated by fractional distillation, lead-furnace bag-house "fumes," and residues from the purification vats of electrolytic zinc plants and lithopone plants.

The maximum capacity for metallic cadmium reported by producers is 29,000 lbs. a month, or about 175 tons a year. This capacity will be increased by the entrance into the producing list of other electrolytic zinc plants. If the price of cadmium and the demand for it should justify expansion, the producing capacity could no doubt be brought up with reasonable promptness to 500 short tons or more yearly. The price of cadmium will be the deciding factor also in determining what grade of cadmium fumes can be worked at a profit.

Between February 1, 1918, and January 31, 1919, 42,320 lbs. of metallic cadmium, valued at $63,020, or an average of $1.49 per lb., were licensed for export to the countries listed, according to information furnished the War Trade Board. Of this quantity, 26,734 lbs. were licensed for export before June 30, 1918, and 15,586 lbs. between July 1 and December 10, 1918. It is believed that practically all of this cadmium was really exported.

In 1875 cadmium was quoted in the United States at $3.20 per lb. In 1886 the average price for the total output of Germany was 80 cents per lb., but in 1890 and 1892 it fell to 38 cents. In 1897, because of certain purchases by the German government, the price rose to $1.23 per lb. In 1907, when the United States began making cadmium, the German average price was 84 cents. The price in the United States went down to 53 cents in 1909, but it has been steadily rising since.

The price of cadmium in sticks and small bars in the first quarter of 1918 gradually declined from an average price of $1.75 per lb. to $1.40. In April and May the average price was $1.40, and in June and July it was $1.45. For the remainder of the year the quotation was $1.50 per lb. The average price for 1918 as calculated from sales was $1.48, as compared with $1.47 in 1917 and with $1.56 in 1916. The price in London during the first half of 1918 was $1.90 per lb. and during the last half year slightly under that figure. The average selling price of cadmium sulfide in the United States in 1918 was $1.36 per lb., as compared with $1.41 in 1917 and with $1.26 in 1916.

The value of the output of cadmium in the United States in 1918, calculated at the average selling price, was $188,203, as compared with $305,097 in 1917, and the value of the cadmium sulfide produced was $70,315, as against $70,939 in 1917.

The total value of the output of metallic cadmium in the United States since the beginning of production in 1907 is $1,018,876 and of cadmium sulfide $221,704, a total of $1,240,580.

The Nenana Coal Field, Alaska. G. C. Martin. Bulletin 664. 54 pp. The coal of the Nenana field occurs in many beds of different thickness, the thickest measuring perhaps 30 or 35 ft., which are distributed rather uniformly through the coal measures. At least twelve beds are of workable thickness, and six or more measure over 20 ft. No geographic or stratigraphic variation in the character of the coal was noted. The analyses given on pages 8 and 9 show that the coal is a lignite of good grade, of about the same quality as that of Cook Inlet. The coal will probably be used as locomotive fuel on the government railroad for generating power and for thawing at the mines in Tanana Valley, as domestic fuel in Tanana Valley, and as fuel on Tanana River boats and possibly on some of the Yukon steamers. Nenana coal, rather than the better and nearer Matanuska coal, should, if possible, be used on the greater part of the railroad, because the heavy freight traffic will be northbound, and the southbound empties will be available for hauling coal. The Nenana coal field is nearer the summit of the Alaska range than any known coal field south of the divide.

Natural-Gas Gasoline in 1917. J. D. NORTHROP. Separate from Mineral Resources of the United States, 1917, Part II. 21 pp. Issued March 17, 1919.

For the natural-gas gasoline industry in the United States the year 1917 was one of marked expansion in every phase. The quantity of raw gasoline recovered from natural gas in that year, including that produced by compression, by absorption, and by vacuum pumps, as well as that saved as drips from gas mains, was 217,884,104 gallons, a gain of 114,391,415 gallons, or 111 per cent, over the output in 1916. Of this quantity, 168,866,555 gallons, or 77.5 per cent, were recovered by compression and by vacuum pumps, and the remaining 49,017,549 gallons, or 22.5 per cent, by absorption and by salvage from gas mains. The combined gasoline obtained by compression and by vacuum pumps was greater than in 1916 by 83,943,768 gallons, or 99 per cent, and the gasoline obtained by absorption and from drips was greater by 30,447,647 gallons, or 164 per cent.

The quantity of commercial gasoline represented by the raw gasoline in 1917, though not susceptible of accurate determination, probably amounted to more than 300,000,000 gallons.

The average price received in 1917 for the raw gasoline at the sources of production was 18.45 cents a gallon, and the market value of the entire output was $40,188,956, a gain of 4.6 cents in average unit selling price and of $25,857,808, or 180 per cent, in gross market value, compared with 1916, which reflects the steadily appreciating value of motor fuels in the period under review.

The volume of natural gas from which the natural-gas gasoline was recovered in 1917 amounted to about 429,000,000,000 cubic feet, and the average recovery of gasoline per 1,000 cubic feet by all methods was about half a gallon.

The number of plants, including vacuum pump plants, recovering gasoline from natural gas increased from 596 at the beginning of 1917 to 886 at the end of that year, a gain of 49 per cent, and the combined daily capacity of all plants increased during the same period from 495,448 gallons to 902,385 gallons, or about 82 per cent.

Fuel Briquetting in 1918. C. E. LESHER. Separate from Mineral Resources of the United States, 1918, Part II. 3 pp. Issued April 30, 1919.

The production of fuel briquets in 1918 was 477,235 net tons, valued at $3,212,793, an increase, compared with 1917, of 70,379 tons, or 17 per cent, in quantity and of $978,905, or nearly 44 per cent, in value. The production in 1918 was the highest recorded and represented the third successive year of material progress in the industry, being more than double the output in 1915.

Of the 12 plants in operation in 1918, 6 used anthracite as a raw material, 1 Arkansas semianthracite, 1 semibituminous slack, 1 anthracite culm and bituminous slack, 1 bituminous slack and subbituminous coal, and 2 oil-gas residue. Six plants used coal-tar pitch and asphaltic pitch for binders, 1 used sulfite pitch, 3 used vegetable binders or other special processes in manufacturing, and 2 used no binder.

Gold and Silver in 1917. H. D. MCCASKEY AND J. P. DUNLOP. Separate from Mineral Resources of the United States, 1917, Part I. 47 pp. Issued May 9, 1919.

In addition to the production of gold and silver by domestic smelters and refiners from domestic sources in 1917, amounting to 4,051,440 fine ounces of gold and 71,740,362 fine ounces of silver, these plants produced 769,171 fine ounces of gold and 50,106,811 fine ounces of silver from foreign ores. These figures represent a decrease of 31,634 ounces of gold and an increase of 3,855,794 ounces of silver compared with the corresponding figures for 1916. The foreign ores producing this bullion were mainly from Mexico and Canada.

The value of the new gold used in the arts and industries in the United States in 1917 was $34,803,445, and the quantity of silver used for such purposes in 1917 was 15,998,807 fine ounces.

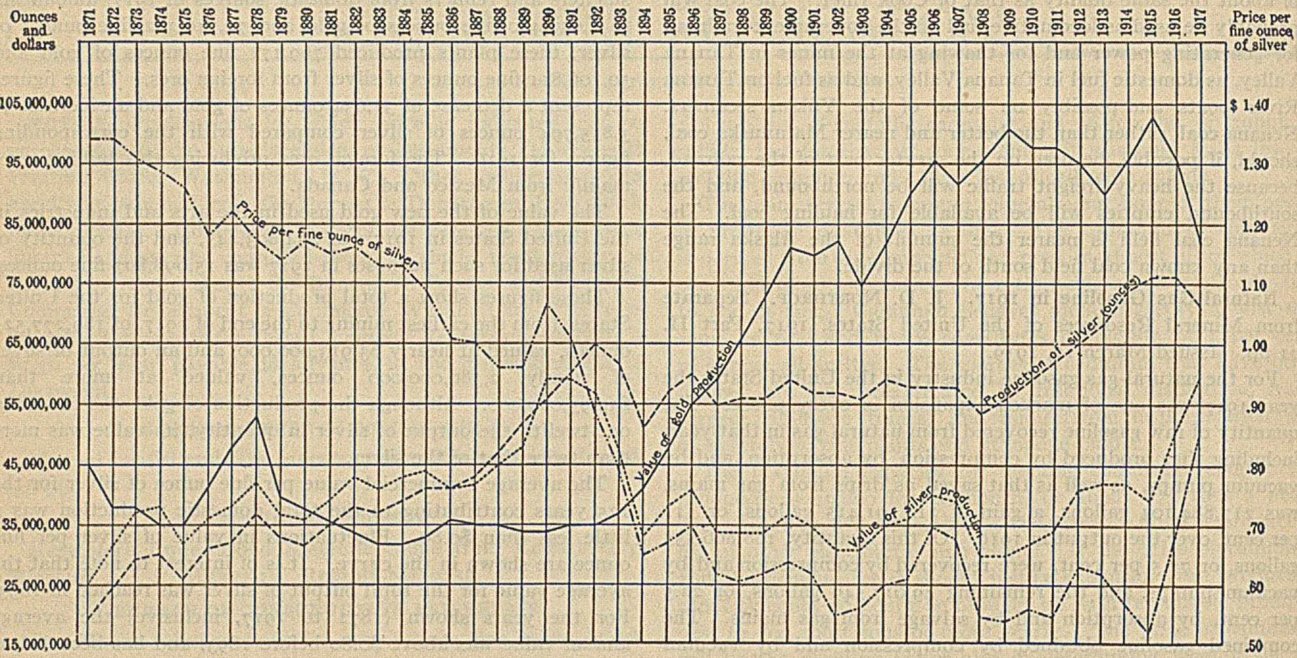
These figures show a total production of gold for the United States, from the earliest mining to the end of 1917, of 189,277,525 ounces, valued at nearly $3,913,000,000, and an output of silver of nearly 2,380,000,000 ounces, valued at more than $1,895,000,000. Although the production of gold was less than one-twelfth the output of silver in quantity, its value was more than twice that of the silver.

The average commercial value per fine ounce of silver for the 125 years contributing to the total domestic production was a little less than $0.80. Fluctuations in value of silver per fine ounce are shown in the curve. It is of interest to note that the average value for the total output of silver was reached in 1893. For the years shown (1871 to 1917, inclusive) the average annual value was above $0.80 before 1893, and has been below that figure every year since, until 1917, when the average value was $0.8235, or 2.35 cents more than the average value 1871–1916.

A decrease in production of gold from mines of the United States of $10,789,685 is shown for 1917, following a decrease of $6,782,884 in 1916. A decrease of 8,209,645 ounces of silver is shown, following an increase of 6,506,298 ounces in 1916.

The average extraction values in gold and silver were comparatively high for the siliceous ores of Colorado, New Mexico, Nevada, Montana, Oregon, Utah, Idaho, Texas, and Washington, and low for the larger ore bodies of California, South Dakota, and Alaska. Some of the states produced comparatively small quantities of copper ore carrying high extraction values in gold and silver, but the copper ores of the important copper-producing states showed low extraction values. The average recovery in gold and silver from the copper ores of Arizona was $0.41 a ton, that of Tennessee $0.15 a ton, that of Montana $1.63 a ton, that of Nevada $0.26, that of New Mexico $0.11, that of Utah $0.27, that of California $1.57, and that of Michigan $0.18. The lead ores of Utah showed an average recovery in gold and silver of $10.55 a ton, and the lead ores of Idaho only $4.62 a ton. Idaho produced the largest quantity of gold- and silver-bearing lead ores, and also of lead-zinc ores. Utah yielded the next largest quantity of lead ore; but the gold and silver content of such ore was less than that of Montana ore of similar character. About 18.1 per cent of the output of ore considered as producing gold and silver was dry or siliceous ore, against 19.5 per cent in 1916; 73 per cent was copper ore, against 71.5 per cent in 1916; 3.71 per cent was lead ore; 4.16 per cent was lead-zinc ore; 0.95 per cent was zinc ore, and 0.05 per cent was copper-lead ore. The average precious-metal extraction value per ton of siliceous ores of the United States decreased from $5.73 to $5.56, that of zinc ores from $1.21 to $0.90, and that of copper-lead ores increased from $5.54 to $14.58. The average gold and silver value of copper ores per ton was 51 cents in 1916 and 49 cents in 1917, and that of lead-zinc ores increased from $2.31 to $2.82.

It has been estimated by H. D. McCaskey that the consumption of quicksilver in the amalgamation process in the United States (including Alaska) for the period 1911 to 1917, inclusive, has varied between 90,000 and 100,000 lbs. annually. The consumption at mills treating ore and by dredging and other methods of placer mining are given in the separate chapter



Curves Showing Production and Value of Gold and Silver and Price per Fine Ounce of Silver in the United States, 1871–1917

entitled "Quicksilver in 1917," prepared by F. L. Ransome and published elsewhere in Mineral Resources for 1917.

It has not been possible to obtain a complete report showing the total consumption of potassium cyanide and sodium cyanide used in the recovery of gold and silver in the United States in 1917. If the quantity used in California, Alaska, and Oregon is added to the 3,710,886 lbs. reported to have been used in other western states the estimated total consumption was probably several hundred tons less than the estimated quantity, 2,600 tons, consumed in 1916.

The figures given indicate the elimination of the use of potassium cyanide in the recovery of gold and silver, for only about 69 tons were used in 1917 and this was probably from old stocks at mines. The growing scarcity of potassium cyanide necessarily increased the use of sodium cyanide. The domestic supply of sodium cyanide was sufficient to supply the domestic consumption. As the quantity of bullion recovered was less in 1917 than in 1916, however, the quantities of quicksilver and of cyanide used were less. The quantity of cyanide used per ton of ore or tailings treated and the quantity of gold and silver recovered per pound of cyanide show considerable variations. These variations are doubtless due in part to greater efficiency in large milling plants in some of the states but are mainly caused by the difference in the character and varying metal content of the ores treated.

Clay-Working Industries and Building Operations in the Larger Cities in 1917. J. Middleton. Separate from Mineral Resources of the United States, 1917, Part II. 62 pp. Issued May 12, 1919.

The total value of all clay products marketed in 1917 was $248,023,368—an increase of $40,763,277, or nearly 20 per cent. In 1916 the increase over 1915 was $44,139,859, or 27 per cent. In 1917 brick and tile products, embracing structural products, engineering refractories, and miscellaneous wares—the coarser clay products—were valued at $191,860,846, or more than 77 per cent of the total, and pottery products were valued at $56,162,522, or nearly 23 per cent of the total. Brick and tile products increased in value $32,817,997, or nearly 21 per cent, and pottery products increased $7,945,280, or more than 16 per cent, compared with 1916.

The most noteworthy features of the year were (1) the large increase in the quantity and value of fire brick; (2) the decrease in the quantity and value of common brick, especially in the Hudson River region; (3) the large increase in the value of hollow building tile; and (4) the successful manufacture of glasshouse pots for optical glass from domestic clays.

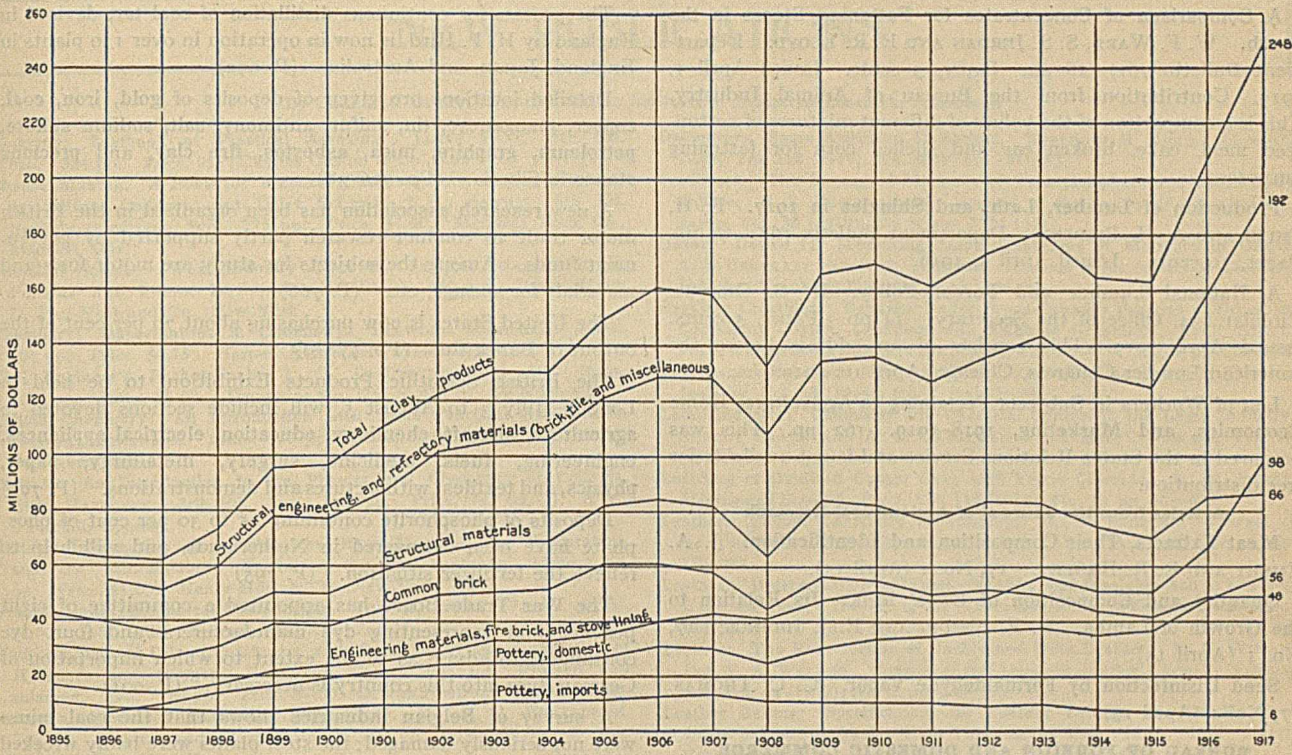
The engineering products and refractory brick—vitrified brick, draintile, sewer pipe, fire brick, and stove lining—valued at $98,085,793, increased $30,469,293, or 45 per cent, and the clay structural materials, valued at $85,659,887, made a net increase of $1,016,635, or 1 per cent, in 1917, compared with 1916.

The increase in refractories was caused principally by the demand for these wares in the munitions industries, and especially in the erection of by-product coke ovens, which require a very high-grade refractory, though the use of refractories for other purposes is increasing rapidly with the industrial development of the country. One who is unfamiliar with the many uses of refractories finds it difficult to realize their importance. They are absolutely essential to the iron and steel industries, the basis of our modern industrial development; they are used in railroad locomotives and in steamships, in the manufacture of lead and zinc, in the manufacture of glass, in the baking of bread, in the tanning of leather, in the burning of many clay products, in kitchen stoves and ranges, and almost everywhere else that fires are used, either for the generation of power or for heat.

The large decrease in common brick was caused principally by the decrease in building operations throughout the country, but it may be attributed in part to the increased and increasing use of hollow building tile.

The imports of clay products, 97 to 98 per cent of which are pottery, which have in recent years been decreasing, in 1917 showed an increase of $876,908, or 15 per cent, compared with 1916. This increase was principally in pottery—$732,729. Owing to the unusual demand at home, however, this increase had little or no effect on the domestic production, the proportion of which to consumption was 92 per cent, the same as for 1916 and the highest recorded.

The exportation of clay products, an unimportant factor in the industries, showed another large increase in 1917 and reached the maximum value—$6,953,263, which was $1,952,368, or



Value of Clay Products Sold in the United States, 1895–1917

39 per cent, greater than the previous maximum in 1912. Fire brick continues to be the principal clay product exported.

Value of the Clay Products of the United States in 1916 and 1917, and Increase or Decrease in 1917, by Products

Products	1916	1917	Increase or Decrease in 1917 Value	Per cent
Common brick	$ 49,357,411	$ 47,936,344	—$ 1,421,067	— 2.88
Vitrified brick or block	12,236,890	10,664,560	— 1,572,330	—12.85
Front brick	11,464,614	10,391,368	— 1,073,246	— 9.36
Fancy or ornamental brick	109,072	192,072	+ 83,000	+76.10
Enameled brick	827,443	889,899	+ 62,456	+ 7.55
Draintile	10,083,647	11,008,163	+ 924,516	+ 9.17
Sewer pipe	13,577,006	17,307,211	+ 3,730,205	+27.47
Architectural terra cotta	6,466,336	6,173,550	— 292,786	— 4.53
Fireproofing and hollow building tile	9,942,912	13,255,433	+ 3,312,521	+33.32
Tile, not drain	6,475,464	6,821,221	+ 345,757	+ 5.34
Stove lining	601,776	619,882	+ 18,106	+ 3.01
Fire brick	30,806,129	58,012,264	+ 27,206,135	+88.31
Miscellaneous	7,094,149	8,588,879	+ 1,494,730	+21.07
Total brick and tile	$159,042,849	$191,860,846	+$32,817,997	+20.63
Total pottery	48,217,242	56,162,522	+ 7,945,280	+16.48
Grand Total	$207,260,091	$248,023,368	+$40,763,277	+19.67

BUREAU OF STANDARDS

A Study of the Goutal Method for Determining Carbon Monoxide and Carbon Dioxide in Steels. J. R. Cain and E. Pettijohn. Technologic Paper 126. 8 pp. Issued April 30, 1919.

Standard Samples Issued or in Preparation. Supplement to Circular 25. 6 pp. Issued April 1, 1919.

Silica Refractories: Factors Affecting Their Quality and Methods of Testing the Raw Materials and Finished Ware. D. W. Ross. Technologic Paper 116. 84 pp. Paper, 20 cents. Issued April 19, 1919.

Aluminum and Its Light Alloys. Circular 76. 120 pp. Paper, 20 cents. Issued April 21, 1919. The circular deals primarily with the physical properties of the metal or alloy. All other features, except a few statistics of production and such as methods of manufacture, presence of impurities, etc., are discussed only in their relation to these physical properties. It must be realized that the physical properties of metals and alloys are often in great degree dependent upon such factors, so that the statement of values for such properties should include accompanying information regarding these factors by which the properties are affected.

The endeavor, therefore, in the circular is to reproduce only such data as have passed critical scrutiny and to suitably qualify in the sense outlined above all statements, numerical or otherwise, made relative to the characteristics of the metal. The data and information have been put in the form of tables and curves, the curves being reproduced in such dimensions that accurate interpolation of values on them is possible by the use of a rule graduated in decimal parts of a centimeter. The probable degree of accuracy of data is indicated or implied by the number of significant figures in the values given.

Viscosity of Gasoline. W. H. Herschel. Technologic Paper No. 125. 18 pp. Paper, 5 cents. Issued May 5, 1919.

DEPARTMENT OF AGRICULTURE

A Simple Steam Sterilizer for Farm Dairy Utensils. S. H. Ayers and G. B. Taylor. Farmers' Bulletin 748. Revised. 16 pp.

Muscadine Grape Paste. C. Dearing. Farmers' Bulletin 1033. 15 pp. This is a contribution from the Bureau of Plant Industry. It gives directions for securing suitable fruit, the extraction of the pulp, and the sweetening, cooking, drying, and storing of the product, as well as the making of various combinations, fancy pastes, and pastes from other fruits.

Digestibility of Certain Miscellaneous Animal Fats. A. D. Holmes. Department Bulletin 613. 25 pp. Paper, 5 cents. Issued April 25, 1919. This paper deals with the digestibility of goat's butter, kid fat, hard palate fat, horse fat, oleo oil, oleo stearin, ox-marrow, ox-tail, and turtle fats.

Experiments on the Digestibility of Wheat Bran in a Diet without Wheat Flour. A. D. Holmes. Department Bulletin 751. 20 pp. Paper, 5 cents. Issued April 22, 1919. This gives the results of experiments made to secure data on the digestibility of wheat that will be of value in determining the most economical and physiologically efficient method of utilizing wheat for human food.

A Comparison of Concentrates for Fattening Steers in the South. W. F. WARD, S. S. JERDAN AND E. R. LLOYD. Department Bulletin 761. 16 pp. Paper, 5 cents. Issued April 7, 1919. Contribution from the Bureau of Animal Industry. This is a comparison of the values of different mixtures of cottonseed meal, cake, broken ear and shelled corn for fattening purposes.

Production of Lumber, Lath, and Shingles in 1917. F. H. SMITH AND A. H. PIERSON. Department Bulletin 768. 44 pp. Paper, 10 cents. Issued April 5, 1919.

A National Lumber and Forest Policy. H. S. GRAVES. Circular 134, Office of the Secretary. 14 pp. Paper, 5 cents. Issued April 1919. This consists of an address before the American Lumber Congress, Chicago, April 16, 1919.

List of Workers in Subjects Pertaining to Agriculture, Home Economics, and Marketing, 1918–1919. 162 pp. This was prepared in the States Relations Service and is not available for free distribution.

Articles from the Journal of Agricultural Research

Meat Extracts, Their Composition and Identification. J. A. EMERY AND R. R. HENLEY. 17, No. 1 (April 15).

Quantity and Composition of Ewes' Milk: Its Relation to the Growth of Lambs. R. E. NEIDIG AND E. J. IDDINGS. 17, No. 1 (April 15).

Seed Disinfection by Formaldehyde Vapor. C. C. THOMAS. 17, No. 1 (April 15).

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

Industrial Standards Series. Text as adopted by American Society for Testing Materials. Spanish-English editions prepared under supervision of Bureau of Standards. Series covers industrial standards for materials, which includes standards prepared by Government and by technical societies and other organizations.

14—Standard specifications for carbon steel car and tender axles. Revised 1918. 15 pp. 5 cents.

24—Standard specifications for staybolt iron. Revised 1918. 15 pp. 5 cents.

26—Standard specifications for refined wrought-iron bars. Revised 1918. 16 pp. 5 cents.

29—Standard specifications for cast-iron locomotive cylinders. Revised 1914. 15 pp., 4 text figs. 5 cents.

30—Standard specifications for extra-high-carbon steel splice bars. Revised 1914. 15 pp., 2 text figs. 5 cents.

34—Standard specifications for structural nickel steel. Revised 1916. 21 pp., 4 text figs. 5 cents.

35—Standard specifications for structural steel for cars. Revised 1916. 19 pp., 2 text figs. 5 cents.

36—Standard specifications for structural steel for ships. Revised 1916. 19 pp., 2 text figs. 5 cents.

37—Standard specifications for rivet steel for ships. Revised 1914. 17 pp., 4 text figs. 5 cents.

38—Standard specifications for billet-steel concrete-reinforcement bars. Revised 1914. 17 pp.

45—Standard specifications for iron and steel chain. Revised 1918. 19 pp. 5 cents.

47—Standard specifications for cast-iron car wheels. Adopted 1905. 21 pp. 5 cents.

48—Standard specifications for malleable-iron castings. Revised 1915. 13 pp., 2 text figs. 5 cents.

51—Standard specifications for medium hard-drawn copper wire. Revised 1915. 21 pp. 5 cents.

COMMERCE REPORTS—MAY 1919

In a Swedish summary of the **dyestuff situation**, it is stated that the United States is more than supplying its own needs, while in England, France, and Italy there is still a shortage. (P. 630)

France, once first in **beet sugar** production and fourth, in 1914, has suffered very serious loss in this industry, owing to destruction of plants and farms, and to removal by the Germans of machinery, etc. A marked shortage of sugar in France is therefore feared for some years. (Pp. 643–4)

The process for continuous **distillation of coal tar**, devised in England by H. P. Hird, is now in operation in over 130 plants in England, Japan, and Australia. (P. 692)

Detailed locations are given of deposits of **gold, iron, coal, copper, manganese, tin, sulfur, antimony, salt, sodium sulfate, petroleum, graphite, mica, asbestos, fire clay,** and **precious stones** in Siberia. (Pp. 726–38)

A new **research association** has been organized in the British motor trade to conduct research partly supported by government funds. Among the subjects for study are motor fuels and materials for springs, etc. (P. 766)

The United States is now purchasing about 70 per cent of the output of **Banca tin.** (Pp. 778–9)

The British Scientific Products Exhibition, to be held in London, July 3 to August 5, will include sections devoted to **agriculture, aircraft, chemistry, education, electrical appliances, engineering, fuels, medicine, surgery, metallurgy, paper, physics,** and **textiles**; with lectures and demonstrations. (P. 793)

Deposits of **phosphorite** containing 25 to 30 per cent of phosphate have been discovered in Netherlands, and will help to relieve the fertilizer situation. (P. 795)

The War Trade Board has appointed a committee of eight persons, four representing **dye** manufacturers, and four, dye consumers, to advise as to the extent to which importation of German dyes into this country is necessary. (P. 901)

A survey of **Belgian industries** shows that the coal mines were not seriously damaged; the steel plants were badly wrecked and dismantled; the pottery and glass industries can soon resume work; the sulfuric acid plants have suffered very severely; the soda plants and powder plants are in fair condition; the paper mills were badly stripped and can resume only partial operation. Detailed organizations have been developed for renewal of industries, and preliminary estimates of requirements have been made. (Pp. 902–13)

The manufacture of **casein,** and its use as a dry powder in bread, etc., is described. Other uses are in **adhesives, plastics,** etc. France is the largest producer. (Pp. 939–41)

Hydrogenation is being used in South Africa to produce **stearin** for **candles.** The **hydrogen** is obtained by electrolysis of water, the oxygen being sold as a by-product for **acetylene** welding. (Pp. 1022–3)

Great efforts are being made to expand the **flax** and **flaxseed** industry in Canada. (Pp. 1031–4)

The materials and methods used in the **soap industry** of South Africa are described in detail. (Pp. 1049–54)

Most of the **pulp wood** in Canada is used in ground wood and the balance chiefly in sulfate and sulfite pulp, with only a small amount of soda pulp. Much of this is made into paper in Canada for export. (Pp. 1059–61)

SUPPLEMENTS ISSUED

NORWAY—10*a*
CANADA—23*a*
COLOMBIA—42*a*
PORTUGUESE EAST AFRICA—76*a*

STATISTICS OF EXPORTS TO THE UNITED STATES

MOZAMBIQUE—Sup. 76*a*
Antimony
Beeswax
Copal gum
Copra
Corundum
Rubber
Mangrove bark

FRANCE—P. 1012
Alcohol
Chemicals
Glue
Hides
Rubber
Oils
Paper
Perfumery
Soap
Pottery
Glass

COLOMBIA—Sup. 42*a*
Asphalt
Balsam tolu
Copaiba
Divi-divi
Fustic
Indigo
Ipecac
Mangrove bark
Gold
Silver
Hides
Rubber
Platinum

BRITISH COLUMBIA—Sup. 23*a*
Brick
Cascara bark
Gum copal
Gum kauri
Chrome ore
Copper ore
Copper
Explosives
Gold
Hides
Rubber
Iron
Lime
Fish oil
Lubricating oil
Cottonseed oil
Sugar-beet seed
Silver
Kelp ash
Zinc ore
Manganese ore

NEW PUBLICATIONS

By Clara M. Guppy, Librarian Mellon Institute of Industrial Research, Pittsburgh

Assaying: Textbook of Practical Assaying. James Park. 5th Ed. 8vo. 354 pp. Price, 9s. Charles Griffin & Co., London.

Cheese Making: A Book for Practical Cheesemakers, Factory Patrons, Agricultural Colleges, and Dairy Schools. J. L. Sammis. 6th Ed. Entirely rewritten. 8vo. 225 pp. Price, $1.90. Mendota Book Co., Madison, Wis.

Chemical Science: What Industry Owes to Chemical Science. R. B. Pilcher and Frank Butler-Jones. 12mo. 150 pp. Price, $1.50. D. Van Nostrand Co., New York.

Chemistry: Opportunities in Chemistry. Ellwood Hendrick. 12mo. 101 pp. Price, $0.75. Harper & Brothers, New York.

Civil Engineer's Pocket-Book. J. C. Trautwine. 20th Ed. 16mo. 1608 pp. Price, $6.00. Trautwine Co., 257 S. 4th St., Philadelphia.

Colloid Chemistry: An Introduction with Some Practical Applications. Jerome Alexander. 16mo. 90 pp. Price, $1.00. D. Van Nostrand Co., New York.

Colloids: An Introduction to the Physics and Chemistry of Colloids. Emil Hatschek. 3rd Ed. 8vo. 116 pp. Price, 4s. 6d. J. & A. Churchill, London.

Cotton: Information Concerning the Raw Material, Its Preparation, and the Manufactured Products. George Bigwood. 12mo. 206 pp. Price, $1.60. Henry Holt & Co., New York.

Graphical and Mechanical Computation. Joseph Lipka. 372 pp. Price, $4.00. John Wiley & Sons, Inc., New York.

Hydrogenation of Oils: Catalyzers and Catalysis of the Generation of Hydrogen and Oxygen. Carleton Ellis. 2nd Ed. Revised and enlarged. 8vo. 767 pp. Price, $7.50. D. Van Nostrand Co., NewYork.

Industrial Electrical Measuring Instruments. K. W. E. Edgecumbe. 2nd Ed. Revised and enlarged. 8vo. 413 pp. Price, $5.00. D. Van Nostrand Co., New York.

Inks: Printing Inks; Their Composition, Properties, and Manufacture. Reprinted by permission from Circular No. 53, United States Bureau of Standards. Together with some helpful suggestions about the everyday use of printing inks. Philip Ruxton. 8vo. 71 pp. United Typothetae of America, Committee on Education, Boston.

Metallic Alloys: Their Structure and Constitution. G. H. Gulliver. 3rd Ed. 8vo. 446 pp. Price, 12s. 6d. Charles Griffin & Co., London.

Oxy-Acetylene Welding Manual. Lorn Campbell, Jr. 8vo. 154 pp. Price, $1.25. John Wiley & Sons, Inc., New York.

Paper: How Paper is Made; A Primer of Information about the Materials and Processes of Manufacturing Paper for Printing. W. B. Wheelwright. 8vo. 59 pp. United Typothetae of America, Committee on Education, Boston.

Physical Chemistry: A System of Physical Chemistry. W. C. McL. Lewis. 3 Vols. 2nd Ed. Price, Vol. 1, 15s.; Vol. 2, 15s.; Vol. 3, 7s. 6d. Longmans, Green & Co., London.

Rocks: Manual of the Chemical Analysis of Rocks. H. S. Washington. 3rd Ed. Revised and enlarged. 8vo. 271 pp. Price, $2.50. John Wiley and Sons, Inc., New York.

Vegetable Oils: Production and Treatment of Vegetable Oils. T. W. Chalmers. 4to. 152 pp. Price, $7.50. D. Van Nostrand Co., New York.

Wool: Information Concerning the Raw Material, Its Preparation, and the Manufactured Products. Frank Ormerod. 12mo. 221 pp. Price, $1.60. Henry Holt & Co., New York.

RECENT JOURNAL ARTICLES

Acetone Oils: Examination of Acetone Oils. W. J. Jones. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 9, pp. 108*t*–110*t*.

Adsorption by Precipitates. H. B. Weiser and J. L. Sherrick. *Journal of Physical Chemistry*, Vol. 23 (1919), No. 4, pp. 205–252.

Alkali: Determination of Alkali in Permanganate Liquors. T. J. I. Craig. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 8, pp. 96*t*–97*t*.

Brass: Analysis of Brass Ingots from Swarf. R. H. Deakin. *The Chemical News*, Vol. 118 (1919), No. 3080, pp. 193–194.

China: Impact Tests and Porosity Determinations on Some American Hotel China and Semi-Porcelain Plates. H. F. Staley and J. S. Hromatko. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 3, pp. 227–240.

Clay Industries: The Designing of Factory Layouts for the Clay Industries. T. W. Garve. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 3, pp. 195–207.

Cloth: Notes on the Quantitative Testing of Rainproof and Waterproof Cloth. Geoffrey Martin and James Wood. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 7, pp. 84*t*–87*t*.

Coke: Precautions Necessary in Grinding Samples of Coke for Analysis. A. E. Findley. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 7, pp. 93*t*–94*t*.

Dolomites: Some American Dolomites. Burleigh B. Reed. *Chemical News*, Vol. 118 (1919), No. 3079, pp. 181–183.

Fertilizers: The Setting of Mixtures of Superphosphate and Ammonium Sulfate. F. S. Fowweather. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 9, pp. 110*t*–112*t*.

Gases: Device for Measuring Small Quantities of Moisture in Gases. A. J. Crockatt and R. B. Forster. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 8, pp. 95*t*–96*t*.

Graphite Crucibles: Behavior Under Brass Foundry Practice of Crucibles Containing Ceylon, Canadian, and Alabama Graphites. R. T. Stull. *Journal of the American Ceramic Society*, Vol. 2 (1919), No. 3, pp. 208–226.

Indophenine Reaction. Edward Wray. *Journal of the Society of Chemical Industry*, Vol. 38 (1919), No. 7, pp. 83*t*–84*t*.

Lamp Industry: Chemistry and Chemical Control in the Lamp Industry. Albert Brann and A. M. Hageman. *The Electric Journal*, Vol. 16 (1919), No. 5, pp. 198–201.

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MARKET REPORT—JUNE, 1919

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON JUNE 15, 1919

INORGANIC CHEMICALS

Acetate of Lime, Basis 80%	100 Lbs.	2.00	@	2.05
Alum, ammonia, lump, U. S. P.	100 Lbs.	4.25	@	4.50
Aluminum Sulfate, (iron free)	Lb.	3	@	3¼
Ammonium Carbonate, domestic	Lb.	13	@	13½
Ammonium Chloride, white	Lb.	19	@	20
Aqua Ammonia, 26°, drums	Lb.	6½	@	7
Arsenic, white	Lb.	8½	@	9
Barium Chloride	Ton	65.00	@	85.00
Barium Nitrate	Lb.	12	@	14
Barytes, prime white, foreign	Ton	30.00	@	35.00
Bleaching Powder, 35 per cent, Works	100 Lbs.	1.50	@	1.60
Blue Vitriol	Lb.	7¼	@	7¾
Borax, crystals, in bags	Lb.	7¼	@	10¼
Boric Acid, powdered crystals	Lb.	13¼	@	14
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.	4¾	@	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	@	8¼
Iodine, resublimed	Lb.	4.25	@	4.30
Lead Acetate, white crystals	Lb.	14	@	15
Lead Nitrate, C. P.	Lb.	85		
Litharge, American	Lb.	9¾	@	10
Lithium Carbonate	Lb.	1.50		
Magnesium Carbonate, U. S. P.	Lb.	21	@	22
Magnesite, "Calcined"	Ton	60.00	@	65.00
Nitric Acid, 40°	Lb.	7.50	@	7.75
Nitric Acid, 42°	Lb.	8.00	@	8.50
Phosphoric Acid, 48/50%	Lb.	26	@	30
Phosphorus, yellow	Lb.	35	@	40
Plaster of Paris	100 Lbs.	2.00	@	2.50
Potassium Bichromate	Lb.	26	@	27
Potassium Bromide, granular	Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 @ 85%	Lb.	15	@	17
Potassium Chlorate, crystals, spot	Lb.	28	@	30
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%	Lb.	60	@	70
Potassium Iodide, bulk	Lb.	3.30	@	3.50
Potassium Nitrate	Lb.	27	@	30
Potassium Permanganate, bulk, U. S. P.	Lb.	55	@	65
Quicksilver, flask	75 Lbs.	92.00		
Red Lead, American, dry	100 Lbs.	10.25	@	10.75
Salt Cake glass makers'	Ton	17.50	@	22.00
Silver Nitrate	Oz.	65	@	67
Soapstone, in bags	Ton	10.00	@	12.50
Soda Ash, 58%, in bags	100 Lbs.	1.70	@	1.80
Sodium Acetate, broken lump	Lb.	8½	@	10½
Sodium Bicarbonate, domestic	100 Lbs.	2.45	@	2.50
Sodium Bichromate	Lb.	9	@	10
Sodium Chlorate	Lb.	15	@	17
Sodium Cyanide	Lb.	29	@	30
Sodium Fluoride, commercial	Lb.	14	@	15
Sodium Hyposulfite	100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot	100 Lbs.	4.07½		
Sodium Silicate, liquid, 40° Bé	Lb.	1¾	@	2
Sodium Sulfide, 60%, fused in bbls.	Lb.	3½	@	3¾
Sodium Bisulfite, powdered	Lb.	5	@	7
Strontium Nitrate	Lb.	25	@	30
Sulfur	100 Lbs.	2.25	@	4.60
Sulfuric Acid, chamber 66° Bé	Ton	16.50	@	18.50
Sulfuric Acid, oleum (fuming)	Ton	23.00		
Talc, American, white	Ton	15.00		
Terra Alba, American, No. 1	100 Lbs.	1.17½		
Tin Bichloride, 50°	Lb.	26	@	28
Tin Oxide	Lb.	65	@	70
White Lead, American, dry	Lb.	9	@	9½
Zinc Carbonate	Lb.	18	@	20
Zinc Chloride, commercial	Lb.	14	@	14½

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.	Lb.	38	@	40
Acetic Acid, 56 per cent, in bbls.	100 Lbs.	5.75	@	6.00
Acetic Acid, glacial, 99½%	100 Lbs.	12.00	@	12.25
Acetone, drums	Lb.	13½	@	16
Alcohol, denatured, 180 proof	Gal.	40	@	43
Alcohol, Ethyl, non-beverage, 190 proof	Gal.	4.70	@	4.95
Alcohol, wood, 95 per cent, refined	Gal.	1.22	@	1.24
Amyl Acetate	Gal.	3.75	@	3.85
Aniline Oil, drums extra	Lb.	23	@	24
Benzoic Acid, ex-toluol	Lb.	1.00	@	1.10
Benzene, pure	Gal.	24	@	28
Camphor, refined in bulk, bbls.	Lb.	1.24½	@	1.25
Carbolic Acid, U. S. P., crystals, drums	Lb.	10	@	15
Carbon Bisulfide	Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals.	Lb.	13½	@	14
Chloroform, U. S. P.	Lb.	30	@	32
Citric Acid, domestic, crystals	Lb.	98	@	1.02
Creosote, beechwood	Lb.	2.00	@	2.10
Cresol, U. S. P.	Lb.	15¾	@	17¾
Dextrine, corn (carloads, bags)	Lb.	7	@	8
Dextrine, imported potato	Lb.	nominal		
Ether, U. S. P. 1900	Lb.	23	@	24
Formaldehyde, 40 per cent	Lb.	20	@	21
Glycerin, dynamite, drums extra	Lb.	20	@	21
Oxalic Acid, in casks	Lb.	33	@	35
Pyrogallic Acid, resublimed, bulk	Lb.	2.60	@	2.75
Salicylic Acid, U. S. P.	Lb.	25	@	35
Starch, corn (carloads, bags) pearl	100 Lbs.	5.37		
Starch, potato, Japanese	Lb.	9¼	@	9¾
Starch, rice	Lb.	19	@	19½
Starch, sago flour	Lb.	7	@	8
Starch, wheat	Lb.	10	@	10½
Tannic Acid, commercial	Lb.	65	@	80
Tartaric Acid, crystals	Lb.	86½	@	87

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	50	@	55
Black Mineral Oil, 29 gravity	Gal.	24	@	25
Castor Oil, No. 3	Lb.	19		
Ceresin, yellow	Lb.	16	@	17
Corn Oil, crude	100 Lbs.	19½		
Cottonseed Oil, crude, f. o. b. mill	Lb.	22		
Cottonseed Oil, p. s. y. Oct. option	100 Lbs.	26.70	@	27.10
Menhaden Oil, crude (southern)	Gal.	62	@	65
Neat's-foot Oil, 20°	Gal.	1.75		
Paraffin, crude, 118 to 120 m. p.	Lb.	8½	@	9
Paraffin Oil, high viscosity	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.	Bbl.	12.15	@	12.25
Rosin Oil, first run	Lb.	75	@	76
Shellac, T. N.	Lb.	nominal		
Spermaceti, cake	Lb.	31	@	33
Sperm Oil, bleached winter, 38°	Gal.	1.95	@	1.97
Spindle Oil, No. 200	Gal.	38	@	40
Stearic Acid, double-pressed	Lb.	18½	@	19
Tallow, acidless	Gal.	1.30	@	1.35
Tar Oil, distilled	Gal.	36	@	38
Turpentine, spirits of	Gal.	79	@	80

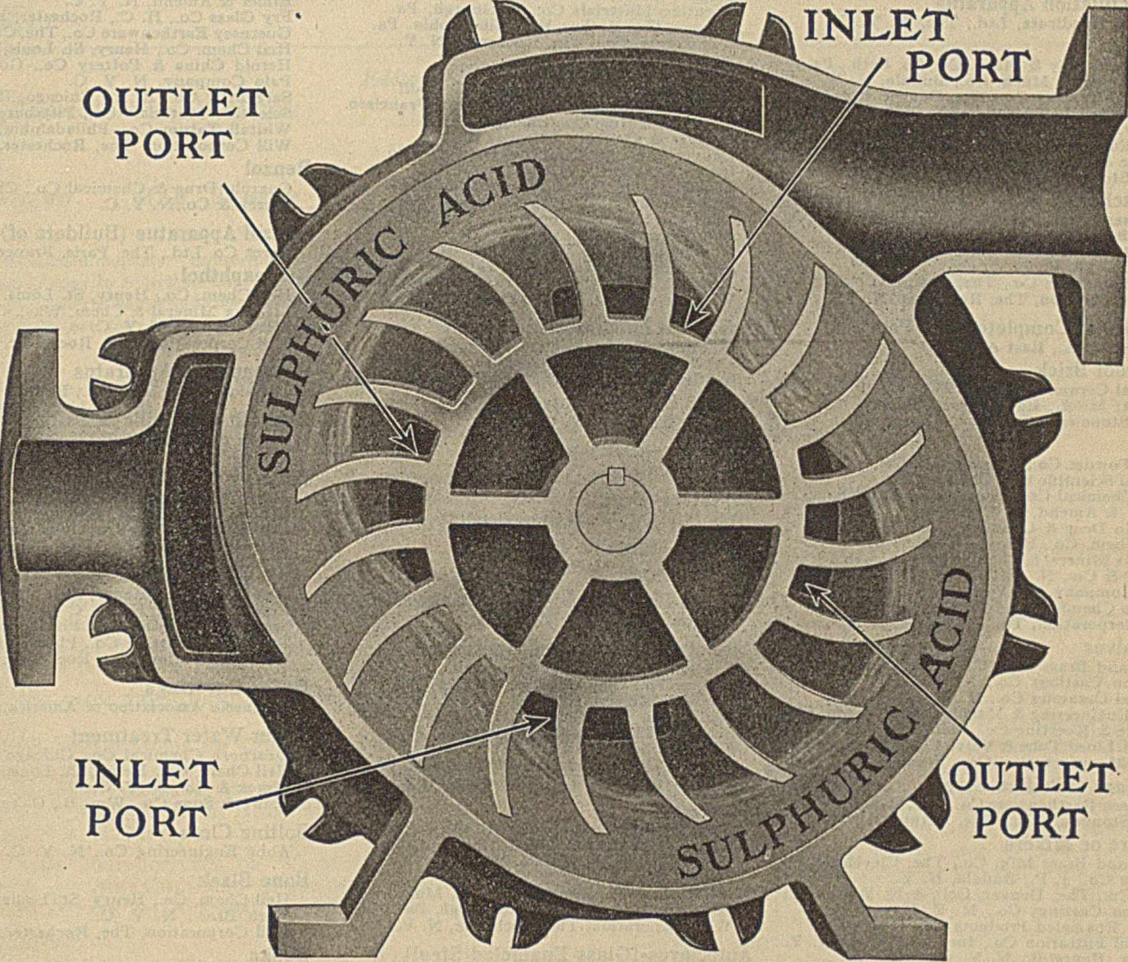
METALS

Aluminum, No. 1, ingots	Lb.	33	@	
Antimony, ordinary	100 Lbs.	8.50		
Bismuth, N. Y.	Lb.	nominal		
Copper, electrolytic	Lb.	17¾		
Copper, lake	Lb.	17½		
Lead, N. Y.	Lb.	5.50		
Nickel, electrolytic	Lb.	55	@	56
Platinum, refined, soft	Oz.	105.00		
Silver	Oz.	1.12½		
Tin	Lb.	72½		
Tungsten (WO_3)	Per Unit	7.00		
Zinc, N. Y.	100 Lbs.	9.40	@	9.60

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	4.90	@	—
Blood, dried, f. o. b. New York	Unit	5.15	@	5.25
Bone, 3 and 50, ground, raw	Ton	35 00	@	37.00
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	15.50	@	16.00
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	9.50	@	10.00
Potassium "muriate," basis 80 per cent	Ton	120.00	@	130.00
Pyrites, furnace size, imported	Unit	15	@	17
Tankage, high-grade, f. o. b. Chicago	Unit	4.50	@	4.75

The Nash "HYTOR" for ACID GAS



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General Ceramics Co.. N. Y. C.
Knight, Maurice A., East Akron, Ohio.
Lummus Co., The Walter E.. Boston, Mass.
Thermal Syndicate, Ltd., The, N. Y. C
U. S. Stoneware Co., The, Akron, O.

Acid and Alkali Resistant Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.
Cleveland Brass Mfg. Co., The, Cleveland, O.
Duriron Castings Co., N. Y. C.
Elyria Enameled Prod. Co., Elyria, O.
Jacoby, Henry E., N. Y. C.
Pfaudler Co., Rochester, N. Y.

Acid Distillation Apparatus
Thermal Syndicate, Ltd., The, N. Y. C.

Acid Eggs
Bethlehem Fd'y & Mach. Co., So. Beth., Pa.
Buffalo Fdy & Mach. Co., Buffalo, N. Y.
Denver Fire Clay Co., The, Denver, Colo.
Devine Co., J. P., Buffalo, N. Y.
Jacoby, Henry E., N. Y. C.
Pratt Engineering & Machine Co., Atlanta, Ga
Schutte & Koerting Co., Phila., Pa.
U. S. Stoneware Co., The, Akron, O.

Acid Pitchers
Guernsey Earthenware Co., The, Cambridge, O.
Heil Chem. Co., Henry, St. Louis, Mo.
Knight, Maurice A., East Akron, O.
Palo Co., N. Y. C.
U. S. Stoneware Co., The, Akron, O.
Will Corporation, The, Rochester, N. Y.

Acid Plants (Complete or in Part)
Knight, M. A., East Akron, O.

Acid Proof Brick
General Ceramics Co., N. Y. C.
Knight, M. A., East Akron, Ohio.
U. S. Stoneware Co., The, Akron, O.

Acids
Atlas Powder Co., Wilmington, Del.
Central Scientific Co., Chicago, Ill.
Dow Chemical Co., The, Midland, Mich.
Eimer & Amend, N. Y. C.
Gazzolo Drug & Chemical Co., Chicago, Ill.
Heil Chem. Co.. Henry. St. Louis. Mo
Lithflux Mineral & Chem. Wks., Chicago. Ill.
Merck & Co., N. Y. C.
Palo Company, N. Y. C.
Primos Chemical Co., Primos, Del. Co., Pa.
Will Corporation, The, Rochester, N. Y.

Acid Valves
Cleveland Brass Mfg. Co., The, Cleveland, O.
Duriron Castings Co., N. Y. C.
General Ceramics Co., N. Y. C.
Pratt Engineering & Machine Co., Atlanta, Ga.
Schutte & Koerting Co., Phila., Pa.
United Lined Tube & Valve Co., Boston, Mass.
York Manufacturing Co., York, Pa.

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Guernsey Earthenware Co., The, Cambridge, O.
U. S. Stoneware Co., The, Akron, O.

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Cleveland Brass Mfg. Co., The, Cleveland, O.
Devine Co., J. P., Buffalo, N. Y.
Dorr Co., The, Denver, Col., & N. Y. C.
Duriron Castings Co., N. Y. C.
Elyria Enameled Products Co., Elyria, O.
General Filtration Co., Inc., Rochester, N. Y.
Jacoby, Henry E., N. Y. C.
Pfaudler Co., Rochester, N. Y.
Sowers Mfg. Co., Buffalo, N. Y.
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Hubbard's Sons, Norman, Brooklyn, N. Y.
Nash Engineering Co., So. Norwalk, Conn.
Schutte & Koerting Co., Phila., Pa.

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General Filtration Co., Inc., Rochester, N. Y.

Air Washers
Carrier Engineering Corp., N. Y. C.

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Alkalis
Arnold Hoffman & Co., Inc., N. Y. C.
Lithflux Mineral & Chem. Wks., Chicago, Ill.

Alundum Ware
Denver Fire Clay Co., The, Denver, Colo.
Heil Chem. Co., Henry, St. Louis, Mo.
Norton Co., Worcester, Mass.
Scientific Materials Co., Pittsburgh, Pa.
Will Corporation, The, Rochester, N. Y.

Ammeters
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General Electric Co., Schenectady, N. Y.

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Atlas Powder Co., Wilmington, Del.
Heil Chem. Co., Henry, St. Louis, Mo.

Ammonia Fittings and Supplies
York Manufacturing Co., York, Pa.

Ammonia—Salts of
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Analysis—Gas
Sarco Co., Inc., N. Y. C.

Analysis—Gas Apparatus
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Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Denver Fire Clay Co., The, Denver, Colo.
Eimer & Amend, N. Y. C.
Emil Greiner Co., The, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Sarco Co., Inc., N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
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Analytical Apparatus
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Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A, Chicago, Ill.
Denver Fire Clay Co., The, Denver, Colo.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chem. Co., Henry, St. Louis, Mo
Mine and Smelter Supply Co., The, N. Y. C.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Thomas Co., Arthur H., Philadelphia, Pa.
Will Corporation, The, Rochester, N. Y.

Analytical Laboratories
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Dearborn Chemical Co., Chicago, Ill.
Sadtler & Son, Samuel P., Philadelphia, Pa.

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Antimony—Salts of
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Sly Mfg. Co., W. W., Cleveland, O.

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Merck & Co., N. Y. C.

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Denver Fire Clay Co., The, Denver, Colo.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa.
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Thomas Co., Arthur H., Philadelphia, Pa.
Will Corporation, The, Rochester, N. Y.

Autoclaves
Central Scientific Co., Chicago, Ill.
Denver Fire Clay Co., The, Denver, Colo
Devine Co., J. P., Buffalo, N. Y.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa
Will Corporation, The, Rochester, N. Y.

Autoclaves (Glass Enameled Steel)
Pfaudler Co., Rochester, N. Y.

Autoclaves (High and Low Pressure)
Buffalo Fdy. & Mch. Co., Buffalo, N. Y
Devine Co., J. P., Buffalo, N. Y.

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Brown Instrument Co., The., Phila., Pa.
Tagliabue Mfg. Co., C. J., Brooklyn, N. Y.
Taylor Instrument Cos., Rochester, N. Y

Automatic Temperature Regulators
Brown Instrument Co., The, Phila., Pa.
Engelhard, Charles, N. Y. C.
Tagliabue Mfg. Co., C. J., Brooklyn, N. Y.
Taylor Instrument Cos., Rochester, N. Y.

Bakelite
General Bakelite Co., N. Y. C.

Balances and Weights
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Denver Fire Clay Co., The, Denver, Colo.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chem. Co., Henry, St. Louis, Mo.
Mine and Smelter Supply Co., The, N. Y. C.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Standard Scientific Co., N. Y. C.
Thomas Co., Arthur H., Philadelphia, Pa.
Whitall Tatum Co., Philadelphia, Pa
Will Corporation, The, Rochester, N. Y.

Barium—Salts of
Dow Chemical Co., The, Midland, Mich.
Heil Chem. Co., Henry, St. Louis, Mo.
Lithflux Mineral & Chem. Wks., Chicago, Ill.
Merck & Co., N. Y. C.
Will Corporation, The, Rochester, N. Y.

Barrels (Steel)
Scaife & Sons Co., Wm. R., Oakmont, Pa.

Barometers
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
Standard Scientific Co., N. Y. C.
Will Corporation, The, Rochester, N. Y.

Beakers
Braun-Knecht-Heimann Corp., San Francisco
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Denver Fire Clay Co., The, Denver, Colo.
Eimer & Amend, N. Y. C.
Fry Glass Co., H. C., Rochester, Pa.
Guernsey Earthenware Co., The, Cambridge, O.
Heil Chem. Co., Henry, St. Louis, Mo.
Herold China & Pottery Co., Golden, Col.
Palo Company, N. Y. C.
Sargent & Co., E. H., Chicago, Ill.
Scientific Materials Co., Pittsburgh, Pa.
Whitall Tatum Co., Philadelphia, Pa
Will Corporation, The, Rochester, N. Y

Benzol
Gazzolo Drug & Chemical Co., Chicago, Ill.
Merck & Co., N. Y. C.

Benzol Apparatus (Builders of)
Egrot Co. Ltd., The, Paris, France.

Betanaphthol
Heil Chem. Co., Henry, St. Louis. Mo.
Lithflux Mineral & Chem. Wks., Chicago, Ill.
Merck & Co., N. Y. C.
Will Corporation, The, Rochester, N. Y.

Betanaphthol Apparatus
Buffalo Fdy. & Mch. Co., Buffalo, N. Y.

Bismuth—Metallic & Salts
Merck & Co., N. Y. C.
Powers-Weightman-Rosengarten Co., Phila

Blowers
Abbé Engineering Co., N. Y. C.
Central Scientific Co., Chicago, Ill.
Crowell Mfg. Co., Brooklyn, N. Y.
Denver Fire Clay Co., The, Denver, Colo.
Duriron Castings Co., N. Y. C.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C
Scientific Materials Co., Pittsburgh, Pa.
Schutte & Koerting Co., Phila., Pa.
Will Corporation, The, Rochester, N. Y.

Boiler Coverings
Magnesia Association of America, N. Y. C.

Boiler Water Treatment
Dearborn Chemical Co., Chicago, Ill.
Heil Chem. Co., Henry, St. Louis, Mo.
Merck & Co., N. Y. C.
Scaife & Sons Co., Wm. B., Oakmont, Pa.

Bolting Cloth
Abbé Engineering Co., N. Y. C.

Bone Black
Heil Chem. Co., Henry St. Louis, Mo.
Toch Bros., N Y. C.
Will Corporation, The, Rochester, N. Y.

Books
Blakiston's Son & Co., P., Phila., Pa.
Chemical Publishing Co., The, Easton, Pa
Denver Fire Clay Co., The, Denver, Colo.
Heil Chem. Co., Henry, St. Louis, Mo.
Sargent & Co., E. H., Chicago, Ill.
Wiley & Sons, Inc., John, N. Y. C.

Bottle Blowers
Wheaton Co., T. C., Millville, N. J.

Bottles (Glass)
Central Scientific Co., Chicago, Ill
Denver Fire Clay Co., The, Denver, Colo.
Eimer & Amend N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Scientific Materials Co., Pittsburgh, Pa.
Wheaton Co., T. C., Millville, N. J.
Whitall Tatum Co., Philadelphia, Pa
Will Corporation, The, Rochester, N. Y.

Brinell Machines
Central Scientific Co., Chicago, Ill.
Denver Fire Clay Co., The, Denver, Colo.
Eimer & Amend, N. Y. C.
Heil Chem. Co., Henry, St. Louis, Mo.
Palo Company, N. Y. C.
Scientific Materials Co., Pittsburgh, Pa
Will Corporation, The, Rochester, N. Y.

Burner Guards
Heil Chem. Co., Henry, St. Louis, Mo.
Knight, M. A., East Akron, O.
Will Corporation, The, Rochester, N. Y.

Burners—Gas and Oil
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco.
Central Scientific Co., Chicago, Ill.
Daigger & Co., A., Chicago, Ill.
Denver Fire Clay Co., The, Denver, Colo.
Detroit Heating & Lighting Co., Detroit, Mich.
Eimer & Amend, N. Y. C.
Griebel Instrument Co., Carbondale, Pa.
Heil Chemical Co., Henry, St. Louis, Mo.
Mine and Smelter Supply Co., The, N. Y. C.