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## EDITORIALS.

### ANTIQUATED CUSTOMS.

The timidity of capitalists and manufacturers is proverbial. When this timidity is coupled with the idea that a certain practice is profitable, the normal wise conservatism of practical men degenerates into the fetich worship of obsolete customs. The common alkalis depend for their usefulness in chemical manufacture upon their alkalinity—there is little possibility of a chemical argument about that point. The determination of the value of a given shipment of alkalis would naturally involve an alkalimetric analysis and a calculation to the result to  $\text{Na}_2\text{O}$  (the trade custom),  $\text{NaOH}$  or  $\text{Na}_2\text{CO}_3$ , as the case might be. It is customary to base the price of alkalis upon "60° alkali" which means a hypothetical alkali containing 60 per cent.  $\text{Na}_2\text{O}$ . The price is then adjusted according to the analysis. In the purchase of caustic soda, no allowance is made for the small amount (2-4 per cent.) of sodium carbonate always present. These points, however, are not of the greatest importance in this connection. Instead of using the rational method of calculating the percentage of  $\text{Na}_2\text{O}$  present by using the factor 31 ( $\text{Na}_2\text{O} = 62; 62/2 = 31$ ), derived from the atomic weights of the elements, it is customary in the trade to use methods of calculation which are known as the "English," "Newcastle," or "Liverpool" "tests." Pure sodium carbonate contains the equivalent of

58.49 per cent.  $\text{Na}_2\text{O}$  thus:  $\frac{31 \times 100}{53} = 58.49$  per cent. According to the "Newcastle" "test," however, it would contain 59.26 per cent. thus:  $\frac{32 \times 100}{54} = 59.26$  per cent. According to the "Liverpool" "test," the figure is higher yet, since the factor 32 is arbitrarily used in place of 31. The calculation is:  $\frac{58.49 \times 32}{31} = 60.37$  per cent. Therefore, according

to the Liverpool test, pure sodium carbonate would contain 60.37 per cent.  $\text{Na}_2\text{O}$ , instead of 58.49 as demanded by theory! This amounts to an increase of 3 per cent. in round number. This practice is hoary with age, venerable and venerated by the soda trade. Manufacturers and middlemen look upon it in the light of gospel and revelation. The chemical trade is full of such customs, which have grown flat and stale but not necessarily unprofitable. Another example is the so-called "refraction test" or "West Coast method" which is applied to the analysis of commercial sodium nitrate, which is largely imported from Chile for use in the manufacture of nitric acid, explosives and fertilizers. The valuable constituent in this chemical is nitrate nitrogen, and this can easily be determined by one of several good methods—possibly best by Lunge's nitrometer, or the Schloesing-Wagner method. In the trade, however, no direct determination of nitrate nitrogen is recognized. Instead the "refraction test"—save the name!—is applied. The refraction test consists in determining moisture, insoluble matter, sodium sulphate (calculated from  $\text{SO}_4$ ), sodium chloride (calculated from  $\text{Cl}$ ) and subtracting the sum of these from 100 per cent. Naturally the result shows more nitrate of soda than is actually present. There is no excuse for the continuance of obsolete trade customs such as these. They are thoroughly unscientific and misleading. It would probably be urged by the producers and middlemen that as prices are based on analyses and calculations made according to these so-called "tests," it would upset the trade to change the custom. As a matter of fact the price readjustment could be made overnight, and afterwards would take care of itself. In matters of this sort (and we have mentioned but two of a large number of bad trade customs) the conservatism of trade is almost if not quite identical with the inertia of stupidity.

### THE PHOSPHORUS MATCH.

WILLIAM H. TAFT, President of the United States, in his Message to Congress of December 6, 1910, wrote in regard to the phosphorus match industry:

I invite attention to the very serious injury caused to all those who are engaged in the manufacture of phosphorus matches. The diseases incident to this are frightful, and as matches can be made from other materials entirely innocuous, I believe that the injurious manufacture could be discouraged and ought to be discouraged by the imposition of a heavy federal tax. I recommend the adoption of this method of stamping out a very serious abuse.

A leading daily newspaper commented editorially as follows on this part of the President's message:

In nearly every civilized country except the United States, the use of white phosphorus in the making of matches is prohibited by law. The cost of production is increased only about 5 per cent. by the adoption of substitutes for white phosphorus, but because of competitive conditions one manufacturer cannot adopt the safer and more expensive method unless all will do the same. The leading manufacturers of matches in this country, it is said, would welcome any legislation that will put an end to the use of white phosphorus in their industry.

Legislation in harmony with this wise recommendation ought to be enacted at the present session of congress. The imposition of a prohibitive federal tax on the manufacture and sale of matches containing white phosphorus would constitute the best method of dealing with the problem.

On the editorial page of another prominent daily newspaper appeared the following:

It is hoped that the present session of congress, short as it is to be, will see the passage of Representative Esch's bill directed against poisonous matches. President Taft has again taken sufficient interest in the subject to mention the necessity of legislation relating to it in his message. The American Federation of Labor and other bodies are interested in the abolition of the poisonous match for the sake of the match workers who are constantly exposed to the deadly phosphorus fumes.

Matches made with the only known substitute for white phosphorus are controlled by a patent held now by the match trust. This patent will expire in five years, but in the meanwhile the terms on which the trust allows it to be used by independent manufacturers are such that the latter have not generally taken advantage of them. And in the meanwhile five years remain for the workers to be exposed to the poison. The trust demands \$100,000 for the rights remaining its property. If our chemists cannot discover another process by which to make matches at once good and safe, it would be worth that sum to save the workmen from five years of danger.

Distasteful as a prohibitive tax on matches would be, it seems the only remedy in the circumstances. This country is a whole generation behind Europe in the regulation of this dangerous trade. It should either be made safe or be taxed out of existence.

Throughout the country the newspapers have generally given voice to their ideas in similar outspoken tones. The universal attitude in the matter appears to be that the United States government has been negligent in failing to protect the workers in the yellow phosphorus match industry. At the same time the plea is made that this protection be no longer withheld and that the Esch bill be passed. American matches have not enjoyed the highest reputation possible in the past. Mr. Carl Baedeker, careful observer of international conditions for the benefit of the traveler, says in "The United States: Handbook for Travellers:" "The prices of many manufactured goods are much higher in the United States than in Europe; and the traveler should, therefore, come provided with an ample supply of all the articles of personal use he is likely to require, down to such small items as . . . . ., and matches (often very poor in America)." This merely in passing.

During the year 1910, the Bureau of Labor issued a monograph from the pen of Dr. John B. Andrews, entitled "Phosphorus Poisoning in the Match Industry in the United States." This was published

in Bulletin 86 of the Bureau of Labor, and was undoubtedly the occasion for the paragraph in President Taft's Message quoted above. Dr. Andrews' report was based on the results of a careful investigation into the working conditions in 15 out of the 16 factories operating in the United States. During the preliminary investigation, 16 cases of phosphorus necrosis were discovered in the factories and when the investigators, in an intensive study of three factories, directed their attention to the homes of the workers, a total of 82 cases was discovered in the homes of the workers in these three factories. It was ascertained that at least eight perfectly developed cases occurred in two factories during 1909. According to the report, 65 per cent. of the workers in the 15 factories investigated were working under conditions which exposed them to phosphorus fumes, and the women and children were much more exposed than the men, the figures being 95 and 83 per cent. respectively. In the 15 factories 3591 employees were at work. Of these 2024 were men, 1253 were women and 314 children under 16 years of age. In a number of the factories, ventilating and general sanitary arrangements, such as washing facilities and eating places, were found to be far from satisfactory.

Exposure to the fumes of phosphorus gives rise to two forms of poisoning. The first is rare and is a mild chronic form characterized by cachexia, jaundice, anemia and albuminuria. In more advanced cases there may be chronic enteritis, diarrhea, bronchitis and even a peculiar fragility of the bones. The ordinary form or phosphorus necrosis gives rise to periostitis and necrosis of the lower jaw. It usually begins, though not necessarily, from a decayed tooth or a lesion of the gum. The teeth become loose and drop out, the jaw becomes swollen and painful, and discharges large quantities of pus together with pieces of dead bone. The removal of the entire lower jaw is often necessary to stop the course of the disease. Death frequently results. This form of poisoning is known to the workers in match factories as "phossy jaw." It is the element phosphorus itself, and not its compounds, which produces the symptoms. It has been found in the blood as such. Its oxygen acids are without poisonous effect. Practically all cases of phosphorus poisoning have been due to white (yellow) phosphorus, since this is more volatile and more soluble than the red variety. Phosphorus sesquisulphide,  $P_4S_3$ , which is used in the French government match factories, appears to be even safer than red phosphorus, for the small amounts of phosphorus released from it in the tissues are too small to induce symptoms. In tabular form a brief statement of the history of the development of chemical and friction matches would appear as follows:

- 1669 Brand (Hamburg) discovered phosphorus.
- 1771 Scheele prepared phosphorus from bone ash.
- 1812 Sulphur matches tipped with  $KClO_3$  and sugar.  
Ignited by  $H_2SO_4$ .
- 1816 Derosne made phosphorus mass for matches.

- 1827 Friction matches (England)  $Sb_2S_3$  and  $KClO_3$ .  
 1837 Substitution of  $PbO$ , and  $Pb(NO_3)_2$  for  $KClO_3$  in phosphorus match.  
 1845 Schrötter (Vienna) discovered and identified red phosphorus.  
 1848 Böttger invented "safety match" containing no phosphorus, and striking on red-phosphorus-coated striking surface.  
 1858 Lundström manufactured safety matches in Jönköping (Sweden).  
 1897 France prohibited use and manufacture of yellow phosphorus match.  
 1903 Germany prohibited yellow phosphorus match. Law effective Jan. 1, 1907.  
 1906 Berne treaty. Prohibition of yellow phosphorus match in France, Denmark, Luxemburg, Italy, Switzerland, Netherlands, Germany.  
 1908 Great Britain prohibited yellow phosphorus match. Law effective Jan. 1, 1910.

At the present time there are three principal kinds of matches manufactured. First the "safety" match containing no phosphorus and designed to be struck on a prepared surface containing red phosphorus. A characteristic composition for match heads of this sort contains potassium chlorate, potassium bichromate, sulphur, manganese dioxide, iron oxide, glass powder, glue and gum arabic. The striking-surface composition contains red phosphorus, antimony trisulphide, dextrin, and lampblack. The second kind of match is the ordinary "strike-anywhere" or parlor match, containing yellow phosphorus and designed to light when rubbed against any rough surface. A characteristic composition contains glue, glass powder, iron oxide, lead oxide, and phosphorus. The principal variety of this kind of match is that which lights only when rubbed on the tip, not on the side. The third kind of match strikes anywhere but contains no elementary phosphorus. The most successful match of this sort heretofore has been that whose composition contained phosphorus sesquisulphide,  $P_4S_3$ . It is stated that 3.5 g. of this substance, corresponding to 6000 matches, shows no harmful action. The French government match factories, following the procedure of Sévène and Cahen, use phosphorus sesquisulphide in formulas containing also potassium chlorate, zinc oxide, ocher, glass powder, and glue. Various other substitutes for yellow phosphorus in "strike-anywhere" matches have been suggested and tried, with more or less success, in an endeavor to discover a better substance for the purpose than phosphorus sesquisulphide. The latter has the disadvantage of decomposing when stored for some time in a damp place, giving rise to the offensive hydrogen sulphide gas. The list includes a mixture of phosphorus trisulphide and pentasulphide or triphosphorus hexasulphide, zinc thiophosphite, bright-red phosphorus (Schenk), phosphorus suboxide and cupro-barium polythionate. The list will no doubt be extended in the near future, and an entirely unobjectionable substance found.

As many as five years ago matches were manu-

factured and distributed in the United States containing no poisonous phosphorus, thus demonstrating the practicability of the process. Each box bore the legend: "These matches do not contain phosphorus. A new discovery." They were found upon experiment to strike perfectly on suitable rough surfaces such as wood and cloth and ordinary objects.

The following statements are quoted verbatim from Dr. Andrews' report:

Those who have followed the results of studies of the conditions surrounding industrial employments with reference to the effect upon the health of the employees are impressed by the possibilities of a scientific movement to improve working conditions and reduce occupational dangers. The manufacture of matches in the United States beyond any other industry presents an opportunity to improve conditions and easily to make a most dangerous industry entirely harmless. Peculiar to this industry is a disease which, without great expense, without a long struggle against poverty, indifference, ignorance, and neglect, may be absolutely eliminated by the prohibition of the use of white phosphorus. This disease, known to medical and dental professions as phosphorus necrosis, continually threatens those who work in match factories where poisonous phosphorus is used. The phosphorus most frequently attacks the jaw bones, and sometimes necessitates the removal of an entire jaw by surgical operation. A harmless substitute for the poison that is commercially practicable is readily available. Why, then, do our manufacturers not use this substitute? Many would gladly do so, but it costs just a little more to make nonpoisonous matches. Condition is so keen that a single manufacturer can not place himself at natural disadvantage with his rivals in business.

In the leading countries of Europe the governments have come to the aid of both workers and manufacturers by requiring all manufacturers to discontinue the use of the poison. In these countries the manufacturers are all on an equal footing in competition and the danger of phosphorus poisoning is entirely eliminated.

And again further on:

The company owning the patent rights for the use of sesquisulphide of phosphorus in the manufacture of matches in America believing this article to be a remedy for the prevailing trouble in manufacturing matches, namely phosphorus necrosis, has expressed (in writing) its willingness to permit the use of the sesquisulphide of phosphorus by other manufacturers on equal terms, if the use of white phosphorus is prohibited by law.

It would seem that the time has come when the government must take definite and positive action which will lead to the prohibition of the poisonous phosphorus match. Regulation will not suffice. Prohibition is necessary. If President Taft's recommendation for a prohibitive tax is the best form for the legislation to take, the needed law should be passed without delay.

#### THE PRICE OF GLYCERINE.

CRUDE, C. P. and dynamite glycerine have commanded high prices during the year 1910. During the latter part of the year C. P. glycerine was selling for 24½c. per pound in drums, the price not including the package. In early November, soap lye crude glycerine reached the astonishing price of 17c. per pound, basis of 80 per cent., and saponification crude sold proportionally higher. The causes of these high prices have been variously stated by different observers. Among the explanations advanced are the following: the prevailing high prices of all commodities; the high prices commanded by fats and fatty oils; the great demand for explosives for construction work on the Panama canal; general activity

in construction and mining requiring the use of explosives. Whatever the immediate cause, undoubtedly the demand for glycerine to be used in the manufacture of nitroglycerine explosives is the determining factor. The United States is a great producer and consumer of glycerine. In spite of the fact that this country produces enormous quantities of glycerine in soap and candle factories, very large quantities of crude and refined glycerine are imported from all parts of the world. A considerable part of the glycerine imported from foreign countries is probably derived from fats and oils originally exported from the United States. At the same time, Australia, Argentina and Russia are large producers of animal fats, and tropical oils are entering the European market in constantly increasing volume. At present prices, when glycerine sells for two or three times the price of the raw material from which it is derived, it must be considered as something more than a by-product—it becomes one of the principal products of the saponification of fats, even in the commercial sense. The amount of glycerine left behind in soap and not won from fats in the autoclave becomes of greater relative importance. Of the total glycerol theoretically yielded by fats (about 10.6 per cent. for neutral tallow), good soap factory practice will recover from 80 to 90 per cent. and of this the still will win 97 per cent. or more. These are good yields and the percentages in many factories will not run so high. In the autoclave, 95 per cent. can usually be recovered. Nevertheless there appears to be an opportunity here to improve the practice in such a way, that to the future chemist, present-day yields will appear low and present-day practice wasteful. For some months, the soap-factory chemist has been watching the soap kettle closely to obtain greater yields and studying methods to reduce the percentage of glycerol in cold-made soap (of no apparent use there); and beyond a doubt the soap factories all over the world are obtaining higher yields of glycerol to-day than they were two years ago. Thus may the enhanced value of a product stimulate chemical control to the point of developing improved practice without any new discoveries or innovations in manufacture.

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## ORIGINAL PAPERS.

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### WASTE WOOD AND ITS UTILIZATION.

By GEORGE B. FRANKFORTER.

The United States is the most wasteful nation in the world: wasteful in living, wasteful in manufacturing, and wasteful in conserving its natural resources. This prodigality of the nation's wealth has been largely due to extravagant methods of manufacture. A quarter of a century ago, when economical methods were not considered essential to industrial life, practically every industry in the whole country was the very synonym of waste and extravagance. Our unparalleled wealth of natural resources, together with high tariff walls, made it unnecessary for manu-

facturers to utilize by-products in order to earn large dividends or to compete with other nations.

It is a remarkable fact that while these great storehouses of natural products had become necessary to the world's industrial progress, in only a few cases were the raw materials converted into marketable products at home. On the contrary, they were sent abroad to be worked up by highly technical institutions, and returned at many times the value of the crude products. In the early years of our industrial development, the very idea of utilizing what was then called industrial waste, seems to have been distasteful to the whole nation. Our manufacturers did not understand the new by-product movement which had given the European nations industrial supremacy; neither were they willing even to try to understand it. They saw only the great treasures stored up in our mines, our forests or in our great fertile plains. They would not see the small but no less important things which belonged to the new by-product movement. It was doubtless this unfortunate condition which kept the highly technical chemical industries from the rapid growth which would have followed under more favorable conditions. With everything at our doors for which a nation could ask, and with a demand for the products which can only be made from by-product waste, it seems strange to the chemist of to-day that our industries should have remained so long in this undeveloped condition. The only logical conclusion which may be drawn is that the American people were either not desirous or not capable of developing the industries to that degree which has made the German Empire what it is to-day.

It should be stated here, in justice to the chemists of the present, and out of genuine respect for the pioneers of the last generation, that the undeveloped condition of our chemical industries can in no way be attributed to them. As a matter of fact, chemists have, throughout the whole of our industrial life, occupied a peculiar position. Their work has been largely a labor of love, a love for the science and a love for mankind; at any rate, they have received little else for their labor. They have repeatedly sounded warning notes of waste and extravagance to the industries and incidentally urged them to employ the new economical methods of manufacture if the United States were to be considered in the industrial race of the future. This frantic appeal to the people of the country to stop the wanton destruction of our national resources has, until recently, been entirely ignored. The classical work of the chemists of the East, with their campaign of industrial education, is having a most wholesome influence upon the eastern industries. The work in the Middle West, North, West and South is likewise having a salutary effect upon the manufacturers, for they are beginning to see that it is better to save at the spigot than it is to save at the bung. On the whole, there is hope of a great industrial revival such as that which has made Germany the greatest of the industrial world-powers.

It is at least encouraging to the chemist at the present time to find that industrial conditions are changing for the better. What changes one can safely predict in the near future may be inferred from the great industrial chemical wave which swept over Germany during the latter half of the 19th century. That magical change which enabled the German people to spring from the fourth to the very first of the industrial world-powers, was due to the wonderful development of their chemical industries and to the amazing methods of conserving their natural resources. Germs of this same reconstruction period, I think, may be found in our own conservation movement. Waste in manufacturing is no longer entirely overlooked by the industries as it was a quarter of a century or even a decade ago.

Notwithstanding the marked improvement in our present industrial condition, it is still evident that industrial conservation will be ignored by the majority of manufacturers unless they have convincing proof that conservative methods mean greater profits and less expense. Their one thought, perhaps a logical one, seems to be of profits. Unfortunately, they have not recognized the fundamental fact that an industry is of vital importance as a national asset only when it conserves the nation's resources and produces the greatest possible returns for the least possible consumption of natural products.

*The Wood Industry.*—That a revolution of our industrial world has been going on is evident from a study of any one of our great industries. We have already reached the reconstruction period, as is evident from a glance at the greatest of our conservation problems—the wood industry. Fifteen years ago it was impossible to interest lumbermen in any of the wood by-product industries. The real reason seems to have been that the lumbermen found it unnecessary to build up highly technical by-product plants in order to earn large dividends, either in home or foreign markets.

Of the great wastage problems before the American people to-day, wood refuse probably stands first. Few realize the awful waste in the processes used at the present time by the lumbering industries. The industrial chemist is astonished to find that millions of cords of good wood are being burned, either on the ground, where it took hundreds of years to grow, or in huge burners built at the mills for the express purpose of destruction. He is more than astonished to find that laws have been enacted in some of the great timber states compelling the lumbermen to burn all waste wood left on the ground after the logs have been removed. These laws were ostensibly passed for the prevention of forest fires, but doubtless without fully realizing the actual value of the millions of cords of waste.

The term timber has a distinctly local significance. In its broadest meaning, and especially in the great lumbering states of the North, West and South, it represents the forests capable of being converted into lumber. On the Pacific coast, the term is applied only to those mighty forests which have been

growing for a thousand years. On the western plains, any growth of trees, scrub, oak, elm, ash or birch, is called timber. The term is little used in the Middle States, since the depletion of the virgin forests. I have used the word in its broadest sense, as representing trees of all kinds, large or small, which may be converted into marketable products.

Concerning the study of the timber industry of the middle, northern and western states, the writer has had exceptional opportunities. His early years were spent in close touch with lumbering industry of the middle states. Later, on the great plains of the west, he learned the true value of timber. On coming to one of the greatest timber states some seventeen years ago, he realized more fully than ever the frightful waste in the conversion of timber into lumber. With this almost criminal waste of over half of the great forests vividly in mind, he decided to devote some time, at least, to the wood by-product industry. In these early years the task proved so herculean that grave doubts often arose as to whether waste wood from the logging and milling industries could ever be utilized. The work was all the more discouraging on account of the indifference of the lumbermen. They were too busy with the industry as it then existed to give any attention to waste problems. Furthermore, they sincerely believed that wood waste was unavoidable and that its utilization was an absolute impossibility. During these early years, about the only hope of the chemist was in making the lumbermen realize that better and more economical methods were possible and impressing upon them the important fact that wood waste, with proper encouragement, would become the greatest by-product industry in the world.

The important questions which naturally occur to the industrial chemist in these days of conservation are: first, to what extent are the great industries actually wasting our natural resources, and second, can our present industrial methods be so improved as to materially reduce this waste? It requires but a glance to convince one that the waste attending logging and milling industries is the most colossal ever recorded in the history of manufacture. Here, then, is such an opportunity for conservation methods as occurs in no other industry in the country.

It is impossible to even estimate the waste which followed the lumbering industries a single decade ago. A general idea may be obtained of the waste at present, however, by glancing at any of the large mills. The best that these model mills can do to-day, by most rigid economy and by using all the modern improvements known to the industry, is to save a scant 40 per cent. of the total weight of wood in lumber, lath and shingles. Fifteen years ago the average was probably not over 30 per cent.

*The Logging Industry.*—That the waste wood problem might be more thoroughly investigated, the whole timber industry was studied. Logging, now considered as an entirely separate industry, naturally came first. It was studied in the Middle West and later on the western coast. If the chemist is sur-

prised at the waste produced by the mills, he is simply appalled at the waste which follows the logging industry. It is impossible to give a clear idea of the amount of wood destroyed through the present methods of logging, without details regarding machinery, quality of timber and methods used in different localities, all of which are too technical for this short paper.

*The Proportion of Lumber to Waste.*—Early in these investigations it was found that no one, not even the lumbermen themselves, knew what proportion of the tree was converted into lumber and what proportion was waste. That at least approximate results might be obtained, several determinations were made, weighing the whole tree so far as possible and the amount of lumber obtained.

The following is an average of three trees:

	Lbs.
Total weight of trees.....	6600
Total weight of lumber.....	2300
Waste.....	4300

Per cent. of lumber, 34.84; per cent. of waste, 65.16.

Stumps, tops, slabs and sawdust are included under waste, but not leaves, twigs, small limbs and small roots. No attempt was made to determine the relative weights of lumber and waste in the large trees of the West, on account of the magnitude of the undertaking, of which one may get an idea from the actual size of the tree. For instance, a Douglas fir stump from the Pacific coast was blasted out and shipped to Minneapolis for experimental purposes. This large stump made nine large dray loads of wood when cut up. To have determined the exact proportion of lumber and waste in this tree would have been a difficult task. Expert lumbermen are inclined to think that the percentage of lumber in these large trees will be somewhat greater than that given above. This will doubtless depend upon conditions. In the case of resinous fir, the trees are frequently cut from ten to fifteen feet above the ground in order to eliminate the resin which exists largely in the roots and the lower part of the trunk. The waste in such cases will exceed the above results.

*Waste Wood as Slabs and Sawdust.*—While waste wood in the form of stumps and tops represents a large proportion of the total weight of the tree, probably not far from the total weight of the lumber, the actual loss produced in sawing the logs is considerable. From 5 to 15 per cent. of the logs goes into slabs. A part of these slabs is cut into shingles and lath. There is still, however, considerable loss from this source, although less than from the sawdust. The old-fashioned circular saw of thirty years ago cut as high as three-eighths of an inch and the old blade saw even more than that. The waste in sawdust, using a three-eighths inch saw, would probably amount to one-third of the weight of the whole log. The cut has been reduced nearly one-half by the introduction of band, gang and band-gang saws. The waste, however, is still great, not far from 20 per cent. when inch lumber is sawed.

In order to put the waste wood problem in such

form as to give a general idea of the amount of wood destroyed annually by the lumber industries, I have chosen a single locality and a single lumbering plant, calculating results from actual lumbering data. The great mills of the C. A. Smith Timber Company, at Marshfield, Oregon, have been selected because they are recognized by lumber experts throughout the country as the most economical mills in existence. These mills are using every known device which will save a single foot of lumber or a single day's labor. They are among the largest in the world and have been repeatedly called "models of economy." A very brief description of some of the economical machinery will, I am sure, be of some interest to the industrial chemist. The mills are located, as are practically all of the great mills of the country, so that the logs may be transported a part of the way, at least, by water. The trees are felled, cut into as great lengths as possible, and brought down the mountains by means of cables and donkey engines to the logging railroads. They are loaded on specially constructed cars and hauled to the nearest streams of water, where they are thrown in and floated to the mills in booms. At the mill they are cut to proper lengths and split into forms called slips or fitches, by great band saws. These saws are capable of handling logs 80 feet in length and 8 feet in diameter. The slips then go directly to the band-gang or tandem saws. The band-gang saws are entirely new inventions. They are not only more rapid than the old circular and gang saws but also far more economical, wasting approximately 30 per cent. less wood than the old circular saw. From the band-gang saws the lumber is finished by going through the edgers and trimmers.

Of special interest is the lath machinery, consisting of horizontal band saws, which are also an entirely new invention. These saws work automatically and cut 25,000 lath every ten hours. The great importance of this new machinery is its comparative economy. Probably 20 per cent. more lath may be cut from the waste than by the old form.

*The Destruction of Waste Wood.*—In the early development of the lumbering industries, one of the serious problems which confronted the lumbermen was the disposal of the mill waste, including the sawdust, slabs and bark. In the older mills of fifty years ago, this was hauled away and dumped. A little of it, of course, was used in the mill for fuel, but it has always been regarded by the lumbermen as a nuisance, largely on account of the danger from fire. When the great mills of the Middle West were built, the quantity of sawdust, slabs and bark was so great that the question of its disposal became a serious one. For very good reasons, lumbermen were not permitted to dump any of the waste into rivers or lakes. Some simple means of disposal became absolutely necessary. The so-called waste burner, which was finally devised, has become a regular fixture in the modern lumbering mill. It consists of a vertical cylinder, the size of which depends upon the amount of waste to be burned. The largest is more than

100 feet high, from 40 to 50 feet in diameter, and so constructed that the wood is carried part way to the top and dropped down on the fire below. With a strong draught, the wood burns very rapidly. One may get some idea of the amount of wood burned from the fact that a single large burner will destroy from 800 to 1000 cords in ten hours. Twenty years ago, when the lumbering industry was at its height in Minnesota, there were destroyed at Minneapolis and the neighboring mills 1500 to 2000 cords of waste daily, or enough to have supplied the farmers of the whole state of Minnesota with fuel.

These figures include wastage only from the trees actually felled and transported to the mills for lumber. They do not include the millions of young trees which are destroyed, either by the large falling trees or by the fires which follow in the wake of the loggers. The Bureau of Forestry has called attention to the fact that this destruction of young timber, although minimized by the lumbermen, is, in reality, more vital to the nation than the actual lumber waste, because it seriously menaces the lumber industry of the future generations.

*The Annual Wood Wastage.*—It seldom occurs, even to the chemist, that wood is by far the most abundant organic substance in the world. The weight of wood or vegetable fiber, as compared with animal matter, is probably not far from a hundred thousand to one. Wood, then, is one of the nation's greatest assets, and its conservation and preservation means the conservation and preservation of the nation's wealth.

The Marshfield mills will again give one a general idea of the waste which accompanies the lumbering industry. This plant saws, on an average, 100,000,000 feet of lumber a year. The average weight of 1000 feet (board measure) of lumber is about one and one-half tons. The annual output of this mill, then, is approximately 150,000 tons of lumber. On the basis of 60 per cent. of waste, the enormous quantity of 225,000 tons of wood are burned, either on the ground where hundreds of years were required for its growth, or in engines of destruction at the mills. A very conservative estimate of the standing timber in this locality, which will eventually be cut by these mills, is 30,000,000,000 feet. Assuming that this timber will all be cut on the above basis, there will be the astounding equivalent of 45,000,000,000 feet of waste which, converted into weight, will amount to the colossal sum of 67,500,000 tons. These figures are enormous, but they seem small when compared with the lumber output during the last decade or even the yearly output. There were cut in 1907, according to the Bureau of Forestry, 40,256,154,000 feet of lumber. On the above basis, there were in that year over 100,000,000,000 feet and over 150,000,000 tons of wastage.

*Wood Analyses.*—At the time this work was begun there were no analyses of either Norway pine or Douglas fir. The first work on these species was a study of the physical properties of the wood, followed by analyses, including the distillation products, fiber,

the resin and the terpenes. The physical properties of the wood showed a striking variation, even in wood from the same tree. It was not uncommon to find the extreme wood limits of specific gravity in the same tree. A series of determinations on different parts of the same tree gave the following:

	Fir.	Norway.
Specific gravity of very lean wood . . . .	0.6074	0.6025
Specific gravity of medium wood . . . . .	0.6711	0.5432
Specific gravity of resinous wood . . . . .	0.8225	0.7984
Specific gravity of very resinous wood . .	0.9456	0.9322
Specific gravity of green roots, very resinous . . . . .	0.9746	0.9721

The above averages of five different determinations indicate that the two species are quite similar. There was a difference, however, in distribution of the resinous matter. The Norway pine was quite uniform, the stumps and the roots being nearly always resinous. The fir, on the contrary, was extremely variable. It was not uncommon to find parts of fir trees containing as high as 50 per cent. of oleoresin, while other parts of the same tree contained as low as 3 per cent.

The first resin and terpene analyses were made for the purpose of determining the relative amounts of resin and terpenes in the various samples of wood, and further for the purpose of studying the physical and chemical properties of the resin and the terpenes themselves. These determinations were made by extracting the wood in large modified forms of Soxhlet extractors, using the various organic solvents. An average of some twenty analyses gave the following:

	Lean wood.	Resinous wood.	Average wood.
Per cent. of oleoresin in Norway pine	6	43	14
Per cent. of oleoresin in Douglas fir.	4	46	16

The amount of oleoresin in the average wood will be seen to be considerably less than the mean of the lean and the rich wood. This was found to be due to the fact that the greater portion of the wood was lean. These results were all obtained from stumps. Analyses of the trunks themselves gave considerably lower results. Parts of the tree near wind-shakes, however, gave even higher results than the stumps. A single analysis of a resinous wind-shaken tree from the Puget Sound district gave 52.5 per cent. of oleoresin. The oleoresin was finally subjected to steam distillation and the amounts of resin and terpenes determined:

	Fir.	Norway.
Per cent. of resin in oleoresin from . . . .	78	78
Per cent. of terpenes . . . . .	22	22

These results are an average of many determinations and indicate that the proportions of resin and terpenes are practically constant in oleoresin fresh from the tree. The terpenes decrease slowly on exposure to the air. An analysis of wood from a stump twenty years after the tree had been cut showed 42.4 per cent. of resinous matter, 21 per cent. of which was turpentine. The only part of this stump which seemed to have changed was the surface; here the resinous matter had become hard and impervious to both air and water.

*The Terpenes.*—The terms terpenes and turpentine have been used synonymously for the reason that the turpentine from the northern species is complex, containing several high boiling terpenes. Common turpentine has been so closely associated with so many branches of industrial art that, were it taken away, the loss would be irreparable unless some good substitute could be found. At the present time nearly all the turpentine is obtained from the forests of the South. The old method of boxing sooner or later kills the tree. In the early history of the industry, three or four years was the average life of the boxed tree. Much better results are now obtained by the new methods of turpentine orcharding. A few years ago, the destruction of the forests of the South was so rapid that the United States government became alarmed lest the turpentine industry should be completely destroyed.

At the present time, the northern and western states play a very small part in the resin and turpentine production of the country, but, as has already been stated, these northern species contain large quantities of both resin and turpentine. Owing to the peculiarities of the species, however, their recovery becomes strictly a problem of by-product chemistry. In fact, resin and turpentine are abundant enough in both the Norway pine and the Douglas fir to make them an important factor in the resin and turpentine output of the country, if economical methods for their recovery were used.

Using again the lumbering plant above mentioned, some idea may be obtained of the amount of resin and turpentine wasted by the lumbering industries of the West. Probably one-fifth of the fir and Norway pine waste wood is rich enough in oleoresin to make its recovery profitable, even by the old process of destructive distillation. While the average of oleoresin in the northern species of pine can only be approximated, over one hundred analyses of wood of all kinds and degrees of resinousness indicates that one-fifth of the fir wood waste from the Puget Sound district contains twenty per cent. of oleoresin. On the above basis, there are 45,000 tons of rich resinous wood, containing 9,000 tons of oleoresin, of which 1,980 tons are turpentine, destroyed annually by the above-mentioned mills. This does not include the resinous matter in the other four-fifths of the wastage. If the standing timber in the locality be again taken at 30,000,000,000 feet, the wastage would at the present rate of lumbering amount to 67,500,000 tons. One-fifth of this waste, or 13,500,000 tons, is sufficiently rich in resinous matter to warrant the use of any good method for its recovery. Assuming that this amount will average even 10 per cent. of oleoresin, there would be the enormous sum of 1,350,000 tons of resinous matter, of which 22 per cent., or 297,000 tons, are turpentine. Translated into common terms, it reaches the colossal sum of over 80,000,000 gallons. Again, assuming that the annual consumption of turpentine is 21,000,000 gallons, the above amount would supply the whole world for nearly four years.

*Present Methods of Utilizing Waste Wood.*—There are numerous methods of utilizing waste wood at the present time, but the more important may be grouped under the following heads:

1. Fuel, yielding heat and power.
2. Destructive Distillation, yielding charcoal, and distillates, as tar, wood alcohol and pyroligneous acid.
3. Extraction, yielding resinous matter, turpentine, wood pulp.

*Fuel.*—The present generation is truly one of conservation, for men are beginning to estimate everything from the energetic point of view. Coal, for instance, is bought to-day largely on the basis of the amount of heat energy it will produce. Waste wood becomes significant even when considered from the standpoint of heat energy for the amount of energy wrapped in our forests is incalculable. An idea of the loss of energy in waste wood may be obtained by determining the amount of heat energy liberated when wood burns. The heat of combustion of average fir wood is about 7,800 British thermal units per pound of wood. This heat energy may be converted into ergs or into horse power, a more familiar term; or better, it may be converted into the equivalent of bituminous coal. Good coal yields about 13,000 British thermal units per pound of coal. One ton of wood will then be equivalent to six-tenths of a ton of coal. If the total annual waste, above mentioned, be translated into the equivalent of bituminous coal, it will amount to the enormous sum of 90,000,000 tons.

*Destructive Distillation.*—Destructive distillation of wood has been used for centuries. Primarily, the object was to obtain charcoal, although in some cases distillation of hard wood was carried on for the purpose of obtaining the distillates. Destructive distillation in retorts on a large scale is a distinctly modern process and is one of the most important by-product industries. The distillation of coal by the closed retort process yields by-products of greater value than the coke itself.

At the time these experiments were begun, the only means of utilizing waste wood of any kind in this country, so far as I am aware, was by destructive distillation. It was soon found that the distillation of pine wood was quite a different process from the distillation of hard wood. In the distillation of hard wood, it makes comparatively little difference how the heat is applied to the retort so long as the temperature is raised sufficiently high to drive off all the distillates. The distillation of pine wood, on the contrary, is different. The nature and the yield of tar, and more especially terpenes, were found to be largely dependent upon the manner of heating the wood.

In order that definite results might be obtained concerning the manner of heating the wood, experiments were made in a small retort, so arranged that the retort could be heated to a red heat in a few minutes. The amount of turpentine, tar and acids was greatly reduced by this rapid heating. A sam-



ple of wood containing 30 per cent. of oleoresin, 22 per cent. of which was turpentine, was suddenly heated to a bright red heat, yielded less than half of the total weight of resin in tar and only a quarter of the total amount of turpentine. The yield in the same sample of wood was nearly doubled by slow and cautious heating.

Having found that the yield of by-products is largely dependent upon the manner of heating, experiments were next made with different shaped retorts, in order that the best and most efficient form might be determined. The one which gave best results was so constructed that the temperature of the wood could be gradually raised to the distilling point. This was accomplished by using a long inclined cordate tube retort, the lower end of which could be heated to a red heat, while the upper end could be kept moderately cool. The retort was arranged so that the wood was admitted at the upper or cool end, gradually passing downward by gravity and by a mechanical device until it reached the lower or red hot end of the retort. By this means, the least possible amounts of both resin and turpentine were decomposed. The retort was also constructed so that the oleoresin could escape from the retort without being distilled. To accomplish this, openings were made in the cordate lobes of the upper end of the retort, in order that the oleoresin when removed from the wood, by "trying out," might pass through these bottom openings instead of passing through the ones in the top of the retort by vaporization. It was found that a portion of oleoresin could be removed by this process with but slight indications of decomposition. The amount of tar was increased, its quality improved and nearly all of the turpentine was recovered.

In order to obtain as accurate data as possible, waste pine wood from the forests and mills of the North and West was subjected to destructive distillation and the distillates as well as the charcoal determined. The following table is a comparison of the results obtained by distilling the three common species:

	Norway pine. Lbs.	Southern pine. Lbs.	Douglas fir. Lbs.
Weight of wood taken.....	100	100	100
Charcoal.....	24	22	24
Gaseous products.....	25	26	24
Tar and terpenes.....	14	14	14
Pyroigneous acid, including water.	37	38	38

From these results it will appear that the three species of pine are very nearly alike. Each sample was what would be called resinous wood. The samples of the northern and western wood were largely taken from the stumps although some were from the resinous part of the tree. The southern samples were confined to the trunks of several trees brought from the turpentine forests of Florida. The yield of turpentine in each case was somewhat less than the total amount existing in the wood or obtained by either steam distillation or by extraction. The loss was found to be due to the decomposition of the oleoresin by heat. This was especially noticeable when the distillation took place rapidly. For instance,

wood containing 5 per cent. of turpentine only yielded 2 per cent. by rapid distillation.

While the retort described gave very satisfactory results so far as by-products were concerned, the chief difficulty lay in the market value of the products. The tar, which has a real value abroad and even in the South, was found to be practically worthless in the North and West, despite the determined efforts to utilize it in the paint, wood preservation and other industries. Most of the distillation plants of the North and West actually burn the tar and throw away the pyroigneous acid. As pine wood yields only a trace of alcohol, the only marketable products left are the turpentine and charcoal. The latter, however, has little value, hence the whole process of pine wood distillation in the North resolves itself into the recovery of the turpentine. As a considerable quantity of the turpentine is lost, even by the most improved processes of distillation, other methods of utilizing the waste wood seemed absolutely necessary. The above experiments are of some interest, however, because they were the first made on the wood of the northern and western species of pine and incidentally show that the yield of gaseous as well as other products is dependent largely upon the method of distillation.

Realizing, after years of labor in perfecting apparatus for the economical distillation of pine wood, that some other process than distillation must be found if the waste wood of the North and the West is to be converted into products of any economical value, the whole plan was changed from distillation to extraction. The reason for the change is evident from a comparison of the products obtained by the two processes. As has already been stated, the only real marketable product obtained by distillation is turpentine. By the extraction process, practically all of the wood is converted into commercial products, namely, resin, turpentine and wood fiber, any one of which is worth more at least in the North than all of the distillation products.

At the time this work was begun there was little hope of an extraction process which could be used for the recovery of both the resin and the terpenes. The cost, with the losses which necessarily follow a process of this kind, excluded the use of all of the common solvents. The first experiments made along this line were with steam. It was found that the terpenes could be easily removed from the wood by superheated steam. That definite results might be obtained, retorts were built so that steam could be passed through them under pressure. The wood was chipped into small pieces, placed in these retorts and distilled with superheated steam. The terpenes were quickly and quantitatively removed. The difficulty with this process was that the resin still remained in the wood and some method for its recovery was necessary before the process could be considered satisfactory. The only solution, therefore, was in the use of the common solvents.

As the steam process required two separate operations, experiments were made, excluding the steam

and using the solvents direct. All of the common solvents were tried, among them, petroleum ether, benzene, ether and carbon disulphide. It is worthy of note that in the early stages of this work the cost of benzene entirely excluded its use. Later, however, the supply of crude benzene from the coke industry made it more satisfactory than its sister solvent, petroleum ether.

After trying various forms of apparatus, one depending upon common extraction principles was adopted as giving best results. The apparatus was so constructed that several extraction chambers, arranged somewhat after a beet sugar diffusion battery, were connected with a large steam-heated boiler containing the solvent. The arrangement was such that by heating the boiler, the vapors of the solvent could be forced through any one of the extraction chambers containing the wood, where the vapors were condensed and returned to the boiler laden with the oleoresin. After the extraction was completed, the last traces of the solvent were removed by forcing through the wood, air, steam, and finally, hot alkali, for the conversion of the wood into pulp. By this treatment all of the resinous matter was removed, the solvent recovered with very slight loss, and the wood was converted into pulp.

The terpenes of both the Norway pine and the Douglas fir have already been described.<sup>1</sup> The properties of the terpenes obtained by extraction were identical in every respect with those obtained by boxing. The resin from the Norway pine has likewise been described.<sup>2</sup> The resin from the Douglas fir, under examination at present, resembles the resin of the southern pine. It is composed chiefly of abietic acid with an acid of unknown composition and a small quantity of unsaponifiable matter.

*Paper from Waste Wood.*—The paper industry has become one of the greatest and most important parts of our commercial fabric. But a few years ago, nearly all of the paper was made from cotton and linen rags, hemp, flax and jute. Very little paper was made from wood pulp. At the time this work was begun there was not a single pulp mill in the whole northwest. They are now counted by the score. Spruce wood is chiefly used in this locality for the reason that it is readily reduced and requires little bleaching. Spruce, however, is becoming scarce. The price has nearly doubled within the last five years. At the present rate of consumption, all of the spruce wood in Minnesota, Michigan and Wisconsin will have been used up within the next decade and other sources must be found. White pine, cottonwood, basswood, hemlock, birch and even soft maple give perfectly satisfactory results. As a matter of fact, any wood belonging to the pine family may be used. Even the stumps, roots and branches of the Norway pine and Douglas fir make an excellent grade of pulp when properly treated.

In studying wood waste with the idea of converting the fiber into pulp, various methods for the manu-

facture of paper were tried. The sulphite process, the one universally used in the northwest, was thoroughly tested. It proved unsatisfactory on account of the fact that even a very small amount of insoluble resinous matter turns black in sulphite solution. The soda process, with certain modifications, was found to work satisfactorily and especially with extracted wood. A number of pulp determinations were made, using wood from different parts of the tree. An average of several determinations gave the following:

Wood pulp in	Per cent.
Norway pine stumps.....	27
Douglas fir stumps.....	24
Fir sawdust.....	22
Southern pine.....	23

The highest yield of 43 per cent. of fiber was obtained from lean fir wood, thoroughly seasoned, while the lowest, of 16 per cent., was obtained from green resinous fir. It was found by actual test that the fiber from this waste wood was equal to the best obtained from spruce, by either the sulphite or the soda process. Recent experiments show that even sawdust, by careful treatment, yields a fiber of good enough quality to make any of the common paper.

If waste wood is again considered from the standpoint of paper, its economic value is greatly magnified. Some idea of the total waste from the paper point of view may be obtained by again using the annual waste from the above-mentioned mills. Of the 225,000 tons of waste wood, at least one-half can be converted into pulp at a minimum cost. From actual experiments, this waste averages 22 per cent. of pulp. The annual amount of pulp wasted in this one locality, then, is little less than 25,000 tons. When one finally considers the total waste throughout the North, West, and South, the waste wood problem from the paper side alone looms up as one of the most vital problems with which the American people have to deal.

In conclusion, I will state that the technical and minor details have been purposely omitted. The chief object of this general résumé of work which I have been carrying on for a number of years is to interest my colleagues in the great wood problem. If waste wood is to be converted into its most valuable by-products, industrial chemists must join in the work. There are hundreds of uses to which this waste may be put when once this great problem is exhaustively studied.

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#### COMMERCIAL BENZOL IN THE UNITED STATES.<sup>1</sup>

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Benzol is a general commercial name applied to the liquid aromatic hydrocarbon mixtures derived from coal tar light oil. It is the purpose of this paper to consider briefly the manufacture, classifica-

<sup>1</sup> Presented October 10, 1910, at the meeting of the Philadelphia Section of the American Chemical Society.

<sup>1</sup> *J. Am. Chem. Soc.*, 28, 1467.

<sup>2</sup> *Ibid.*, 31, 561.

tion, properties and commercial uses of the various grades of benzol.

Coal tar light oil is a liquid varying in color from straw to nearly black. Its gravity is less than that of water, and it has a pungent, somewhat unpleasant odor. It is of indefinite constitution, according to the nature of the tar from which it is distilled, but varies rather as to proportion than as to nature of its constituents. It is mainly composed of (1) phenolic acid bodies known as tar acids, of which phenol and the three isomeric cresols are the main constituents; (2) aromatic bases, of which pyridine is the best known type; (3) unsaturated bodies of the type of styrol; (4) aromatic hydrocarbons, as benzene, toluene, xylene, cumene, etc.

This last class of compounds forms the basis of the commercial benzols. Only the first three are separated in the pure state. Benzene and toluene, known in commerce as pure or C. P. benzol, and toluol, are produced in an almost pure state, with less than 0.5 per cent. of impurities. These boil entirely within 2°. Pure xylol consists of a mixture of the three isomeric xylenes, and has a boiling point range of 135°-145° C. No attempt is made in this country to separate the three isomers. The other grades of benzol are classified according to the boiling point.

One hundred per cent. benzol, 90 per cent. benzol and 50 per cent. benzol are mixtures of benzene, toluene and xylene, and their names indicate the amount distilling under 100° C. In addition to these we have commercial toluol and solvent naphtha or 160° benzol. The former is composed mainly of toluene and has a distillation starting at 100° C. and giving 90 per cent. at 120° C.; the latter on distillation test shows a few per cent. at 130° C. and 90 per cent. at 160° C., and mainly contains xylenes and cumenes.

All the above products are highly refined, are water white, and have a pleasant aromatic odor. In addition to these there are straw-color products, known as straw-color benzol and straw-color toluol. These have a poorer odor and contain some unsaturated compounds. The straw-color benzol corresponds in boiling point to 90 per cent. benzol, and the straw-color toluol to commercial toluol.

Two darker naphthas are also produced, one a crude product about corresponding in boiling point to solvent naphtha. It is a dark oil, of about the same evaporative power as turpentine. The other dark naphtha, known generally as heavy naphtha, is heavier than any I have previously mentioned. In boiling it tests a few per cent. at 160° C., and about 85 per cent. at 200° C.

The first process to which light oil is subjected is a preliminary distillation to remove tarry matter, and any heavy oils and naphthalenes. The distilled oil is then treated in lead-lined agitators with dilute sulphuric acid, to remove pyridine and other bases. This is followed by a treatment with caustic soda solution, by means of which the tar acids are removed, and this solution of carboic acids in soda forms the

crude material, from which is made crystal carboic acid and cresols.

The extracted neutral oil is then subjected to a series of fractional distillations, by means of which it is split up into various fractions of different boiling points. This is carried on in column stills resembling those used in alcohol rectification, and it is at this point that the various straw-color and dark products are taken off.

These crude fractions are then chemically washed with strong sulphuric acid, which has the effect of removing unsaturated compounds and leaving the aromatic hydrocarbons, which only require a distillation to remove any tarry matter formed by the action of the acid to give the water-white, refined products. For the pure or C. P. grades, a further column distillation is required, using for this purpose a refined fraction rich in the material sought after.

Before tabulating the most important properties of these various grades of benzol, it might not be amiss to give here the methods of testing used:

(a) Boiling point: 100 cc. of benzol are taken in a 200 cc. glass distilling bulb protected from superheating by an asbestos ring, and connected to a 24" water-cooled condenser. A thermometer is placed with the top of the bulb opposite the exit tube of the flask. The distillation is started and run as fast as separate drops will form. The distillate is collected in a 100 cc. cylinder and the temperature at which the first drop falls is noted and thereafter the per cent. distilled at every even 10° until dry. The temperature at the drying point is also recorded. For C. P. grades finer thermometers are used and readings taken every 1/5° C.

(b) Specific gravity: Taken with a hydrometer or Westphal balance at 15° C.

(c) Flash point: Taken in a Tagliabue open cup tester in the usual way.

(d) Sulphuric acid test (taken on refined grades only): 7 cc. of C. P. 66° H<sub>2</sub>SO<sub>4</sub> are shaken with 21 cc. of benzol in a small stoppered bottle, and the coloration, after standing 15 minutes, noted. With pure benzol, toluol and xylol, the coloration of the acid is at most a very pale straw; with the commercial grades of refined benzol, except solvent or 160° benzol, the acid may be somewhat darker, but the oil should remain white; with solvent naphtha the oil turns a little yellow and the acid colors red.

(e) Evaporation test: This is taken by noting the time required for 2 cc. of the benzol to evaporate from a metal surface with raised edges 3.5" square. It should, to allow for variation in temperature, be compared to pure benzol, which requires 10 minutes for complete evaporation at ordinary laboratory temperatures.

(f) Freezing point: This is taken only on pure benzol. About 50 cc. are taken in a large test tube and cooled down, stirring with a thermometer in the liquid. Pure benzol should solidify and show a constant temperature at about 5° C.

In Table I, I show the range of boiling points, gravities and flash points of the various grades of ben-

zols, and in Table II, the evaporation on all these benzols, along with similar tests on turpentine and several grades of petroleum naphtha.

Unlike the petroleum series, the gravities on the refined grades decrease with increase of boiling point,

TABLE I.—BOILING POINTS, SPECIFIC GRAVITIES AND FLASH POINTS OF BENZOLS.

	Boiling point.	Gravity at 15° C.	Flash point.
Benzol, pure.....	80° to 82° C.	0.881 to 0.884	Below freezing
Benzol, 100 per cent.....	109 per cent. at 100° C.	0.875 to 0.884	Below freezing
Benzol, 90 per cent.....	90 per cent. at 100° C.	0.875 to 0.882	Below freezing
Benzol, 50 per cent.....	50 per cent. at 100° C.	0.871 to 0.875	Below freezing
Toluol, pure.....	110° to 112° C.	0.869 to 0.871	Below freezing
Toluol, commercial.....	90 per cent. at 120° C.	0.869 to 0.872	Below freezing
Xylol, pure.....	135° to 145° C.	0.865 to 0.867	85.5° F.
Solvent naphtha or benzol 160°.....	90 per cent. at 160° C.	0.864 to 0.870	78° F.
Benzol, straw-color.....	Like 90 per cent. benzol	0.862 to 0.870	Below freezing
Toluol, straw-color.....	Like commercial toluol	0.862 to 0.870	Below freezing
Crude solvent naphtha.....	Like solvent naphtha	0.876 to 0.887	78° F.
Heavy naphtha.....	About 85 per cent. at 200° C.	0.925 to 0.940	109° F.

while the evaporation table runs over a wide range so that a benzol for any particular purpose can be readily selected.

The principal use of the various grades of benzol is as a solvent. Benzol is an excellent solvent for gums and resins, oil-aniline colors and rubbers.

TABLE II.—EVAPORATION TESTS.

	Minutes.
Pure benzol.....	10
100 per cent. benzol.....	13 1/2
90 per cent. benzol.....	14
50 per cent. benzol.....	23
Pure toluol.....	29
Commercial toluol.....	33
Xylol.....	89
160° benzol or solvent naphtha.....	107
Straw-color benzol.....	18
Straw-color toluol.....	36
Crude solvent naphtha.....	121
Heavy naphtha.....	303
Turpentine.....	142
80° gasoline.....	4
70° gasoline.....	8
66° benzene.....	16
62° benzene.....	18

Pure benzol and toluol are used as the basis of manufacturing other chemicals, such as nitrobenzol, aniline and benzoic acid, etc. They are also used for solvents where a very high grade of purity is demanded, such as crystallizing drugs and chemicals. Then also where a continuous solvent recovering extraction process is used, a uniform low-boiling material is necessary, and for these purposes pure benzol has been found of great value. Pure benzol is also used as a solvent in the manufacture of cements and coatings for food product cans—being the only practical material pure enough for this purpose.

The other commercial refined benzols are used in various industries, as solvents or thinners, the grade selected being conditioned by the particular needs of the material being manufactured.

In the paint and varnish industry the uses of benzol are varied. In certain varnishes benzol is often used as a thinner, to cheapen the turpentine, being preferred to petroleum benzine because this latter substance has not the power of holding certain gums in solution that benzol has. Benzol is also largely used in wood stains, owing to the great solvent power it has for the oil-soluble aniline colors. For the same reason it is largely the basis of many commercial

stain solvents used to dissolve the dry color. Enamel paints also very often have benzol as a part of their make up, as well as bronze and aluminum paints. The basis of these paints is a concentrated solution of gum, usually damar, and as benzol has a strong

solvent action on this material, it is a very desirable material to use. Then the strong solvent action of benzol makes it an excellent base for varnish removers, and there are many patents covering its use in this connection. For all these purposes the grade of benzol to be selected depends largely on the drying effect desired. All have approximately equal solvent power, so that the rate of evaporation is the important conditioning factor. Mostly water-white or refined grades are used, owing to their greater purity; but in some cases where color and odor are not essential, straw-color grades are used. For tar paints, gilsonite paints, etc., straw-color benzols, and the darker, heavier naphthas are almost exclusively used. The dark naphtha, corresponding to solvent, is largely used as a turpentine substitute, where odor and color are not important features, especially as a thinner where the varnish or paint is not to be sold but to be used in the maker's own factory. Heavy naphtha is mainly used in ship-bottom paints, and in thinning coal tar paints and varnishes.

Then in another field benzol has very large application. Though it does not dissolve pyroxylin or soluble cotton, yet the amyl acetate solutions of this material can be thinned to a greater extent by benzol than by any other commercial solvent. To this property is due its large use in two industries—lacquers and imitation leather. A number of lacquers are only soluble cotton dissolved in amyl acetate and thinned with benzol. Many imitation leathers have as their base such a solution which is applied to cloth, and the resulting coating colored and grained in various ways. Even in the imitation leathers which have a linseed oil base, benzol is largely used as a solvent. In the first class of imitation leathers only refined benzols are used, while in the latter class straw-color benzols also find application.

Benzol is also a perfect rubber solvent. The only commercial article which equals it in solvent power is carbon bisulphide, and this has the disadvantages of being much more expensive and very much more dangerous to handle; so in all high-class rubber cements we find benzol used. The advances in the automobile tire industry have opened up a new and large market for benzol, for in this field benzol is indispensable. Along these lines, too, are rubber solu-

tions, used as the base of insulating varnishes. Here also benzol finds application. Somewhat allied are solutions for cold vulcanization of rubber, which are essentially mixtures of benzol and sulphur monochloride. For all these purposes the refined grades are mostly used.

Other uses of benzol which I may briefly mention are in the composition of metal polishes and metal protective coatings, dry cleaning and scouring, grease extraction, and in coatings for wooden forms used in concrete construction. This last use is a recent one, and where tried has apparently given satisfaction, and this field may be capable of enormous development.

Benzol viewed from a commercial standpoint is really only in its infancy in this country. As time progresses and new sources of supply are opened up, new and larger uses will have to be found for it. On its large and varied solvent power rest its capabilities for further commercial utilization, and to this feature is due the rapid growth of the industry in this country.

BARRETT MFG. CO. LABORATORY,  
CHEMICAL DEPARTMENT,  
FRANKFORD, PA.

#### TIME, TEMPERATURE AND COMPOSITION AS FACTORS IN SOFTENING WATER.<sup>1</sup>

By J. C. WM. GRETH.<sup>2</sup>

Received November 1, 1910.

The problem of softening and purifying water is much more difficult than at first appears to the novice.

The complexity of the impurities and the wide variations in waters from the same sources of supply do not admit of the application of a fixed method for all waters.

The softening of water is understood by many to be merely a question of the addition of lime and soda ash. This is shown by articles in engineering and chemical journals and even government publications, advising the use of so much lime and soda ash for a certain water supply. Looking at the problem from this point of view, the question naturally arises among engineers and water users as to the necessity of the apparatus for the proper softening and clarification of water.

In softening water we have to deal with extremely dilute solutions which are made complex by the number of substances in solution, each to some extent affecting the solubility of the other.

To remove the various salts of lime and magnesia from the dilute complex solutions by means of the two reagents, commercial caustic lime and soda ash, both of which, especially the former, are likely to vary in purity, calls for an accurate method of control, and a wide experience with different waters.

Chemists usually estimate the quantity of reagents required on the basis of the molecular weights of the lime, magnesia and iron salts in the water. It has been my experience that no fixed rules, applicable to all water supplies, can be laid down as to the exact

quantity of reagents required, the method of controlling treatment, the time required for reactions and sedimentation, or for perfect clarification.

The time to be allowed for the complete softening of the water must be determined. No definite time can be set as being sufficient for all waters unless, of course, sufficient time is allowed in all cases to take care of those waters which require the maximum time for complete reaction.

This would hardly be practicable, as the cost of the water-softening system must be considered, and this cost is, in a large measure, dependent on the time allowed for reactions. In many types of water-softening apparatus on the market, the time allowed for reactions has been the uncertain minimum rather than the safe maximum.

That the time allowed for reactions is a question of vital importance, and that it has received little attention, is evidenced by the fact that in many cases a softened water will leave the water-softening apparatus, as it should, perfectly clear; but after standing for a time it becomes turbid, and eventually a deposit is found in the container. This can be seen in many of the track tanks of railroad companies, or in the storage tanks of industrial plants, using water-softening apparatus. In some cases this becomes a serious annoyance and expense.

Again, deposits from softened water are found in feed-water heaters, and in pipe lines connecting the heater and boilers. Reference is not made here to a precipitate due to the reduced solubility of the lime and magnesia salts at the higher temperature, but to precipitation due to the continued reaction between the softening reagents and the lime and magnesia in the water. Moreover, sludge is deposited in the boiler. While this cannot be entirely prevented, yet in some cases the amount of sludge thrown down almost makes one believe that a boiler compound and unsoftened water had been used in place of a softened water. Again, it is extremely common in many water-softening systems to find even the pipe carrying the softened water from the system to be choked with scale. These effects are undoubtedly due to insufficient time for reactions within the softening apparatus.

Temperature is, of course, a factor in the time to be allowed, but in almost all cases it is desirable to soften the water before it is heated; therefore, the softening reactions must take place at temperatures between 32° and 85° F.

Every expedient known to the chemist and engineer must be employed in the design of apparatus to properly soften water on a large scale in a reasonable time. All chemists will agree that the addition of the reagents must be exact and that they must be thoroughly mixed with the water. It would seem but rational to suppose that in the laboratory with a small sample, following the method employed on the large scale, ideal results could be obtained and that these results might be used as a basis for designing water-softening apparatus, at least, as far as the time to be allowed for reactions is concerned, but let us

<sup>1</sup> Read before Pittsburgh Section of the American Chemical Society.

<sup>2</sup> Manager Water Purifying Dept., Wm. B. Scaife & Sons Co.

see what actually occurs in attempting to treat a small sample of water in the laboratory, following as closely as possible the practice which gives results on the large scale.

The following analysis of a well water with data showing the extent of the reactions for given periods of time has been selected from a large number of waters on which similar experiments have been tried to determine what can be done in the laboratory in attempting to parallel the results obtained on a large scale:

DETERMINATIONS.		
	Parts per million.	Grains per U. S. gallon.
Volatile and organic matter.....	75	4.40
Silica.....	9	0.55
Iron and alumina oxides.....	trace	trace
Calcium oxide.....	158	9.30
Magnesium oxide.....	165	9.72
Sodium oxide.....	20	1.15
Sulphuric anhydride.....	343	20.20
Carbonic anhydride (fixed).....	123	7.26
Carbonic anhydride (free).....	none	none
Chlorine.....	12	0.70
Alkalinity as CaCO <sub>3</sub> .....	281	16.50
Total solids by evap.....	896	52.70

PROBABLE COMBINATIONS.		
	Parts per million.	Grains per U. S. gallon.
Volatile and organic matter.....	75	4.40
Silica.....	9	0.55
Iron and alumina oxides.....	trace	trace
Calcium carbonate.....	281	16.53
Calcium sulphate.....	2	0.10
Magnesium sulphate.....	496	29.16
Sodium sulphate.....	21	1.24
Sodium chloride.....	20	1.15
Total solids.....	904	53.13
Suspended matter.....	1	0.05
Free carbonic acid.....	none	none
Incrusting solids.....	788	46.34
Non-incrusting solids.....	41	2.39

The experiments on this water were made at temperatures ranging from 50° to 60° F. Under the heading "Boil," the sample had stood for 24 hours, then 100 cc. of it were brought to a boil, cooled, then filtered, and the determinations made.

	1 hour.	2 hours.	3 hours.	4 hours.	24 hours.	Boil.
CaO.....	51a 3.00b	26a 1.50b	26a 1.50b	17a 0.98b	14a 0.84b	10a 0.56b
MgO.....	53a 3.10b	10a 0.60b	10a 0.60b	5a 0.30b	5a 0.30b	3a 0.20b

These experiments were made on rather bad water, in fact water worse than the average. Now let us see the results of the same experiments on a water considerably better than the average, under a similar set of conditions, a river water.

DETERMINATIONS.		
	Parts per million.	Grains per U. S. gallon.
Volatile and organic matter.....	9	0.55
Silica.....	8	0.45
Iron and alumina oxides.....	2	0.10
Calcium oxide.....	14	0.84
Magnesium oxide.....	3	0.18
Sodium oxide.....	1	0.07
Sulphuric anhydride.....	7	0.44
Carbonic anhydride (fixed).....	7	0.44
Carbonic anhydride (free).....	2	0.11
Chlorine.....	5	0.30
Nitric anhydride.....	2	0.10
Alkalinity as CaCO <sub>3</sub> .....	17	1.00
Total solids by evap.....	53	3.10

a Parts per million.  
b Grains per U. S. gallon.

PROBABLE COMBINATIONS.

	Parts per million.	Grains per U. S. gallon.
Volatile and organic matter.....	9	0.55
Silica.....	8	0.45
Iron and alumina oxides.....	2	0.10
Calcium carbonate.....	17	1.00
Calcium sulphate.....	11	0.68
Magnesium sulphate.....	1	0.06
Magnesium chloride.....	5	0.29
Magnesium nitrate.....	2	0.14
Sodium chloride.....	2	0.13
Total solids.....	57	3.40
Suspended matter.....	9	0.55
Free carbonic acid.....	2	0.11
Incrusting solids.....	47	2.72
Non-incrusting solids.....	2	0.13

	1 hour.	2 hours.	3 hours.	4 hours.	22 hours.	Boil.
CaO.....	39a 2.30b	39a 2.30b	39a 2.30b	39a 2.30b	36a 2.10b	33a 1.96b
MgO.....	3a 0.20b	3a 0.20b	3a 0.20b	3a 0.20b	3a 0.20b	3a 0.15b

From these experiments it would seem that at the end of two hours the treatment is practically completed. But the fact that a further reduction in both the calcium and magnesium oxides takes place after the end of two hours shows that the reactions are not entirely completed, and it is probable that just at this stage many water-softening machines stop in place of allowing sufficient time for the reactions to be completed.

The amount of impurity in the water is also a factor in the time to be allowed in softening a water. This is illustrated by the second analysis just cited. In this experiment, after allowing 22 hours for the reactions to complete themselves, and heating the water to a boil, the total of the calcium and magnesium oxides is higher in the treated water than in the raw water, while in the first experiment the total of the calcium and magnesium oxides is lower in the treated water than in the raw water of the second experiment, showing that other factors besides time and temperature enter into the completeness of the softening.

As these experiments were conducted in exactly the same manner, and the conditions kept as nearly uniform as possible, one would have expected the results to be the same.

The results of such experiments, therefore, serve only as a guide which enables one having before him a large number of similar results, based on like experiments to draw conclusions, first, as to the length of time required on a large scale for complete reactions, and second, as to the minimum to which the calcium and magnesium oxides can be reduced in the treated water.

After the time to be allowed for reactions has been determined, provision must be made for sedimentation and efficient clarification to carry the process to its logical conclusion, which is to remove the lime and magnesia as well as all suspended matter, to the extent that no after-precipitation can occur.

The following analysis shows a water very similar to the one cited for the second experiment:

a Parts per million.  
b Grains per U. S. gallon.

## DETERMINATIONS.

	Parts per million.	Grains per U. S. gallon.
Volatile and organic matter.....	27	1.60
Silica.....	9	0.55
Iron and alumina oxides.....	2	0.10
Calcium oxide.....	12	0.70
Magnesium oxide.....	5	0.32
Sodium oxide.....	21	1.24
Sulphuric anhydride.....	35	2.04
Carbonic anhydride (fixed).....	4	0.22
Carbonic anhydride (free).....	6	0.33
Chlorine.....	12	0.70
Nitric anhydride.....	trace	trace
Alkalinity as CaCO <sub>3</sub> .....	9	0.50
Total solids by evap.....	121	7.10

## PROBABLE COMBINATIONS.

	Parts per million.	Grains per U. S. gallon.
Volatile and organic matter.....	27	1.60
Silica.....	9	0.55
Iron and alumina oxides.....	2	0.10
Calcium carbonate.....	9	0.52
Calcium sulphate.....	17	1.00
Magnesium sulphate.....	16	0.96
Sodium sulphate.....	25	1.44
Sodium chloride.....	20	1.15
<b>Total solids.....</b>	<b>125</b>	<b>7.32</b>
Suspended matter.....	9	0.55
Free carbonic acid.....	6	0.33
Incrusting solids.....	54	3.13
Non-incrusting solids.....	44	2.59

This water, after treatment with lime and soda ash in a four-thousand gallon per hour water-softening system, in which a time of four hours is allowed for the softening, shows calcium oxide 9.5 parts per million; magnesium oxide, 1.4 parts per million; corresponding to calcium carbonate, 17 parts per million; magnesium hydrate, 2 parts per million; so here are two waters very much alike as to total hardness. One water under laboratory conditions is harder after treatment, allowing a longer time for reactions even with the aid of heat, while on a large scale a similar water is softened at atmospheric temperature, and in a much shorter time, to such an extent that both the calcium carbonate and the magnesium hydrate in the water are lower than the solubility of each of these substances in distilled water.

This is almost invariably the case, and proves that in a properly designed water-softening system a softer water can be obtained than by laboratory experiment conducted along correct, scientific lines, paralleling as closely as possible the conditions existing in a regular softening system, even allowing more time for the reactions and with the aid of heat.

The time factor for the treatment of a particular water supply cannot therefore be directly determined by laboratory experiment, but must be found by a comparison of the experimental data with the results in practice.

The presence or absence of certain salts seems to have a direct bearing upon the time required for reactions and upon the solubilities of the calcium and magnesium compounds remaining in the treated water; but so far, no reliable data are available that would warrant stating an opinion as to which of these salts cause this variation; nevertheless, the fact re-

mains that the calcium and magnesium cannot be reduced to the same limits in all waters.

In some waters, at atmospheric temperature, the reactions are completed and the water has settled perfectly clear at the end of two hours. In other waters, under the same conditions, and with the same type of apparatus, this result is not obtained until at the end of eight hours, and in some cases even a longer time. Therefore, in practice the time to be allowed is an important consideration, since the cost, as well as the extent of the softening, is dependent upon the time allowance for reactions and sedimentation.

Each water presents a specific problem that has to be worked out from the analysis, the experimental data, and the known results in practice with water of similar characteristics. In the absence of such data neither the results to be obtained can be accurately foretold, nor troubles avoided that follow imperfect softening.

It is, of course, true that any softening of the water is better than none, but by carefully considering the important factors which enter into the design of a water-softening system for a particular water supply, the additional outlay will be well invested, as there is a vast difference between the extent of softening obtained in many plants, due to improper design, and that which is obtainable with properly designed and operated apparatus.

## THE FOREST PRODUCTS LABORATORY.

By MCGARVEY CLINE, DIRECTOR.

*What It Is.*—The Forest Products Laboratory is a laboratory of practical research conducted by the Forest Service, United States Department of Agriculture, in coöperation with the University of Wisconsin. The purpose of the laboratory is:

1. To secure authoritative information on the characteristic mechanical and physical properties of commercial woods and products secured from them.

2. To study and develop the fundamental principles underlying the preservative treatment of wood, its use for the production of fiber products (pulp, paper, fiber board, etc.), and its use in the manufacture of alcohol, turpentine, rosin, tar and other chemical products.

3. To develop practical ways and means of using wood which, under present conditions, is being wasted.

4. To serve as a public bureau of information on the properties and utilization of forest products.

5. To coöperate with consumers of forest products in improving present methods of use; also in formulating specifications and grading rules for commercial woods, materials secured from them (gums, oils, resin, etc.), and materials used in the treatment of wood (creosote, zinc chloride and other preservatives).

The laboratory is at Madison, Wisconsin, and is situated on the northwest corner of Randall Field, the athletic field of the University of Wisconsin. The university furnishes, without cost to the Forest Ser-

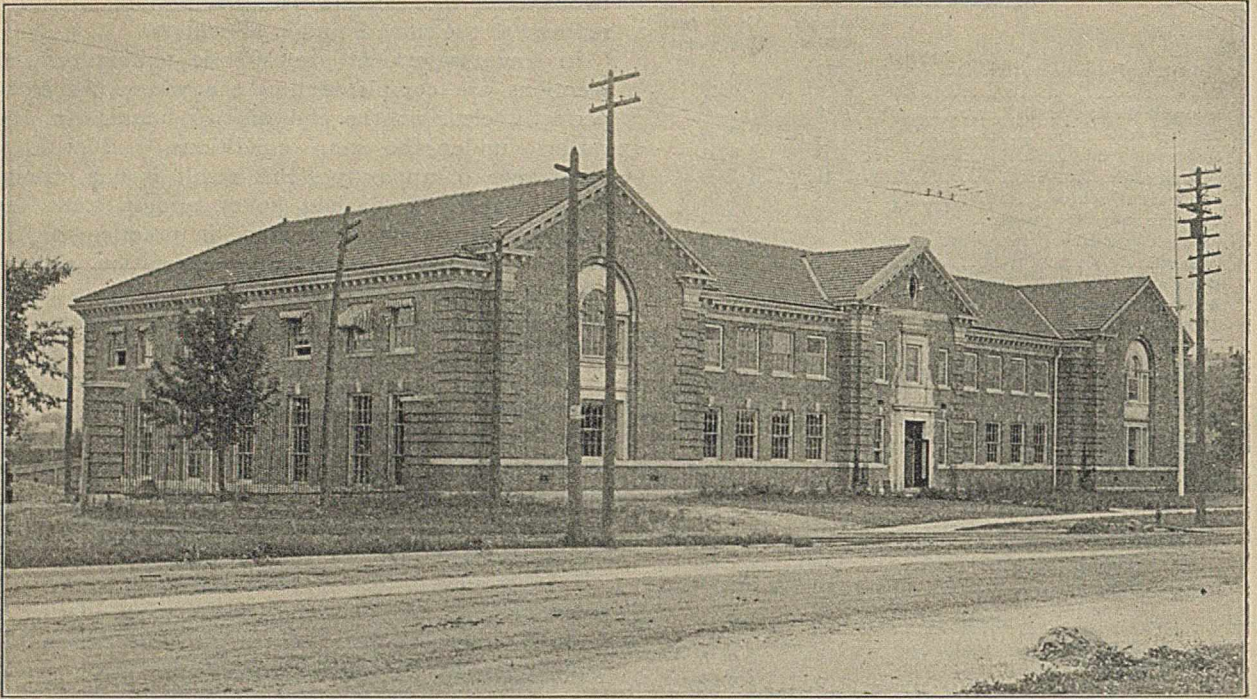


Fig. 1.—Forest Products Laboratory. Front and side view.



Fig. 2.—Forest Products Laboratory Storage Yards and rear view of building.



vice, the building, grounds and the heat, light and power required for the operation of the laboratory. The Forest Service employs the entire staff, supplies all equipment, and pays all other operating expenses. The equipment is available to the faculty and students of the university for research purposes only,

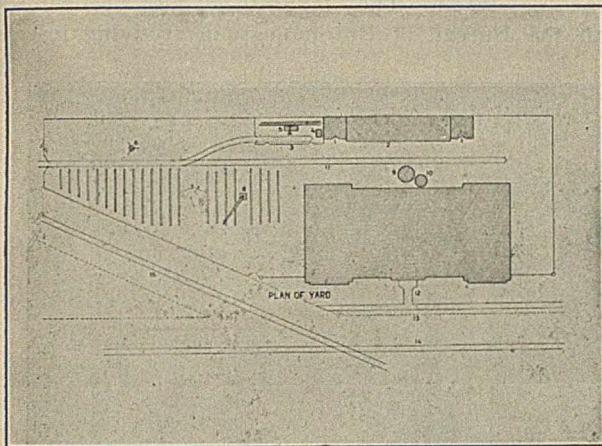


Fig. 3.—Plan of buildings and storage yard.

Legend: 1. Closed sheds for storage. 2. Open sheds for air-drying wood. 3. Sawmill. 4. Small circular saw. 5. Large circular saw with log carriage and direct connected motor. 6. Xylometer for measuring volume of ties. 7. Skids for piling logs and lumber. 8. Derrick. 9. Storage tank for preservatives, having carload capacity. 10. Auxiliary storage tank for preservatives. 11. Switch from C. M. & St. P. Ry. 12. Sidewalk. 13. Curb line, University Avenue. 14. Street car track. 15. Railroad track, C. M. & St. P. Ry.

and the laboratory staff presents a course of lectures at the university on the commercial uses of the forest resources of the country.

*Its Field of Work.*—The following summary of the kinds of work conducted at the laboratory will give the reader a fairly comprehensive idea of its field of work:

#### i. Physical characteristics of wood:

The physical properties of woods studied are its specific gravity, shrinkage, microscopic structure,

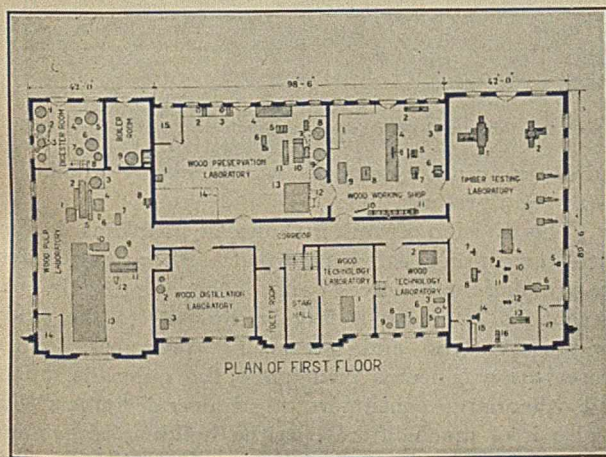


Fig. 4.—Forest Products Laboratory. Plan of first floor, showing location of principal pieces of apparatus.

Legend: Wood Technology Laboratory—1. Work bench. 2. Apparatus for testing beams under dead load. 3. Vacuum oven. 4. Carbon dioxide generator. 5. Motor-driven air compressor. 6. Condenser and

humidifier. 7. Small automobile boiler, for inside of cylinder. 8. Wood conditioning cylinder. 9. Small automobile boiler for cylinder jacket.

Wood Pulp Laboratory—1. Drum washer. 2. 6-Plate screen. 3. Stock tank. 4. Drum washer. 5. Riffler and sand settler. 6. Stuff pump. 7. Power press. 8. Power motor. 9. Stuff chest. 10. Machine screen. 11. Beating engine. 12. Stuff pump. 13. "PuseyJones" paper machine. 14. Office.

Digester and Boiler Rooms—1. Alkali storage tank. 2. "Acid" making system. 3. Acid pumps. 4. Soda digester. 5. Soda blow pit. 6. Sulphite blow pit. 7. Sulphite digester. 8. Relief liquor tank. 9. 10 H. P. boiler.

Wood Distillation Laboratory—1. Condenser. 2. Steam distillation retort. 3. Destructive distillation retort. 4. Turpentine refining still.

Wood Preservation Laboratory—1. Regulating device for controlling the amount and temperature of water for fungus pit. 2. 12" dia. x 24" pressure cylinder; maximum working pressure 300 lbs. per sq. in. 3. 8" dia. x 12" pressure cylinder with pressure pump; maximum working pressure 300 lbs. per sq. in. 4. Concrete open tank. 5. 18" dia. x 4 ft. pressure cylinder; maximum working pressure 600 lbs. per sq. in. 6. Motor-driven centrifugal circulating pump. 7. 300 lbs. to 600 lbs. pressure pump (hydraulic). 8. Compressed air receiver. 9. Measuring tanks. 10. 3.5' x 12' pressure cylinder; maximum working pressure 300 lbs. per sq. in. equipped with treating car. 11. Vacuum pump with surface condensers. 12. Sump. 13. Platform treating car scales. 14. Fungus pit. 15. Office.

(Left out)—Wood penetration apparatus. Hot well. Air compressor. (In pit below floor)—Two receiving tanks. Two tanks for concentrated zinc chloride.

Wood Working Shop—1. Work bench. 2. Wood turning lathe. 3. Mortiser. 4. Short log saw mill and edger. 5. Trimmer. 6. Surfacers. 7. Band saw. 8. Circular saw. 9. Jointer. 10. Cut-off saw. 11. Power motor.

Timber Testing Laboratory—1. 200,000 lbs. Riché testing machine. 2. 100,000 lbs. Olsen testing machine. 3. 30,000 lbs. Olsen testing machine. 4. Torsion testing machine. 5. Power motor. 6. Impact testing machine. 7. Grindstone. 8. Shaper. 9. Hack saw. 10. Large drill press. 11. Small drill press. 12. Emery wheel. 13. Machine lathe. 14. Milling machine. 15. Work bench. 16. Gas furnace. 17. Office.

(Left out)—Bench drill press. Revett precision lathe. Drill grinder.

and, in the case of some species, its specific heat and heat conductivity. Data secured from investigations of this class are chiefly used in correlating the results of other experiments.

#### 2. Mechanical properties of wood:

The term "mechanical properties" as used in the laboratory is applied to those properties of wood which enable it to resist the action of mechanical

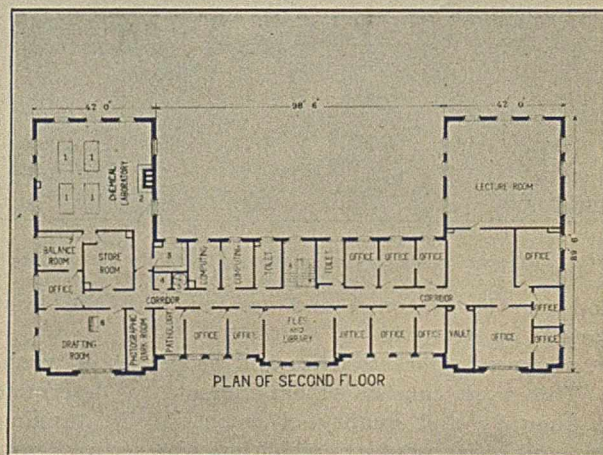


Fig. 5.—Forest Products Laboratory.—Plan of second floor, showing arrangement of offices and laboratories.

Legend: 1. Work benches. 2. Hoods. 3. Distillation room with work benches. 4. Elevator. 5. Spiral stairway to attic. 6. Blue-printing machine. 7. Bench for balances.

forces. Strength, stiffness, hardness, and toughness are examples of such properties. This work includes tests on small clear specimens free from defects, structural timbers, and manufactured forms such as



spokes, axles, etc. Tests are also made to determine the effect of methods of seasoning, preserving, and fire-proofing on the mechanical properties. The chief purpose of work of this character is to furnish engineers and architects data upon which to base moduli for design and upon which to base commercial specifications; to permit manufacturers using wood to judge the desirability of substituting other woods for those becoming scarce; and to determine how

#### 5. Agencies destructive to wood:

A branch of the Office of Forest Pathology of the Bureau of Plant Industry is located at the laboratory for the purpose of studying wood-destroying fungi and how they are affected by various wood preservatives. The chief purpose of this work is to suggest ways and means of perfecting the preservative treatment of wood. The laboratory also coöperates with the Bureau of Entomology in studying insects

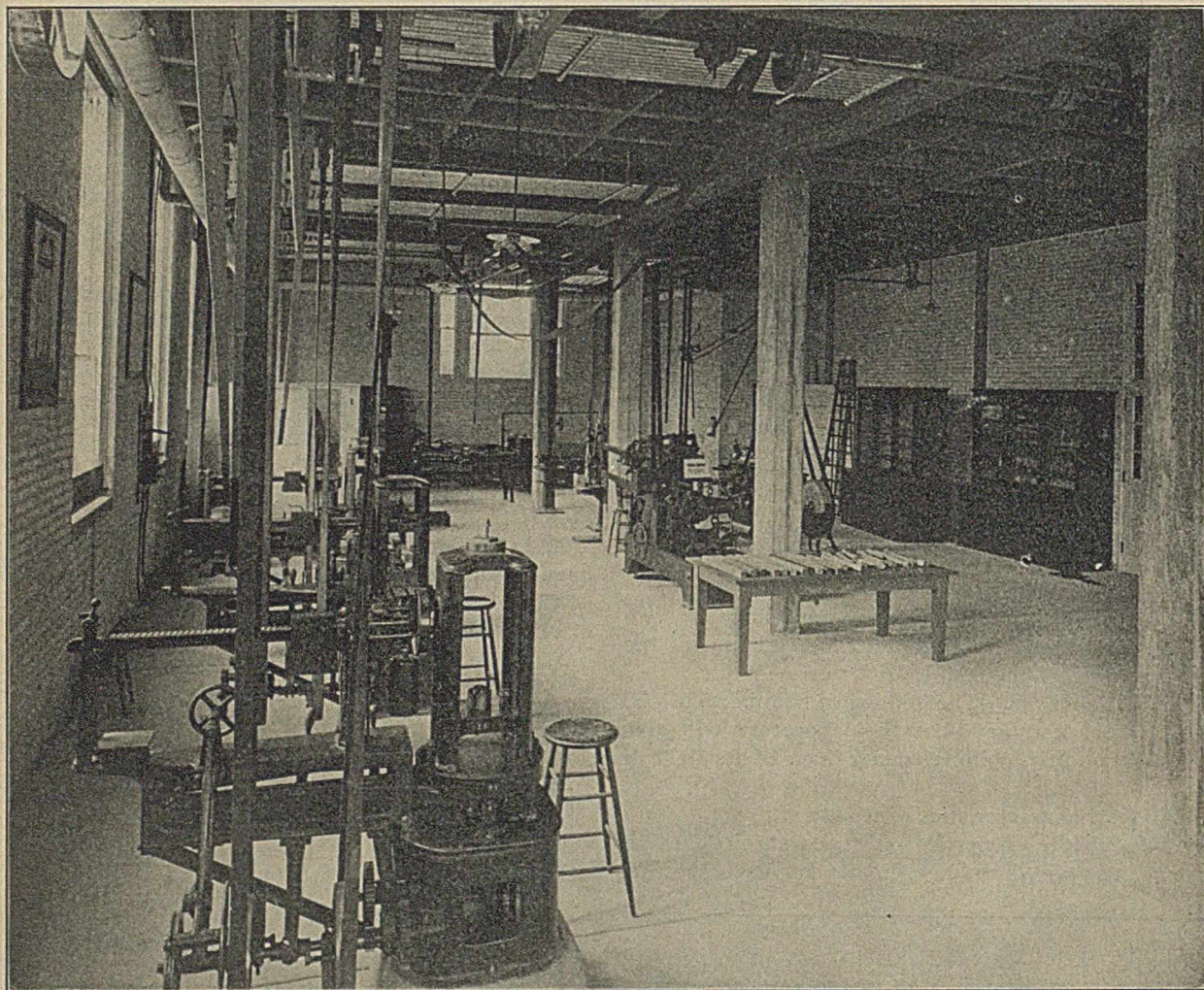


Fig. 6.—Timber Testing Laboratory, showing 30,000 lbs. universal testing machine in the foreground and machine shop equipment in the background.

wood can be seasoned and treated with the least injury to its strength.

#### 3. Chemical characteristics and properties of wood:

This work consists of experiments to determine the quantity and quality of essential oils, tannins, gums and other products which may be secured from different woods. It bears directly on the practicability of using certain forms of forest waste.

#### 4. Artificial drying of wood:

This class of work includes the study of commercial dry-kilns and their operation; also the experimental study of different methods of drying wood. The proper seasoning of wood is a most important factor in its use, and one which is at present too frequently neglected.

and other animal organisms which destroy wood.

#### 6. Wood preservation:

This division of work includes all problems dealing with the impregnation of wood with preservatives, fire-proofing substances and other materials. At present its attention is largely directed to the study of preservatives and preserving processes. Wood preservation concerns principally the railroads, mines and other large consumers of structural timbers, but it also is of much interest to the building trades and to municipalities interested in wood as a paving material.

#### 7. Wood distillation:

This line of activity is directed to the study of methods of distilling wood and methods of refining

and grading the products secured. Work is also done to demonstrate the practicability of using certain of the products for different purposes, thus creating a market for them. This work bears directly on the possibility of using the enormous quantities of mill and forest waste.

#### 8. Pulp and paper industries:

The pulp and paper work of the laboratory is confined to the study of the use of different species and forms of wood for the production of pulp and paper products. The chief purposes of the work are to determine the value, for the production of pulp, of

and result in much unnecessary damage to the standing timber, and cause an unnecessary loss in value of the turpentine and rosin produced. The purpose of the work conducted by the laboratory is to improve this situation.

*Its Organization and Equipment.*—The laboratory is divided into the following nine sections:

- Maintenance.
- Engineering.
- Timber Tests.
- Wood Preservation.
- Wood Technology.

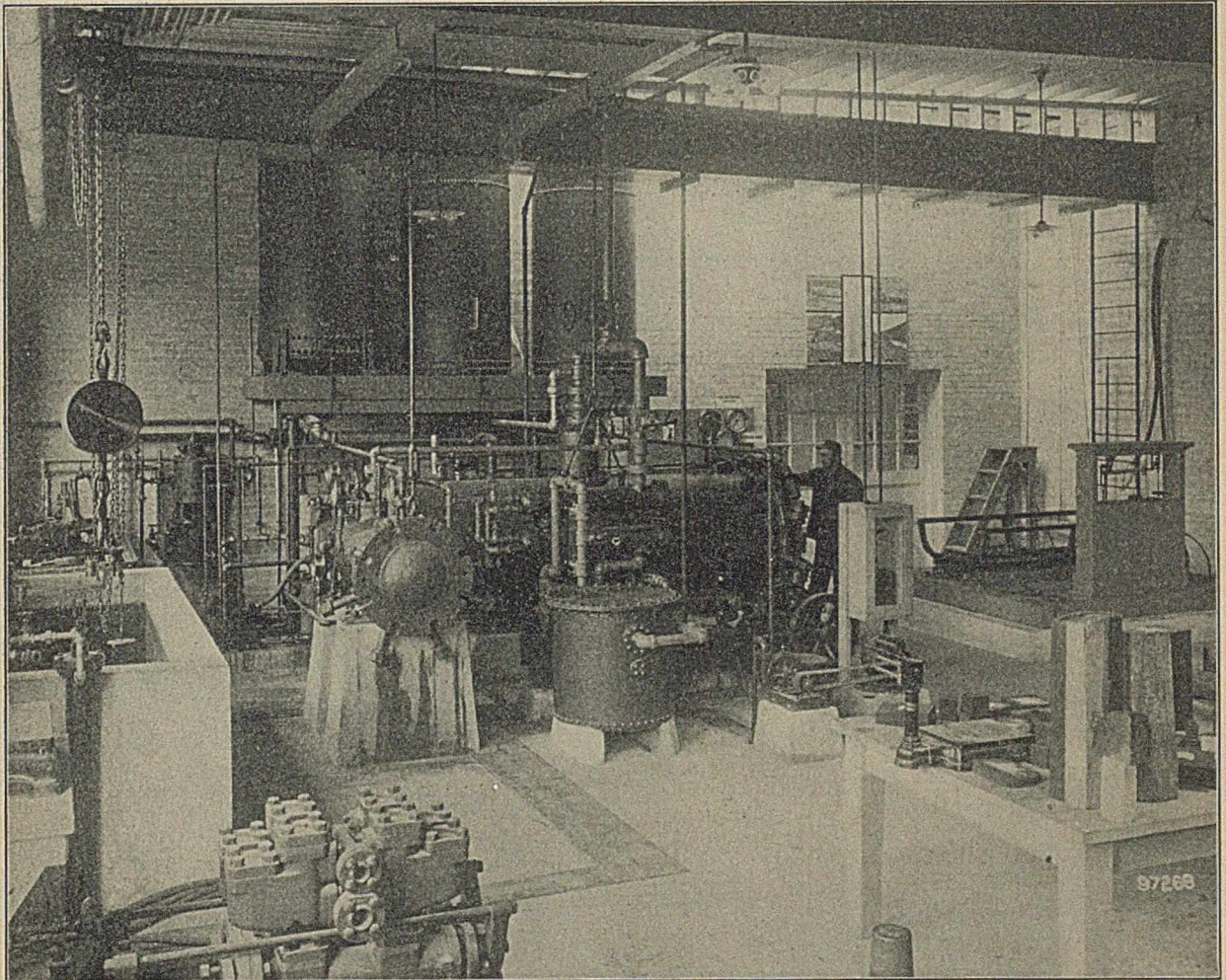


Fig. 7.—Wood Preservation Laboratory, showing experimental cylinders and measuring tanks.

woods not being used at present, and to conduct experiments for the purpose of perfecting present methods of manufacturing wood pulp. Especial attention will be given in this work to the development of methods of manufacturing a commercial pulp from wood which is at present being wasted.

#### 9. Production of naval stores:

Methods employed in the production of turpentine and rosin are also studied by the laboratory. Work of this character is confined to the chipping of the trees, the collection of the gum, and the distillation of the resin secured. The present methods employed in the production of naval stores are crude

- Wood Distillation.
- Pulp and Paper.
- Chemistry.
- Pathology.

These sections are responsible to the Director and to two Assistant Directors.

Figs. 3, 4, and 5 show the general arrangement of the laboratory and the storage yards; also the location of the different section laboratories and the arrangement of the offices. The descriptive keys dealing with each of these figures list the equipment of the different sections.

*Maintenance.*—The section of Maintenance is

charged with the general up-keep of the building and the purchase of all supplies and equipment. It also supervises the force maintained for handling computing work of a routine character and the section of stenography. It also has charge of the library and file room and the indexing and filing of all laboratory records.

*Engineering.*—The section of Engineering has charge of the storage yards, the sawmill, the wood shop, machine shop, and drafting-room. It is charged with the care of all materials stored in the yard, the design and repair of apparatus. Its work, however,

from the forests, and include the study of all the mechanical properties which determine the suitability of wood for different uses.

2. Tests to determine the effect of mechanical operative features of pressure wood-preserving plants on the strength of wood.

3. Tests to determine the mechanical efficiency of joints and fastenings used in wooden structures.

*Wood Preservation.*—The section of Wood Preservation studies the problems confronting the wood-preserving industry. These problems may be broadly classified into:

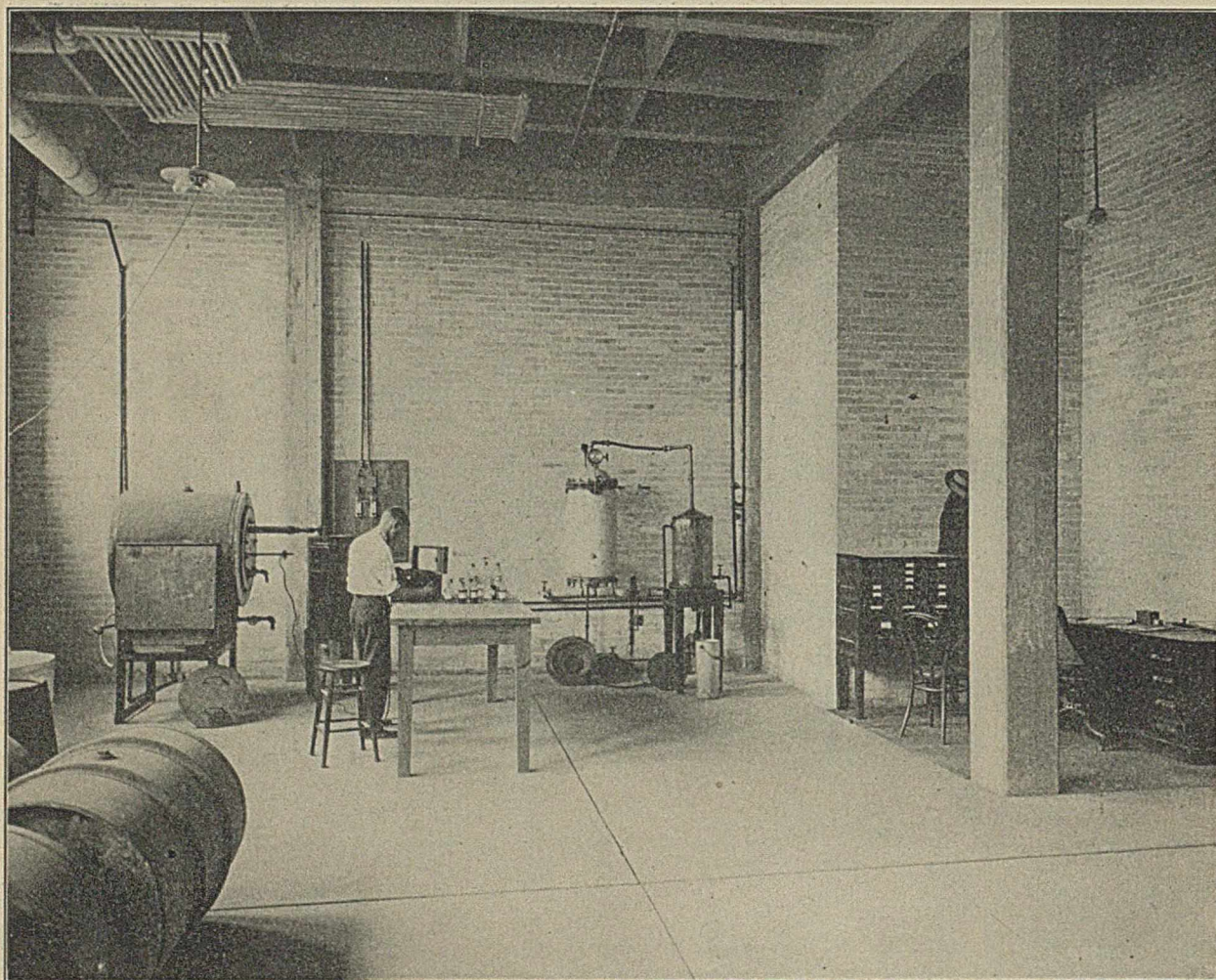


Fig. 8.—Wood Distillation Laboratory, showing experimental retorts for steam and destructive distillation.

is conducted in collaboration with the other sections of the laboratory.

*Timber Tests.*—Fig. 6 shows a general view of the timber-testing laboratory. This section conducts all tests to determine the mechanical properties of natural or treated wood. The following series of tests, which are under way at present, is representative of those conducted in the laboratory:

1. Tests to determine the relative mechanical properties of the commercial woods of the United States.

These tests are being made upon material secured

a. Those dealing with the preservatives themselves.

b. Those dealing with the methods of getting the preservatives into the woods.

To study the first class of problems, the laboratory is provided with a fungus pit which contains chambers thoroughly inoculated with various wood-destroying fungi. The humidity and temperature of the pit will be so regulated that conditions in it will be most favorable to the growth of fungi. Wood will be treated with different preservatives and placed in the pit. The efficiency of the preservative will be

determined by its ability to resist the fungi. In addition to such laboratory experiments, timbers are treated and placed in actual service and are carefully inspected at periodic intervals.

The second class of problems are primarily problems of mechanical engineering, dealing with the methods of forcing the required amounts of various preservatives into the different species and forms of wood. The laboratory is well equipped for studying any of the processes used for the preservative treatment of wood. Fig. 7 gives a general view of the laboratory. The storage tank in the yard is

track will be inspected and its condition reported from year to year by the staff of the laboratory.

2. The fungicidal properties of coal-tar creosote fractions.

These experiments are for the purpose of determining the relative efficiency of different fractions of coal-tar creosote in preventing decay. Specimens treated with the different fractions are also being placed in the waters of the Gulf of Mexico and the Bay of San Francisco to determine the relative efficiency of the different fractions in protecting yellow pine from marine bearers.

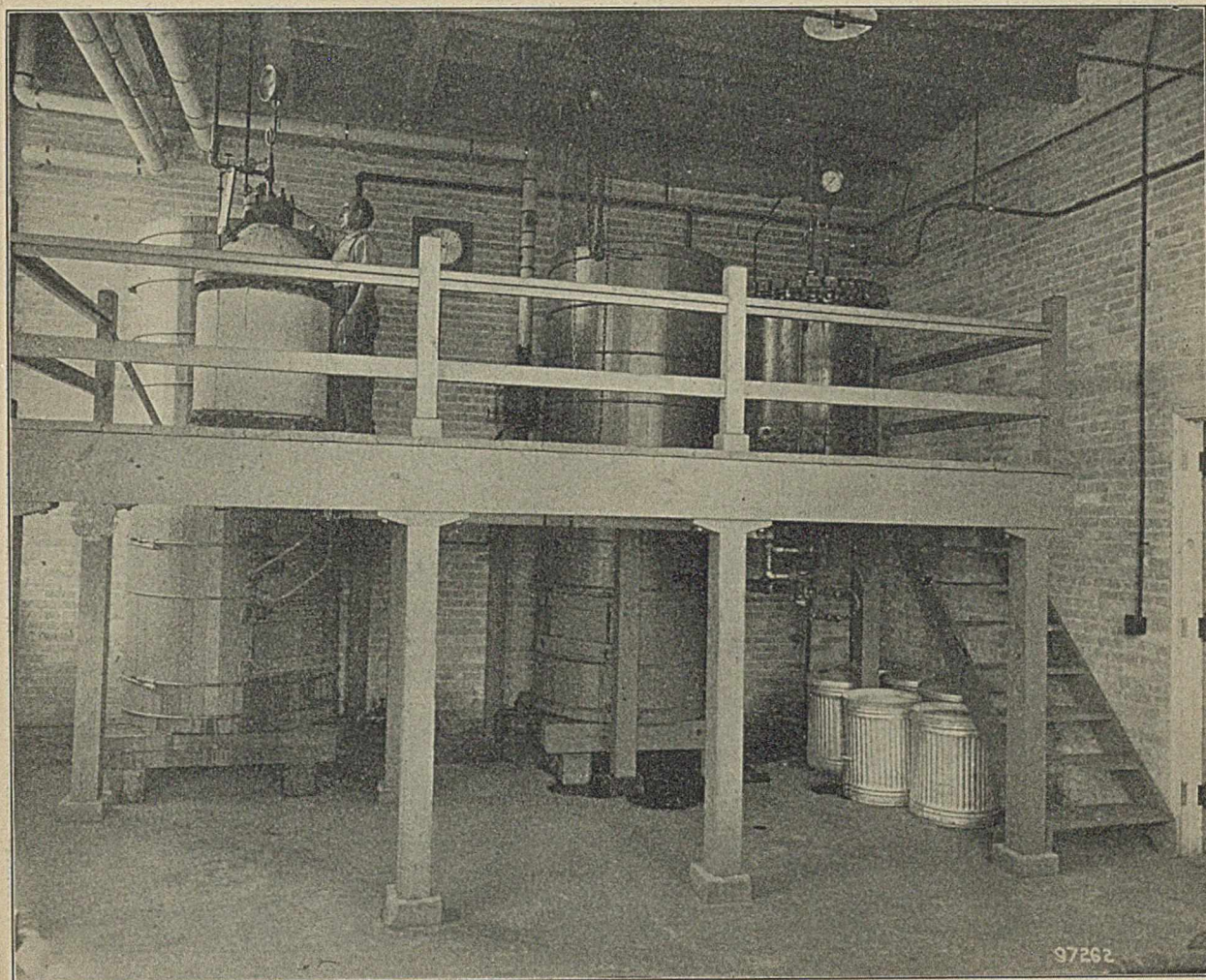


Fig. 9.—Digester Room, Pulp and Paper Laboratory, showing soda and sulphite digesters and blow pits.

sufficient in size to provide for a carload of any preservative. The general arrangement of the equipment of this laboratory may be seen by referring to Fig. 4. Typical projects at present under way are:

1. Service tests on red oak and maple cross ties, in cooperation with the Chicago, Milwaukee & St. Paul Railway Company, to determine the relative efficiency of standard preservatives and processes.

This work calls for the preservative treatment of approximately 1600 red oak and maple cross ties, which, after treatment, will be placed in a test track by the Chicago, Milwaukee & St. Paul Railway. The

3. The preservation of timbers used in the construction of silos.

*Wood Technology.*—In addition to the equipment shown on the laboratory plan, this section is provided with microscopes, microtomes, and other apparatus required for the study of wood structure. It is also equipped with taking photomicrographs. Work at present under way includes:

1. The correlation of microscopic structure of commercial woods with their properties and uses.

2. Temperature changes in wood under treatment. These experiments are designed principally to de-

termine the rapidity with which wood may be heated under different conditions.

3. The analytical study of artificial methods of drying wood.

These experiments will be conducted in an especially designed, steam-jacketed cylinder which is so connected with air pumps and sources of steam supply that a great variety of conditions can be secured.

*Distillation.*—Fig. 8 shows a general view of the distillation laboratory. This laboratory is at present equipped for studying both steam and destructive distillation processes. It is also equipped with a

c. Refining of the crude products.

At the present time the energies of the section are directed entirely to the study of resinous woods. The woods being first investigated are southern pine and Douglas fir.

*Pulp and Paper.*—Fig. 9 shows the experimental digesters and blow pits, while Fig. 10 shows the 15-inch Fourdrinier paper machine, and, in the background, washers, screens and other equipment of the laboratory. In addition to the equipment shown on the plans of the pulp and paper laboratory, the Forest Products Laboratory has just completed the installa-

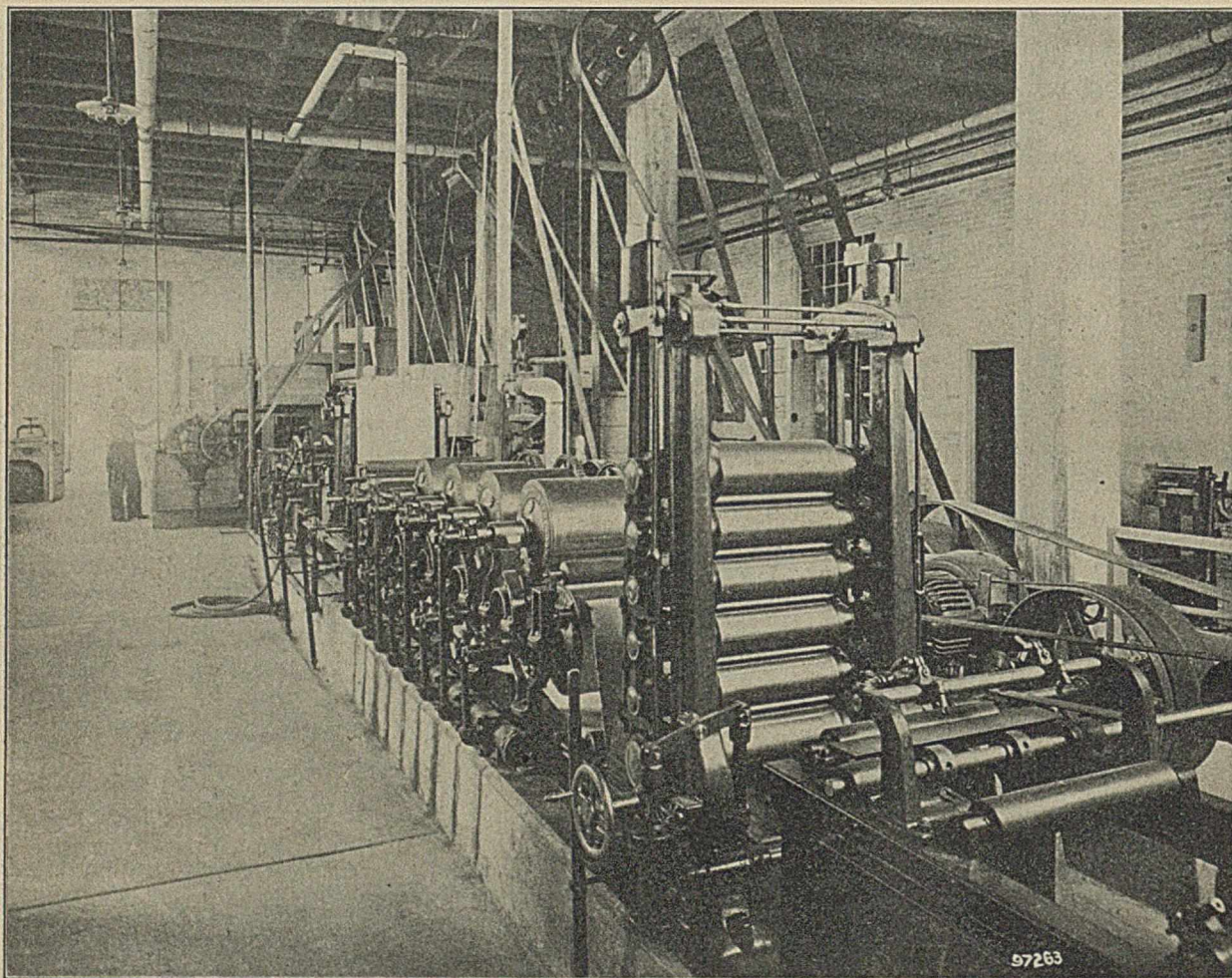


Fig. 10.—Pulp and Paper Laboratory, showing Fourdrinier paper machine, and, in the background, washers, screens, and other equipment.

fractionating column still which, at this time, is set up at the plant of the Atlantic Turpentine Company at Mount Pleasant, Georgia, where experiments are being conducted with it to determine the best method of commercially refining wood turpentine. The still is of such a capacity that materials can be handled on a commercial scale. The work of this section naturally divides itself into:

a. Experiments to determine what products and how much of them can be secured from different woods.

b. The design and operation of machinery best adapted to the production of those products having the greatest value.

tion of a ground-wood laboratory at Wausau, Wisconsin. The laboratory at Wausau is equipped with a heavy-duty commercial grinder connected with a 500 horse-power motor-generator set. It also contains screens, a wet machine, a barker, and other equipment necessary for the commercial manufacture of ground-wood pulp. The plant is so designed that the speed of the grinder can be varied through wide limits. Its chief purpose is to determine whether commercial ground-wood pulp can be made from woods other than spruce. The work at Wausau is being conducted under a special appropriation.

*Chemistry.*—Figs. 11 and 5 show the general arrange-

ment of the chemical laboratory and its equipment. The work of the section of Chemistry is largely to supplement the work of the other laboratories. Its purposes are:

a. To find uses for products at present having little or no commercial value.

b. To secure data upon which to base commercial specifications for wood products, wood preservatives, and other chemical problems that come up in connection with the work of the other sections.

Typical projects are:

1. The classification of commercial creosotes according to their chemical and physical properties.

treated in every respect as a member of the laboratory staff. An extensive collection of wood-destroying fungi is being made and cultures of them are being propagated in the fungus pit of the wood-preserving laboratory. The section of Pathology coöperates with the laboratory in conducting this class of work.

*How It Works—Internal Relations.*—The preceding part of this paper, it is hoped, has given the reader a fair conception of the purpose of the laboratory, its field of work, and its material resources. Its success, however, must depend largely upon the personnel of the organization and upon the ability of the different men composing it to work together in a manner

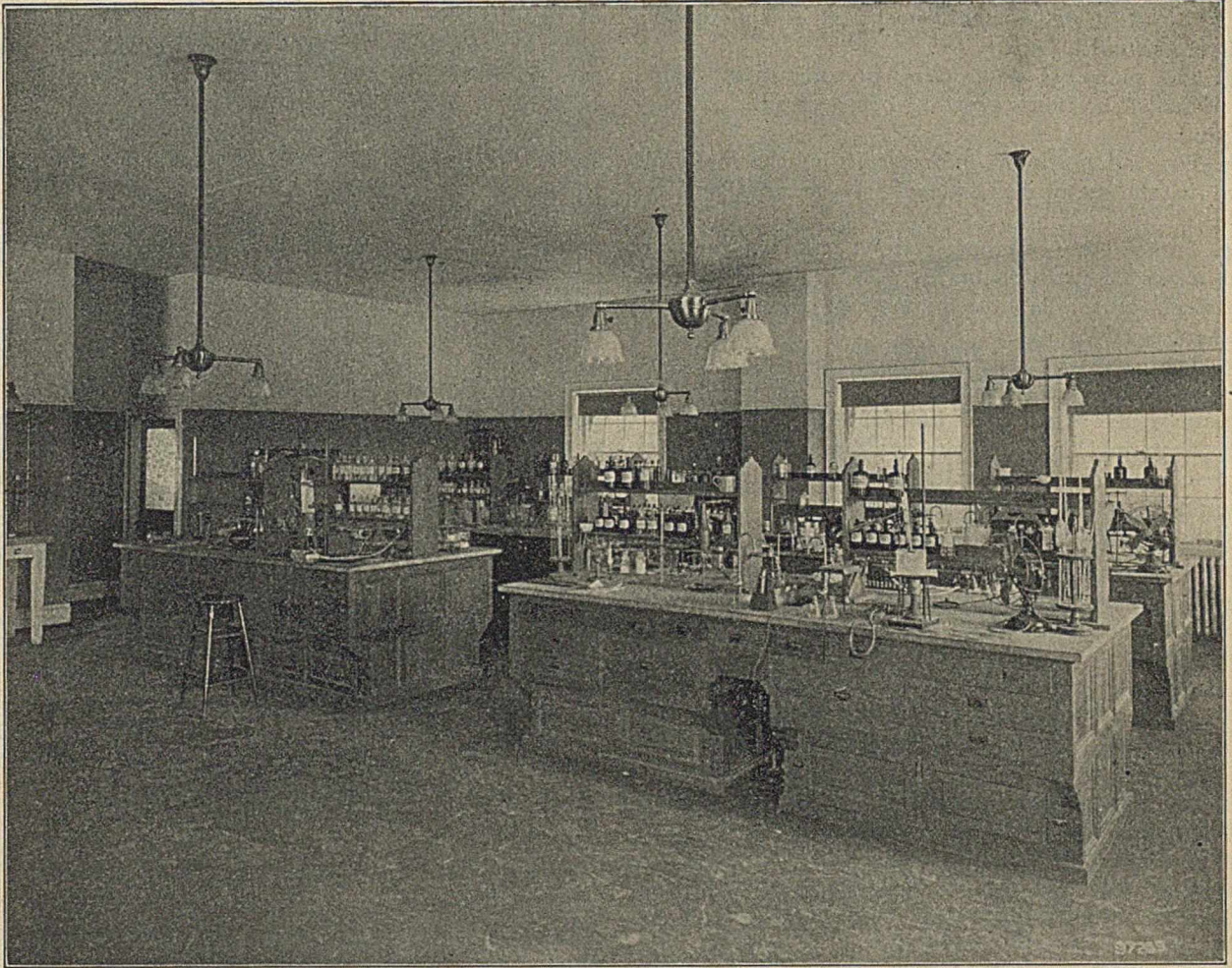


Fig. 11.—Chemical Laboratory.

2. Experiments to determine the quantity and quality of tannin in various kinds of wood and bark.

3. Methods of analyzing treated wood to determine the kind and quantity of preservative in it.

*Pathology.*—As previously stated, the section of Pathology is not, correctly speaking, a section of the Forest Products Laboratory, since its work is under the direction of the Bureau of Plant Industry. The man detailed to the laboratory, however, gives his full time to the study of pathological problems bearing on the use of wood. The Forest Products Laboratory supplies him with facilities for work and he is

which will insure coöperation on the part of the different sections and the proper coördination of their work.

The entire staff of the laboratory, consisting of approximately sixty people, is employed in accordance with the regulations of the United States Civil Service Commission. The men are recruited from the professions of engineering, chemistry, forestry, and pathology, also from the different grades of clerks and skilled laborers. A large percentage of the staff are young and comparatively inexperienced, this condition being due chiefly to the newness of the

work and to the loss of experienced men to commercial interests. It is therefore necessary to have the staff so organized that new material will be trained as soon as possible by the more experienced men of the organization, and that plans of work and records of experiments shall be made and kept in such a way that, with a reasonable amount of study, the work of any man can be taken up and completed by another with the least loss of time and money. With this in view, the following principles are closely adhered to:

1. Each investigator must have a clear conception of the purpose and value of his investigation and the methods which he intends to follow in conducting it, and that he make such conceptions and methods a matter of record.

2. The plans for conducting investigations should be perfected, so far as possible, before work is actually begun.

3. That all pertinent information on the materials used in the experiments should be secured and recorded.

4. That in the different sections standard methods and terms be used, so far as possible, in order that the work of the laboratory may be coördinated to the best of advantage.

5. That frequent partial summaries and analyses of results be made so that plans may be modified, if necessary, before the work has proceeded too far.

6. That final and complete summaries and analyses of results be embodied in a report which shall be a permanent record of the work.

To facilitate the application of these principles and to insure the publication of results as soon as possible, the experimental work of the laboratory is classified into projects. A project may consist of a series of tests or experiments conducted

- (a) For the purpose of investigating some specific problem on experimental research;

- (b) To verify experimental results on a commercial scale;

- (c) To assist outside parties in the application of scientific principles and processes of recognized commercial value with which the laboratory is familiar.

Projects may be conducted independently by the laboratory or in coöperation with an individual or commercial of other organization.

Each project is assigned to a member of the staff who is responsible for taking the initiative in all matters pertaining to it. In general, such an assignment involves:

1. A preliminary investigation: This work embraces a review of literature and results which have been secured by previous investigators, also frequently tentative experiments to ascertain the best methods of attacking a problem. The results of a preliminary investigation are summarized in a written report, which sometimes is made the basis of a publication.

2. Working plan: If the preliminary investigation shows the need of further work, a working plan is prepared. This plan records the purpose of the work, gives instructions for collection of material

required and the methods which it is proposed to follow in conducting the work.

3. Description of material: If the working plan is approved, the materials called for are secured and a record made of their origin and history.

4. Progress reports: From time to time as work on a project progresses, the man in charge of it prepares project reports containing summaries and analyses of results secured, in order to determine whether it is necessary to make modifications in the working plan.

5. Project report: When all the data called for by any plan are obtained, the man in charge of a project prepares a final report, giving a full discussion of results and conclusions reached. Project reports are the bases for most of the circulars and bulletins published by the Department, dealing with the work of the laboratory.

In order to give the fullest opportunity for constructive criticism, all working plans are submitted to one of the technical committees with which the staff is organized, each committee being composed of the members of the staff most experienced in the lines of work referred to it for consideration. Committee work of this character has precedence over all other work of the laboratory. After review by the committee, to give further opportunity for constructive criticism, and to keep the different members of the staff informed on all of the work of the laboratory, working plans are presented and discussed at the general staff meetings which are held each Saturday. All men in charge of important lines of work attend the general staff meetings. After full opportunity has been given for discussion, all plans are submitted to a committee composed of the director and two assistant directors for approval. Results of preliminary investigation, progress on various projects, inspection trips, and other matters of general and technical interest are discussed at the staff meetings.

Once a month seminar meetings, open to the entire technical staff of the laboratory, are held, at which the technical literature relating to the work of the laboratory is reviewed, and technical papers are presented.

*Relations to Societies and Associations.*—It is the constant aim of the laboratory to relate itself closely to the activities of societies and associations interested in its work, and to make such relations of mutual advantage. With this in view, members of the staff are encouraged to become members of the organizations of this character in which they are most interested, and when they are honored by committee assignments, it is the policy of the laboratory to do everything possible in making such service of value to the society or association and a credit to the Forest Service. Such coöperation is not limited to the organizations represented on the laboratory staff, but is extended to all societies and associations which may wish to use the resources of the laboratory.

*Relation to Individuals and Commercial Organizations.*—As stated in the first pages of this paper, one of the chief purposes of the Forest Products Lab-



oratory is to serve as a public bureau of information on the field of work which it covers, but it is not the policy of the Forest Service, aside from making available information which it has, to undertake work of any kind which is not of general interest to the lumbering or to one of the wood-using industries. It is frequently the case, however, that a problem confronting a commercial organization is one of general interest, and is also one in which the laboratory is interested. In such cases it is the policy of the Service to cooperate with the commercial organizations, the cooperating organization sharing the expense of the investigation in proportion to the direct benefits which result to it from the work done. Cooperation of this character varies from cases in which the coöperator merely furnishes a part of the material required for the work, to cases in which the entire expense of the work is borne by the cooperating company, the laboratory merely supplying the men to supervise the work. In all coöperative work of this character the Department of Agriculture reserves the right to first publish the results.

The possible value of the Forest Products Laboratory to the lumbering and wood-using industries will be readily recognized by all who are familiar with the problems confronting these industries. The actual value of the laboratory, however, depends upon its ability to obtain results of practical value. To secure such results to the best advantage it must have the support and coöperation of the men who are in constant and intimate association with commercial problems. The Service therefore invites such men to share with it the responsibility of making the Forest Products Laboratory play an important and useful part in reclaiming the wastes of the forests and in increasing efficiency in the commercial use of wood.

[CONTRIBUTION FROM THE LABORATORY OF SOIL FERTILITY INVESTIGATIONS.]

### OXIDATION IN SOIL.<sup>1</sup>

By M. X. SULLIVAN AND F. R. REID.

The advantage of aerating soils has long been known and is well recognized in the practice of tillage of the soil. Liebig<sup>2</sup> early pointed out the importance of a thorough aeration of soils. The phenomena of oxygen absorption by soils likewise early attracted attention. According to Liebig,<sup>3</sup> Ingenhous and DeSaussure found that vegetable mold extracted oxygen from air with great rapidity and replaced it by an equal volume of carbonic acid. Dehérain and Demoussy<sup>4</sup> considerably later studied the process of oxygen absorption in several soils and found that oxygen was always taken up and carbon dioxide set free. In their method the soils were placed in a closed tube kept at constant temperature and after a certain time the gases were extracted and the carbon dioxide and oxygen determined. The carbon dioxide formed was taken as a measure of oxidation.

The oxidation was attributed by them to the action of microorganisms and to simple chemical action. Both kinds of oxidation increase with heat. Up to 65° C. the carbon dioxide increased. From 65° to 90° it decreased. Above 90° there was another increase in carbon dioxide. At 110° over six times as much carbon dioxide was formed as at 65° C. Some oxidation went on at 22° C. in soils which had been heated at 120° C. for one hour. Often more oxygen was consumed than could be accounted for in carbon dioxide formed.

Wollny<sup>1</sup> studied the rate of oxidation by determining the amount of carbon dioxide produced in a given time at a constant temperature. He concluded that the oxidation is due mainly to the activity of microorganisms. Lime favored oxidation. Chlorides and sulphates retarded while phosphates and nitrates favored.

More recently still Russell<sup>2</sup> studied oxidation by estimating the oxygen absorbed by soils. He found that the same factors which influence fertility also influence the rate of oxidation and apparently to the same extent, that oxidation was greater in fertile soils than in infertile soils, in surface soil than in subsoil. With different soils of the same type the rate of oxidation varies in the same way as the fertility and may be used to measure it. Pasture soils, however, are excluded. Russell suggests that the oxygen absorbed measures the total action of microorganisms which by producing enzymes, etc., hasten decomposition.

As shown by Russell, the assumption that the evolution of carbon dioxide is proportional to the amount of oxygen absorbed is not proved. Many soils, as is well known, have a great power of absorbing carbon dioxide. Russell's method of measuring the amount of oxygen absorbed is a very good method, but requires a somewhat complex apparatus, takes considerable time to show differences in soils and marks respiration of microorganisms as much as oxidative changes in the soil constituents. A simpler test of oxidative processes in soils we have found in the changes produced in easily oxidizable substances brought in contact with the soil, such as aloin, pyrogallol, hydroquinone, paraphenylenediamine, benzidine, guaiac, *α*-naphthylamine, which speedily show oxidative processes and have been used extensively as a test of such processes. By means of these easily oxidizable chromogenic substances the plant roots have been shown to have a strong oxidative power.<sup>3</sup> This power was found to be affected by agencies which affected soil fertility, such as fertilizer salts, toxic substances, etc., and was shown to have a considerable agricultural interest in that it could affect alteration in the soil constituents and thus influence soil fertility, especially in connection with fertilizers and a system of crop rotation. Microorganisms which abound in soil likewise have been found capable of bringing about powerful oxidation

<sup>1</sup> Published by permission of the Secretary of Agriculture.

<sup>2</sup> Liebig's "Complete Works on Chemistry," p. 44, 1852.

<sup>3</sup> *Ibid.*, p. 113.

<sup>4</sup> *Ann. Agron.*, 22, 305 (1896).

<sup>1</sup> "Die Zersetzung der organ. Stoffe. und die Humusbildungen," Heidelberg, 1897.

<sup>2</sup> *Jour. Agric. Sci.*, 1, 261 (1905-6).

<sup>3</sup> Schreiner and Reid, *Bot. Gaz.*, 47, 355 (1909).

of substances in the medium in which they grow.

The oxidizing principles, be they enzymes or other bodies, were found in water in which the roots of growing seedlings had stood for twenty-four hours. Woods<sup>1</sup> has reported that the oxidizing enzymes may remain in soil for a considerable time. So it should be expected that, by the disintegration of microorganisms and plant roots, the material which brings about oxidation should be left in soil. In addition the soil *per se* should have, *a priori*, an oxidizing power due to inorganic oxygen carriers like salts of iron and manganese and probably to organic matter in an unstable, highly oxygenated state analogous to quinone, benzaldehyde, terpene bodies, or organic peroxides, which might readily give up oxygen in an active state or activate the oxygen of the air.

In passing, it may be said that absorption of oxygen by a soil and the oxidation of readily oxidizable substances, such as the chromogens mentioned, by the soil are not necessarily the same phenomenon. In fact, the two methods might be employed together with advantage in the study of different phases of soil oxidation.

Of the reagents employed to test the oxidizing power of the soil, a water solution of aloin was found to be best. The results with this and various other reagents are given in the following table:

TABLE I.—OXIDATION IN SOILS.

Soils.	Reagents.								
	Guaiaic.	Guaiaic + H <sub>2</sub> O <sub>2</sub> .	Aloin.	Aloin + H <sub>2</sub> O <sub>2</sub> .	Hydroquinone.	Hydroquinone + H <sub>2</sub> O <sub>2</sub> .	Pyrogallol.	Pyrogallol + H <sub>2</sub> O <sub>2</sub> .	Paraphenylenediamine + H <sub>2</sub> O <sub>2</sub> .
1. Clarksville loam.....	+	++	+	+	+ sl	++	+	++	+
2. Takoma lawn soil.....	—	—	—	—	—	—	—	?	?
3. Marshall clay loam.....	—	—	—	—	—	—	—	?	—
4. Volusia silt loam.....	—	—	—	—	—	—	—	?	?
5. Arlington clay loam.....	+ sl	+ sl	+ sl	+ sl	—	—	+	+	?
6. Hagerstown loam in sod.....	+	++	+	+	+ sl	++	+	++	+
7. Hagerstown loam.....	+	++	+	+	—	+	+	++	+
8. Hagerstown loam + lime.....	+	++	+ sl	+	—	++	+ sl	++	+
9. Hagerstown loam + lime + manure.....	+	++	+ sl	+	—	++	+ sl	++	+
10. Hagerstown loam + complete fertilizer.....	+	++	+	+	—	+	+	++	+
11. Hagerstown loam + manure.....	+	++	+	+	—	?	+	++	+
12. Norfolk fine sandy loam.....	—	—	—	—	—	—	—	—	—
13. Cecil fine sandy loam.....	—	—	—	—	—	+	+	—	?
14. Leonardtown loam.....	—	—	—	—	—	—	—	—	—
15. Dekalb silt loam.....	+	+	+	+	—	+ sl	+	+	+
16. Duchess silt loam.....	—	—	—	—	—	—	—	—	—
17. Sassafras silt loam.....	+ sl	+ sl	+ sl	+ sl	—	—	—	—	—
18. Orangeburg loam.....	+	+	+	+	—	+	+	+	+

In the experiments given in Table I, ten grams of soil were shaken in test tubes with 25 cc. of two per cent. alcoholic guaiac; 0.125 per cent. water aloin; 0.5 per cent. pyrogallol and hydroquinone. When hydrogen peroxide was added, it was to the extent of 0.5 cc. of a 3 per cent. solution to each tube. In case of testing with paraphenylenediamine, 25 cc. of a solution of a 2 per cent. solution of paraphenylenediamine plus 0.2 per cent. hydrogen peroxide, containing 1 cc. of concentrated sulphuric acid to the liter, were shaken with the soil. When oxidized the reagent develops a blue-black color. The control

<sup>1</sup> *Centralbl. f. Bakt.*, II, 5, 745 (1899).

solution oxidized so readily, however, that it was not considered a good medium for testing oxidation and was regarded as too sensitive for differential work.

As regards the significance of the oxidation as given in the preceding pages, it may be said that soils known to have good productive power had strong oxidative power, as a rule, and that the poorer soils had little or no oxidative power. The oxidative power and productivity, however, do not necessarily agree, since we have found soils of slight oxidative power which have given the better growth as compared with soils of stronger oxidizing power. Crop production, as is well known, is dependent upon many factors, no one of which can be taken as an absolute criterion. As will be shown later, however, certain factors which favor productiveness of soils favor oxidation, so the study of oxidation in soil has considerable value in relation to soil fertility.

#### METHOD OF TESTING OXIDATION IN SOIL.

Since aloin dissolved in water proved to be the best medium for testing oxidation, a water solution of aloin, generally of a strength of 0.125 per cent., was employed in the further study of oxidation in soil. As a rule, 20 grams of soil were shaken four or five times in the course of an hour with 50 cc. of the aloin solution and allowed to settle; then the mixture

was treated with 50 cc. of 95 per cent. alcohol to flocculate the soil and to extract the oxidized aloin. If the oxidized aloin solution was fairly clear, the alcohol was dispensed with. The solution was then centrifuged, the supernatant liquid poured off and the depth of color in the solution compared by means of a colorimeter. The experiments from the time of adding the aloin to the soil to the reading in the colorimeter ran, as a rule, from two to three hours.

#### EFFECT OF VARIOUS TREATMENTS ON SOIL OXIDATION.

*Poisons and Antiseptics.*—Reducing agents like hydroxylamine hydrochloride, oxalic acid, sodium

thiosulphate, and formalin totally check the oxidation by soils. Mercuric chloride, silver nitrate, and carbon bisulphide had little retarding action on the oxidation and sometimes even increased it, though of themselves these antienzymotic substances have no effect on aloin within the time of the experiment. Though the soil by its absorbing and combining powers renders toxic agents less effective than they would be in solution, the fact that oxidation goes on in the presence of comparatively strong solutions of mercuric chloride, 5 cc. of a 1 per cent. solution to 20 grams of soil, silver nitrate, 5 cc. of a 1 per cent. solution to 20 grams of soil, and carbon bisulphide, 2 cc. of a 100 per cent. solution to 20 grams of soil, would indicate, contrary to our expectation, that little if any of the oxidizing action of the soils tested can be attributed to enzymes, though in other soils or under other conditions it may be possible that the oxidizing enzymes play a considerable rôle.

*Dry Heat.*—Several soils which showed a strong oxidation toward aloin were heated one and one-half hours at 105° C. dry heat and after cooling were shaken with the aloin solution. The oxidation of the aloin was reduced considerably by heating in the case of most of the soils tested. In some cases, especially in the Hagerstown loam, the heated soils gave such a different shade of color with so much of the original yellow of the aloin solution, that their oxidative power could not be compared accurately with that of the normal soil. As read by means of the colorimeter, the comparative oxidation was judged to be as follows: Clarksville loam, unheated 100, heated 100; Orangeburg loam, unheated 100, heated 111; Sassafras silt loam, unheated 100, heated no oxidation; Arlington clay loam, unheated 100 (slight), heated no oxidation; Hagerstown loam, unheated 100, heated 66; Hagerstown loam (manured), unheated, 100, heated 45; Hagerstown loam plus complete fertilizers, unheated 100, heated 66.

*Steam Heat.*—Heating the soils for one and two hours, respectively, in an Arnold steam sterilizer lessened oxidation in most soils but had no retarding effect on Orangeburg loam. The relative oxidations of the unsteamed and steamed soils are given in the following table:

TABLE II.—EFFECT OF STEAM HEAT ON THE OXIDATIVE POWER OF SOILS.

	Unsteamed.	Steamed	
		1 hour.	2 hours.
Hagerstown loam.....	100	65	faint
Hagerstown loam manured.....	100	52	faint
Hagerstown loam plus complete fertilizer.....	100	34	faint
Sassafras silt loam.....	100 sl	neg.	neg.
Arlington clay loam.....	100 sl	neg.	neg.
Clarksville silt loam.....	100	54	faint
Orangeburg loam.....	100	104	105

Heat is a more effective inhibitor of the oxidative power of the soil than are the powerful anti-enzymotic substances such as mercuric chloride, silver nitrate, and carbon bisulphide. As compared to heat, these reagents retard oxidation but little and in some soils silver nitrate and carbon bisulphide even increase oxidation. Accordingly it is to be judged that the effect of heat on oxidation by soils

is due to its effect on the soil ingredients and especially on the organic matter or some inorganic-organic complexes of the soil since steam heating for two hours would affect strictly inorganic salts destructively but little, if at all. The organic matter of the soil, however, is known to undergo considerable modification at the temperature of 100° C.<sup>1</sup>

*Incineration.*—When various soils which had a strong oxidative power toward aloin were incinerated the oxidative power was lost.

*Acids on Incinerated Soils.*—The addition of mineral acids such as hydrochloric and sulphuric had little effect in restoring the oxidative power of these soils. Acetic acid had a slight restoring effect. The organic hydroxyacids, on the other hand, greatly restored the oxidative power of the incinerated soils. Taking the Hagerstown loam plus acetic acid as 100, the comparative effect of the organic acids added to the incinerated soils is shown in the following table:

TABLE III.—EFFECT OF ORGANIC ACIDS ON THE OXIDATIVE POWER OF INCINERATED SOILS.

Soils.	Acetic.	Glycolic.	Malic.	Citric.
Hagerstown loam, manured.....	100	184	180	223
Hagerstown loam, complete fertilizer.....	100	184	180	223
Hagerstown loam.....	100	172	192	238

It would seem from the preceding table that the organic hydroxyacids are more effective in restoring the oxidative function of incinerated soils than are non-hydroxyacids or the mineral acids. Of the hydroxyacids tried, citric acid was the most effective in renewing the oxidative power of the incinerated soil.

*Acids on Normal Soils.* In a similar way the hydroxyacids added to normal soils tended to increase the oxidative power while related non-hydroxyacids had little effect on oxidation. Thus acetic acid slightly retarded or but little increased oxidation, while the related hydroxyacid, glycolic, increased oxidation to a great degree; succinic acid had little effect on oxidation or retarded it, while the related hydroxyacids, malic and tartaric, greatly increased oxidation; citraconic, itaconic, and mesaconic acids had little effect on oxidation in soil, while the related hydroxyacid, citric, greatly increased oxidation. Of the hydroxyacids, citric is somewhat the greater activator.

In some soils sodium citrate and tartrate were greater stimulators of oxidation than were equivalent quantities of the free acids. In every case, citric acid and sodium citrate increased oxidation more than tartaric acid or sodium tartrate. Dihydroxystearic acid slightly reduced oxidation in soil, while the potassium and calcium salts slightly increased it.

#### INFLUENCE OF VARIOUS SALTS WITH AND WITHOUT CERTAIN ORGANIC ACIDS AND THEIR SALTS.

Various salts of manganese, iron, aluminum, calcium, and magnesium have a greater or less oxidative action on a water solution of aloin. Accordingly, manganese in the form of the sulphate, chloride,

<sup>1</sup> See in this connection Lyon and Bizzell, *Bull.* 275, Cornell Univ. Agr. Exp. Sta. (1910).

carbonate and dioxide, iron as ferric chloride, aluminum as the oxide and the hydrate, calcium as carbonate, and magnesium as carbonate were added to various soils in the ratio of 100 parts of the metal to one million of soil, with and without the presence of organic acids and their salts. Manganese dioxide increased the oxidative power of the soils somewhat. All the other salts had little effect on the oxidative power of the soil, except in the presence of glycolic, tartaric, malic, and citric acids, and sodium citrate and tartrate. The best oxidation occurred in soils to which manganese and citric acid had been added.

Whether or not the oxidizing principle in the soil is manganese or other salts which are activated by the organic hydroxyacids in the incinerated soils and are rendered more effective in the normal soil, it seems most probable that the oxidizing power of the soil is due not to enzymes, but to a combination of inorganic constituents with definite kinds of organic matter. Since true enzymes readily undergo decomposition in solution, we should expect them to undergo decomposition readily in the soil.

#### INFLUENCE OF VARIOUS FACTORS IN SOIL OXIDATION.

*Water Content.*—The oxidation by the soils at optimum moisture is always considerably greater than that of the soils in air-dried condition.

*Surface Soil Compared with Subsoil.*—Of twenty-two soils which had more or less power to oxidize aloin, samples of the corresponding subsoils were tested. Of these subsoils, sixteen possessed no oxidizing power, three oxidized the aloin to a slight degree, two oxidized the aloin more than the soil did, and one equaled the oxidizing power of the soil.

*Effect of Cropping.*—The effect of cropping on soil oxidation is variable.

*Effect of Fertilizing and Cropping.*—To test the effect of fertilizing and cropping, wheat was planted in the various soils and allowed to grow for seventeen days. If the oxidative power of the fertilized and planted soil is determined immediately after the crop is removed, the planted soils tend to give a turbid solution and the comparative oxidizing power of the soils cannot be measured. If, however, the oxidative test be made ten to fifteen days after the crop was removed, the fertilized and planted soils show the greater oxidative power.

*Effect of Fertilizers.*—Numerous experiments have been made on the effect of fertilizers on the oxidative power of soils with results that show that the fertilizers sometimes increase oxidation, sometimes decrease it, and that the effects of the fertilizers are different in the different soils.

The action of the fertilizing salts must be attributed to the effect they have on the microorganisms of the soil, modifying their numbers and activities with a resulting modification of biochemical activities and a resulting change in both the amount and the condition of inorganic and organic soil constituents or directly on the soil constituents, especially in the organic matter which is undergoing change by auto-oxidation, or as a result of the activity of microorganisms. In short, the fertilizers added to soil or

present in soils do work and bring about various changes, one of which is made manifest by the changed oxidative power.

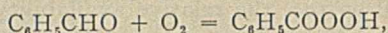
#### THE RELATION OF ORGANIC MATTER TO SOIL OXIDATION.

Oxidation in soils is undoubtedly due to various factors and is dependent not only on the inorganic constituents of the soil, but also on the organic matter. In the case of the Hagerstown loam, the manured soil had by far the best oxidizing power. With the unfertilized soil as 100, the plot which had received ten tons of stable manure to the acre was 136 and over. Decomposing cowpea vines added to sassafras silt loam increased the oxidizing power. When various soils were steam-heated or heated at 105° C. for an hour, the oxidative power was greatly lessened. This decrease in the oxidizing power we have found to be due mainly to changes in the organic matter. When the organic matter of the soil was destroyed by incineration, the oxidizing power was lost. The oxidative power of the soil is dependent on the nature of the organic matter. Thus, when salts of manganese, iron, calcium, magnesium, and aluminum were added to soil of slight oxidative power, oxidation was but slightly increased until certain kinds of organic matter were added, such as citric, malic, tartaric, glycolic acids, or their salts. These compounds we found had a reducing action, converting ferric compounds to ferrous compounds, and probably bring about the stimulation of the oxidative power of the bases mentioned by means of a preliminary reduction to lower, less oxygenated compounds, which, in turn reoxidizing themselves, activate the oxygen of the air. This active oxygen oxidizes other bodies such as organic material of the soil or aloin which is employed as a test of oxidation. It may be, too, that hydroxyacids affect the oxidative powers of complex organic substances or of inorganic-organic complexes.

Fresh plant juices have the power to oxidize aloin directly. On standing, this direct oxidizing power is often lost, either because of change in the reaction of the juices or because the oxidizing principles have undergone changes. After the loss of the direct oxidizing power, the plant juices as a rule have an indirect oxidizing power, that is, they can oxidize with the addition of hydrogen peroxide.

The addition of hydrogen peroxide increased the oxidizing action of some soils, decreased it in others. The peroxide increased the oxidative power of Takoma lawn soil and Cecil fine sandy loam which give no direct oxidation of aloin and decreased oxidation in Sassafras silt loam and Hagerstown loam, manured, which normally oxidize aloin directly. It is possible that the soils which normally give a direct oxidation of aloin contain both organic and inorganic peroxides. It is highly probable that soils rich in organic matter would contain organic peroxides, since such soils have been found by us to have the ability to absorb oxygen. Decomposing cowpea was found to have a strong oxidizing power on aloin, an oxidizing power which was not entirely destroyed in ten minutes'

heating on a steam bath or by carbon bisulphide. That organic bodies will form peroxides in the presence of air is shown by Baeyer and Villiger,<sup>1</sup> who showed that when benzaldehyde is oxidized by atmospheric oxygen, benzoyl peroxide is formed,



and by Ditz,<sup>2</sup> who found that ethyl ether in contact with air forms within itself more or less ethyl peroxide. This ethyl peroxide he found had a stronger oxidizing action than hydrogen peroxide.

Bach<sup>3</sup> concluded that the so-called oxidizing ferments in blood are simply readily oxidizable substances having a special aptitude for forming peroxides which oxidize other substances more difficult to oxidize.

Kastle and Loevenhart,<sup>4</sup> in discussing the nature of the oxidizing ferment of the potato, concludes that the so-called oxidizing ferment is in all probability not a true ferment, but an organic peroxide. They further conclude that oxidation phenomena occurring in plants and probably also in animals can be satisfactorily explained upon the supposition that the readily autoxidizable substances which they contain are oxidized to the peroxide condition by molecular oxygen and that the peroxides thus formed in turn give up part, if not all, of their oxygen to other less oxidizable substances present in the cell. In other words, the process of rendering oxygen active by the living cell is probably brought about in essentially the same way that this is accomplished by phosphorus, benzaldehyde, and other oxygen carriers, that is, it is one phase of autoxidation.

Peroxide-forming bodies, such as benzaldehyde and peroxides like quinone, have a strong oxidizing action on aloin, both in solution and in soil.

It is possible that, in the soil, complex autoxidizable substances are formed in the changes brought about by the action of microorganisms on plant debris, etc. These autoxidizable substances would combine with the oxygen of the air in much the same way that benzaldehyde does and would form complex, more or less unstable, peroxides which in turn would give up a part or all of their oxygen to oxidizable substances in contact with them or could further oxidize themselves.

The possibility of the formation of peroxides in soil even to excess is indicated by Sjollem and Hudig,<sup>5</sup> who found that oat-sick soils were restored to a good condition by manganese sulphate and suggested that oat-sickness may be due to the formation in the soil in the presence of excess of calcareous fertilizers and physiological alkaline fertilizers as nitrite of soda, of large amounts of peroxides injurious to plants. The favorable action of the manganese sulphate is due according to these investigators to the catalytic decomposition of such injurious peroxides.

#### THE EFFECT OF EXCESSIVE OXIDATION.

Whatever induces excessive oxidation in soil or

plant would undoubtedly be injurious. Thus Woods<sup>1</sup> found that excess of the oxidizing enzymes in plants destroyed the chlorophyll. Loew and Sawa<sup>2</sup> and Salomone<sup>3</sup> found that an excess of manganese sulphate added to soil decreased the growth of plants with a great increase of the oxidative power of the plant juices and according to Kastle and Elvove<sup>4</sup> strong oxidizing agents like nitrates, nitrobenzene, picric acid, chromates, chlorates, arsenates, organic peroxides and peracids are poisonous to life. In small amounts these substances may be stimulative to life functions. In a similar manner quinone, a strong oxidizer, is poisonous to plants such as wheat. Under normal conditions, as in the plant, the excessive formation of peroxide is prevented in some way, either by the further oxidation of the peroxides or by the catalytic or peroxide-splitting power of the soils. Most soils have this catalytic power to a greater or less degree and in general we have found that fertile soils have a greater catalytic power, as well as a greater oxidative power, than infertile soils. The relation between oxidation and catalysis is not as clear as it might be, even in the plant where it has been extensively studied.

According to Chodat,<sup>5</sup> the only property of the catalase of which we have certain knowledge is its power to decompose hydrogen peroxide to water and molecular oxygen. According to Loew,<sup>6</sup> Hertlitzka,<sup>7</sup> Battelli and Stearn,<sup>8</sup> and Shaffer,<sup>9</sup> on the other hand, the catalase of plants has a protective influence against excessive oxidation. The catalytic power of the soil may in time be shown to have a similar action in promoting normal oxidation in soils and like oxidation may be connected with soil conditions adapted to the growth of the majority of plants.

In the study of oxidation in soils, we have found that most soils will directly oxidize substances in the manner of an oxidase, while a few will oxidize only in the presence of hydrogen peroxide, like the peroxidase reaction in plants and animals. The addition of certain organic hydroxy acids increases oxidation in soils in a way analogous to the activating action of alfalfa laccase and salts of hydroxyacids as discovered by Euler and Bolin.<sup>10</sup> Dilute mineral acids and alkalis check oxidation in soils as they do the oxidation by plant roots or plant juices. The addition of various salts to soils increases the oxidizing power of soil just as Bach<sup>11</sup> found mineral salts further oxidation changes of tyrosine by tyrosinase. Again, most soils have more or less catalytic power. In short, it would be found undoubtedly that all the

<sup>1</sup> *Loc. cit.*

<sup>2</sup> *Bull. Coll. Agr., Tokyo*, **5**, 161 (1902-3).

<sup>3</sup> *Le Staz. Sper. Agr. Ital.*, **38**, 1015 (1905); **40**, 97 (1907). In connection with the excess of manganese in soil and soil oxidation see also Kelley, Hawaii Sta. Press, *Bull.*, **23**; *THIS JOURNAL*, **1**, 533 (1909); Guthrie and Cohen, *Agr. Gazette of New South Wales*, **21**, 219 (1910).

<sup>4</sup> *Am. Chem. Jour.*, **31**, 195 (1904).

<sup>5</sup> *Schweiz. Wochenschr. Chem. u. Pharm.*, **43**, 626, 642, 655 (1905).

<sup>6</sup> *Report* **68**, U. S. Dept. Agr. (1901).

<sup>7</sup> *Rend. Sci. Fis. Mat. et Nat. Real. Acad. Lincei*, **16**, Series 5, Part 2, 473 (1907).

<sup>8</sup> *Compt. rend.*, **141**, 1044 (1905).

<sup>9</sup> *Am. Jour. Physiol.*, **14**, 299 (1905).

<sup>10</sup> *Z. physiol. Chem.*, **57**, 80 (1908); *Z. phys. Chem.*, **69**, 187 (1909).

<sup>11</sup> *Ber. chem. Ges.*, **43**, 364 (1910).

<sup>1</sup> *B. deutsch. chem. Ges.*, **33**, 1569 (1900).

<sup>2</sup> *Chem.-Zig.*, **29**, 705 (1905).

<sup>3</sup> *Compt. rend.*, **124**, 951 (1897).

<sup>4</sup> *Am. Chem. Jour.*, **26**, 539 (1901).

<sup>5</sup> *Expt. Sta. Record*, **21**, 115 (1909).

various kinds of oxidation going on in plants and animals could be duplicated by a detailed study of oxidation in soil. The oxidation in soil *per se* is due mainly to non-enzymotic forces, inorganic and organic, working separately, conjointly, or in reinforcing or activating combination. In soil oxidation the nature of the organic matters seems to be of great importance. Conjointly with the oxidation in soils which is active whether the soil is planted or unplanted is the oxidizing power of the roots.

#### CONCLUSIONS.

1. Soils have the power to oxidize aloin.
2. This oxidizing power is increased by adding water to optimum moisture, by the commonly used fertilizers in conjunction with plant growth, by salts of manganese, iron, aluminum, calcium, and magnesium, in the presence of simple organic hydroxy-acids.
3. Oxidation in soil is comparable to oxidation in plants and animals.
4. The oxidative power of the soil appear to be mainly non-enzymotic, the results of interaction between inorganic constituents and certain types of organic matter. It may be brought about by organic matter in a state of autoxidation and by inorganic oxygen carriers such as manganese and iron.
5. Oxidation is greater in the soil than in the sub-soil.
6. Oxidation is greater in fertile soils than in infertile soils.

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### THE USE OF NITRATE OF SODA IN COMMERCIAL FERTILIZERS.

By CHARLES S. CATHCART.  
Received November 1, 1910.

The value of a commercial fertilizer is measured by its content and form of nitrogen, phosphoric acid and potash. In order to determine this value with any degree of accuracy, it is the practice of the chemists connected with the fertilizer inspections of the several States to ascertain the amount of nitrogen contained in the sample in the form of nitrate, ammonia salts and organic matter. Determinations are made of the total and insoluble phosphoric acid; the difference between the figures thus obtained is the available phosphoric acid, and, in addition to determining the percentage of water soluble potash it is ascertained whether it is to be considered as in the form of muriate or sulphate. From this procedure it is quite evident that sufficient attention is being given to the form or availability of the valuable constituents of this class of materials with the exception of the organic nitrogen. That there is a very great difference in the character, and, consequently, in the availability of the various organic nitrogenous materials used in compounding the mixtures is conceded by all interested, but it seems that the chemists, and others, have been contented to ignore to a certain extent this important question.

Studies on the availability of various nitrogen compounds have been conducted by investigators in Europe and in this country, and the results show that when the recovery of nitrogen from nitrate of soda, which has the highest percentage of recovery, is considered as 100, the relative availability of nitrogen as ammonia is about 70, and from dried blood about 64.5.

At the present time a pound of nitrogen in the form of the water-soluble compounds, nitrate of soda and ammonia salts, can be purchased for four-fifths of the cost of the same amount of nitrogen when obtained from high-grade organic materials, such as dried blood. On account of this difference in the cost and the higher availability of the water-soluble compounds, it is to be supposed that it would be to the best interests of the manufacturers to use these compounds, and more particularly the nitrate of soda, in a large percentage of their brands, since the cost of materials would be diminished and the resultant mixtures would produce more immediate, if not greater, returns. It is needless to state, however, that we are assuming the manufacturers use only high-grade materials. An examination of the following tabulation which was prepared from the records of the inspection for 1909 in New Jersey will show that the supposition regarding the use of nitrate of soda is not strictly correct.

Total number of brands examined.....	483.0
Total number of brands containing nitrates.....	206.0
Per cent. of brands containing nitrates.....	42.6
Total number of manufacturers.....	108.0
Total number of manufacturers using nitrates.....	55.0
Per cent. of manufacturers using nitrates.....	50.9

If the records of this inspection are more closely studied it will be found that twenty or more manufacturers may be considered as having a local business and that they have nearly sixty brands included in the above, and of this number at least fifty contain nitrate nitrogen. If these figures were eliminated from the tabulation, the results would, probably, more nearly represent the facts when considered on the basis of tonnage sold, and the percentage of brands containing nitrates as well as the percentage of manufacturers using this material would be considerably reduced.

Since these facts are somewhat at variance with our supposition, some inquiries were made in order to account for the condition and the principal reasons given were:

- I. There is a loss of nitrogen in mixtures containing nitrate of soda.
- II. Nitrate of soda causes the fertilizer to become pasty and thus cause trouble when used in the drill.

In order to get some information regarding these two questions, two experiments were outlined; (1) to determine the actual loss of nitrogen, and (2) the mechanical condition.

*Experiment I. Loss of Nitrogen.*—It is generally admitted that there is a loss of nitrogen in mixtures containing nitrate of soda and acidulated goods, and that the amount of this loss depends largely upon the materials used. In order to determine the actual

loss of nitrogen in this class of mixtures and, also, to ascertain whether the loss is immediate or gradual, a series of mixtures was prepared using a constant quantity of acid phosphate with different amounts of nitrate of soda and muriate of potash, high-grade tankage being used as a diluent. These ingredients were purchased from a large fertilizer company and should be fairly representative.

The plan of the experiment was to make all of the conditions as nearly the same as found in the regular manufacture as possible. With this in view a five-pound sample of each of the formulas was carefully prepared after the composition of the various ingredients had been determined. These mixtures were placed in small bags made of the same kind of material that is used for this purpose by the trade. Two days after the samples had been prepared they were removed from the bags, and, after a thorough mixing, subsamples were taken and examined for their content of moisture and nitrogen. The original samples were replaced in the bags and carefully stored. This operation was repeated at the end of two, four and fifteen weeks.

The results obtained for nitrogen in each of these examinations were computed to the same water basis as that calculated for the original mixture, and the following tabulation will give these results as well as the calculated content of nitrogen, phosphoric acid and potash.

TABULATION.

Sample number.	Calculated composition.					Total nitrogen at end of			
	Phosphoric acid. Per cent.	Potash Per cent.	Nitrogen as			Two days. Per cent.	Two weeks. Per cent.	Four weeks. Per cent.	Fifteen weeks. Per cent.
			Nitrate. Per cent.	Organic Per cent.	Total Per cent.				
A 1	7	4	1.01	3.12	4.13	4.16	4.13	4.09	4.09
2	7	6	1.01	2.77	3.78	3.76	3.76	3.73	3.74
3	7	8	1.01	2.43	3.44	3.41	3.43	3.35	3.32
4	7	10	1.01	2.08	3.09	3.07	3.06	3.05	3.01
B 1	7	4	1.47	2.86	4.33	4.34	4.36	4.32	4.22
2	7	6	1.47	2.52	3.99	3.98	4.10	3.96	3.82
3	7	8	1.47	2.17	3.64	3.65	3.66	3.63	3.44
4	7	10	1.47	1.82	3.29	3.41	3.34	3.24	3.14
C 1	7	4	1.94	2.60	4.54	4.48	4.53	4.50	4.29
2	7	6	1.94	2.25	4.19	4.11	4.21	4.16	4.02
3	7	8	1.94	1.91	3.85	3.91	3.77	3.81	3.75
4	7	10	1.94	1.56	3.50	3.46	3.61	3.43	3.34
D 1	7	4	2.40	2.34	4.74	4.34	4.80	4.70	4.42
2	7	6	2.40	1.99	4.39	4.46	4.38	4.49	4.29
3	7	8	2.40	1.65	4.05	4.13	4.05	4.04	3.83
4	7	10	2.40	1.30	3.70	3.63	3.76	3.61	3.47
E 1	7	4	2.87	2.08	4.95	4.95	4.85	4.84	4.52
2	7	6	2.87	1.73	4.60	4.57	4.57	4.47	4.24
3	7	8	2.87	1.39	4.26	4.11	4.19	4.31	3.97
4	7	10	2.87	1.04	3.91	3.90	3.81	3.74	3.61

Inasmuch as each set of samples contained the same quantity of nitrate of soda, the several sets in the series have been averaged as follows:

Set.	Calculated nitrogen.	Found.			
	Per cent.	Run No. 1.	Run No. 2.	Run No. 3.	Run No. 4.
A	3.61	3.60	3.60	3.56	3.54
B	3.81	3.85	3.87	3.79	3.66
C	4.02	3.99	4.03	3.98	3.85
D	4.22	4.24	4.25	4.21	4.00
E	4.43	4.38	4.36	4.34	4.09

By referring to the tabulation it will be noticed that the loss of nitrogen in the first three examinations was not very great and in no case was it a serious consideration, but the results obtained with set E were suspicious. During the entire time of these three periods the atmosphere was very dry and the samples remained in the same condition, practically, as they were mixed, but between the third and fourth examinations, the weather conditions were reversed and the samples absorbed considerable moisture. The content of moisture in the samples as drawn from the bags was not determined, but these figures were obtained for the samples after they had been prepared for analysis. These results, of course, did not give the true content of moisture in the original samples but they indicated the increase. From these determinations it would seem as if the moisture content at the time of the third examination had increased from one to two and one-half per cent. while the last examination would increase these figures to three and one-half to fourteen per cent. As previously stated, all of the nitrogen determinations were calculated to the original water-basis before tabulating and, consequently, the lower results obtained in the fourth examination can not be attributed to the presence of the higher percentages of moisture, but the loss was undoubtedly due to the conditions after the water had been taken up.

It would be unwise to draw a conclusion from a single experiment, but the results indicate that the actual loss of nitrogen would not be of great importance if the materials could be kept dry but that an appreciable loss will occur when there is an absorption of moisture.

*Experiment II. Mechanical Condition.*—One of the important problems in the manufacture of fertilizers is to prepare mixtures that will remain in a good mechanical condition. It is generally assumed that the presence of nitrate of soda in a mixture will cause the material to become more or less moist, depending upon the amount of soda present, and thus make the fertilizer in a poor condition to be used in drills.

In order to get some data on this question, two series of mixtures were prepared, one of which was the same as used in the previous experiment with the addition of one set of samples which contained no nitrate of soda. The second series was the same as the first with the exception that sulphate of potash was used instead of the muriate. These mixtures were prepared at the same time as those in loss of nitrogen experiment and were, of course, subjected to the same weather conditions. These samples were stored on shelves in a large room and allowed to stand for three and one-half months when they were removed from the bags and subsampled. The moisture content was then determined in each sample. The results obtained may not indicate the maximum quantity of water absorbed, nor the effect that would be produced by having a number of bags stored in a pile, but they are comparable because they were subjected to the same conditions.

The following tabulation will give the calculated

content of moisture in the various mixtures and the amounts found to be present at the time of examination.

TABULATION.

Sample number.	Calculated.			Found. Moisture 3½ months after mixing. Per cent.	Moisture. Differ- ence. Per cent.
	Nitrogen from nitrates. Per cent.	Potash muriate. Per cent.	Moisture. Per cent.		
F 1	.....	4	10.57	9.30	- 1.27
2	.....	6	10.22	10.10	- 0.12
3	.....	8	9.87	10.40	+ 0.53
4	.....	10	9.51	13.60	+ 4.09
G 1	1.01	4	10.08	14.48	+ 4.40
2	1.01	6	9.75	14.90	+ 5.15
3	1.01	8	9.42	14.90	+ 5.48
4	1.01	10	9.09	15.80	+ 6.71
H 1	1.47	4	9.88	15.30	+ 5.42
2	1.47	6	9.54	16.90	+ 7.36
3	1.47	8	9.22	17.00	+ 7.78
4	1.47	10	8.89	17.95	+ 9.06
I 1	1.94	4	9.67	18.20	+ 8.53
2	1.94	6	9.34	18.05	+ 8.71
3	1.94	8	9.01	18.45	+ 9.44
4	1.94	10	8.68	18.25	+ 9.57
J 1	2.40	4	9.46	18.25	+ 8.79
2	2.40	6	9.14	17.80	+ 8.66
3	2.40	8	8.80	17.65	+ 8.85
4	2.40	10	8.48	18.45	+ 9.97
K 1	2.87	4	9.26	17.95	+ 8.69
2	2.87	6	8.93	17.65	+ 8.72
3	2.87	8	8.60	17.75	+ 9.15
4	2.87	10	8.27	18.15	+ 9.88

TABULATION.

Sample number.	Calculated.			Found. Moisture 3½ months after mixing. Per cent.	Moisture. Differ- ence. Per cent.
	Nitrogen from nitrates. Per cent.	Potash sulphate. Per cent.	Moisture. Per cent.		
L 1	.....	4	10.65	6.48	- 4.17
2	.....	6	10.34	6.70	- 3.64
3	.....	8	10.03	6.65	- 3.38
4	.....	10	9.71	6.90	- 2.81
M 1	1.01	4	10.16	9.35	- 0.81
2	1.01	6	9.87	9.40	- 0.47
3	1.01	8	9.58	8.60	- 0.98
4	1.01	10	9.29	8.33	- 0.96
N 1	1.47	4	9.96	10.83	+ 0.87
2	1.47	6	9.66	10.35	+ 0.69
3	1.47	8	9.38	10.30	+ 0.92
4	1.47	10	9.09	10.20	+ 1.11
O 1	1.94	4	9.75	11.75	+ 2.00
2	1.94	6	9.46	11.25	+ 1.79
3	1.94	8	9.17	10.72	+ 1.55
4	1.94	10	8.88	10.65	+ 1.77
P 1	2.40	4	9.54	12.38	+ 2.84
2	2.40	6	9.26	11.53	+ 2.27
3	2.40	8	8.96	11.33	+ 2.37
4	2.40	10	8.68	11.35	+ 2.67
Q 1	2.87	4	9.34	14.55	+ 5.21
2	2.87	6	9.05	13.98	+ 4.93
3	2.87	8	8.76	13.27	+ 4.51
4	2.87	10	8.47	13.08	+ 4.61

By a survey of the preceding table it will be noticed that the mixtures prepared with sulphate of potash and no nitrate of soda at the time of the examination contained practically the same amount of moisture and the amount found was considerably lower than the calculated content. The corresponding set prepared with muriate of potash contained different percentages of moisture and the figures increased with the per cent. of potash, but in no instance was the water content as low as in the sulphate set.

The results of these two sets of mixtures would indicate that the sulphate of potash did not absorb much, if any, moisture while the muriate did absorb moisture and the quantity of this absorption was greater as the per cent. of potash increased.

The moisture content in each set of the two series increased with the amount of soda added but in every case the set prepared with the muriate contained more than the corresponding set prepared with the sulphate, and, as found with the set containing no nitrate, the quantity was increased with the per cent. of potash.

All of the samples in the sulphate series, with the exception of set Q, were in a good mechanical condition and those in the muriate set containing 1.47 per cent. nitrate nitrogen and from 6 to 10 per cent. potash were no better than those in the other series which contained 2.87 per cent. nitrate nitrogen. Judging from these results, it appears that fertilizer mixtures can be prepared so that they contain as much as 2.50 per cent. nitrate nitrogen and 10 per cent. potash, stored under severe weather conditions, and will remain in a good mechanical condition, provided the potash is derived from sulphate and not from muriate.

According to the reports of the New Jersey inspections about 6 to 8 per cent. of the brands of commercial fertilizers on the market contain potash in the form of sulphate and, consequently, the poor mechanical condition of many of the commercial brands, after they have been stored for a little time, and particularly those containing a high percentage of potash derived from muriate, can be attributed in part to the muriate of potash that has been used in preparing the mixtures.

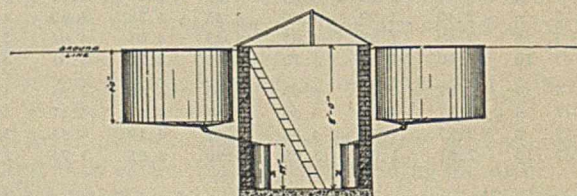
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### TANKS FOR SOIL INVESTIGATION AT THE FLORIDA AGRICULTURAL EXPERIMENT STATION.

By A. W. BLAIR AND S. E. COLLISON.

Received August 15, 1910.

While much light can still be thrown on soil and fertilizer problems by carefully conducted field experiments, there yet remain some problems that can never be solved until we can control and measure the factors more accurately than we can in field



TANKS FOR  
SOIL INVESTIGATION  
FLORIDA EXPERIMENT STATION  
Scale 1/4" = 1'-0"

Fig. 1.

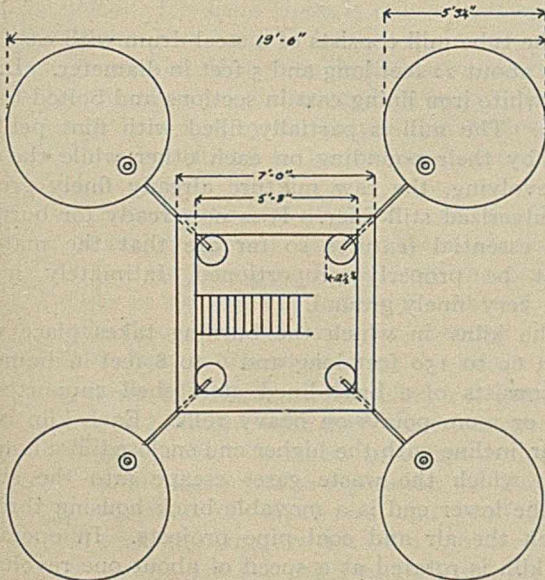
work. To supplement the field work in orange culture that the Florida Experiment Station is conducting, and to make it possible to estimate accurately the loss of soluble fertilizing materials in the drainage



waters under different systems of fertilizing, and also to investigate the effects of the long-continued use of commercial fertilizers on the soil and on the orange tree, a series of soil tanks has been set up. Each of these tanks has an inside diameter of 5 feet  $3\frac{1}{4}$  inches, with a maximum depth of  $4\frac{1}{2}$  feet, and a surface area of one two-thousandth of an acre. The tanks are constructed of heavy galvanized iron (No. 12 gauge), soldered and riveted, and before being placed in the ground they were thoroughly painted inside and out. As may be seen from the accompanying diagrams the bottom of a tank slopes to a point near one side, where there is a strainer opening into a two-inch tin-lined drainage pipe, the length of which is a little more than 4 feet. Four such tanks open into a central collecting pit (one drainage pipe entering at each corner as shown in Fig. 2) where are placed the four receptacles for collecting the drainage waters. Connected with each of these receiving tanks is an overflow tank which is ready for use in case of an emergency (long-continued heavy rains). The collecting pit, which is about 8 ft. deep and 6 feet square inside, is built of brick, with a concrete bottom, and is covered.

The soil tanks were sunk in the ground to within a few inches of the top, and filled with soil to within three inches of the edge.

Over the sloping part of the bottom was placed a layer of smooth quartz pebbles, the coarsest material being placed around the drainage opening and the finest on the top. Above this pebble layer was placed



TANKS FOR  
SOIL INVESTIGATION  
FLORIDA EXPERIMENT STATION  
Scale  $\frac{1}{4}$ " = 1'-0"

Fig. 2.

45 inches of soil, which was put in the tanks in the following manner. When the soil was dug from the site which each tank was to occupy, the top 9 inches were taken off first, followed by three one-foot sections. All four lots of soil were kept separate. In

filling the tanks, the last foot taken from the ground was placed on the gravel in the bottom of the tank, then the next foot, and so on to the top 9 inches. The soil was well tamped as it was put in, each tank

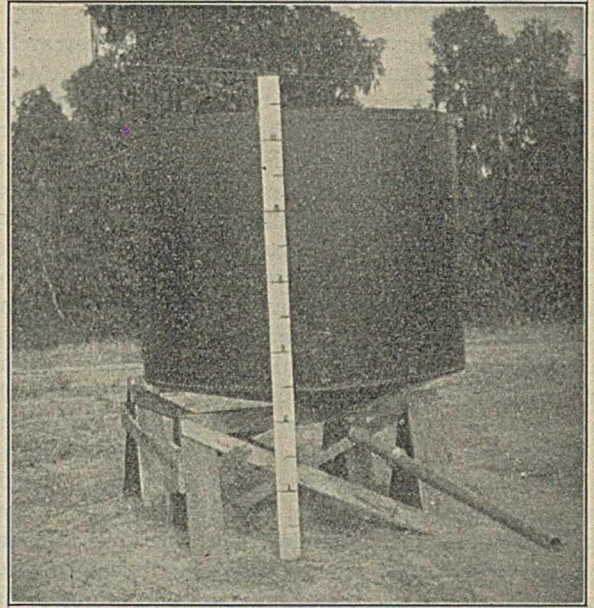


Fig. 3. One of the tanks.

having the same weight of dry soil, 8,625 pounds. The soil is a rather coarse sand, described by the Bureau of Soils as Norfolk sand.

One orange tree has been planted in each tank, and the four trees will be fertilized differently. The tanks are so placed that the trees are about 14 feet apart. Four control trees have been planted a short distance away from the tanks. The tanks are open at the top, and will as far as possible (that is, with due regard to protection from frost) be exposed to natural conditions. Should it become necessary to water artificially, this will be done and a record kept of the amount of water so used. Temperature and rainfall records will also be registered. On the approach of cold waves, the trees will be protected with tents and heaters. It is believed that the tanks will last for a period of 15 years or more, a period long enough for much valuable information to be accumulated. The first samples of the drainage waters have been collected and are being analyzed. Additional series of tanks will be added as means are available.

GAINESVILLE, FLA.,  
Aug. 9, 1910.

## ADDRESSES.

### PORTLAND CEMENT AS A BY-PRODUCT.<sup>1</sup>

By J. H. KEMPSTER.

In a paper read before the Section about a year ago by Mr. Touzalin, of the Illinois Steel Co., it was stated that while iron is the chief product of the blast furnace, immense industries have been built up from the by-products which for many years were allowed

<sup>1</sup> An address delivered before the Chicago Section of the American Chemical Society, November 25, 1910.

to go to waste. Gases are now transformed into power; flue dust is clinkered and recharged into the furnace and slag is granulated and made into Portland cement. Any discussion of Portland cement will be incomplete unless we understand at the outset what Portland cement is and why it was so named.

The cement industry proper dates from the researches of an English engineer, John Smeaton, who had been employed by Parliament to build a lighthouse on a group of rocks in the English Channel. In attacking this problem one of the chief difficulties he had to overcome was the failure of ordinary lime to harden under water. In a series of experiments he found that the pure white limestone ordinarily considered best for lime-making were really inferior to the soft clayey ones, for from the latter he produced a lime that would harden under water. Such a stone was found on the coast of Cornwall, and the hydraulic lime formed by burning this stone was the basis of the mortar used in the construction of the Eddystone lighthouse.

In 1824 Joseph Aspain, a bricklayer of Leeds, England, took out a patent on an improved cement which he proposed to make from the dust of road repaired with limestone or else with limestone itself combined with clay, by burning and grinding. This cement he called Portland cement because when hardened it produced a yellowish gray mass resembling in appearance the stone from the famous quarries at Portland, England (these discoveries are now incorporated in our definition of Portland cement).

According to the standard specifications, "Portland cement is the finely pulverized product obtained by grinding the clinker resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, to which no addition greater than 3 per cent. has been made, subsequent to calcination." Cement may be looked upon, for sake of illustration, as the reaction product between an acid and a base, the lime taking the basic, and the silica and alumina the acid side of the equation. A part of the alumina is replaced by iron oxide and a part of the lime by magnesia. Thus we can readily see that the manufacture of Portland cement is not limited to one particular form of rock, but may be made from any material furnishing the desired elements.

Slag furnishes the silica, alumina and a part of the lime. Slag to be suitable for making cement should contain about  $2\frac{1}{2}$  times as much silica as alumina, and have a low magnesia content. Magnesia in cement causes slow cracking and disintegration if present in sufficient amount, therefore many specifications call for not over 4 per cent. in the finished cement; some call for less than 3 per cent. In order to produce such a slag the furnace is charged with a low-magnesia limestone.

While we are speaking of Portland cement made from slag and stone it might be well to make a distinction between this product and so-called slag cement. Slag cement is a term applied to cement made by intimately mixing, by grinding together,

granulated slag and slaked lime without calcination subsequent to mixing. I wish to make this distinction clear. If you grind lime with slag your product is a slag cement, but if you take the same slag and add to it the proper amount of limestone, burn it, and grind the resulting clinker, you have fulfilled all requirements of a true Portland cement.

A cement plant constitutes a laboratory on a commercial scale. We grind some limestone and we grind some slag. We mix these according to formula and grind them again. We put this mixture in a crucible and heat it to incipient fusion. Cool this clinker and grind to an impalpable powder (adding 2 per cent. of gypsum to control the set) and we have cement.

Briefly, the mechanical processes through which the material passes are as follows: The stone first passes through a gyratory crusher which reduces it to  $1\frac{1}{2}$  in. down and discharges into a bucket elevator. The elevator raises the material to the feed spout of the rotary drier. The rotation of the drier gradually works the stone toward a flame. Similar driers are used for slag, no crushing being necessary. The preliminary grinding of both slag and stone is done in ball mills. This is done by the pounding of steel balls on steel grillage plates inside a revolving shell. From the ball mills the material is conveyed to twin hoppers from which the slag and stone are delivered into opposite hoppers of the automatic weighing device. These scales deliver at each dump a certain amount of slag and stone, depending on their analysis. More will be said about this later. After mixing, the material is further ground and mixed in tube mills.

The tube mill consists of a steel drum with cast iron ends about 22 feet long and 5 feet in diameter. Inside is a white iron lining cast in sections and bolted to the shell. The mill is partially filled with flint pebbles, and by their pounding on each other while the mill is revolving, the raw mixture already finely ground is pulverized still finer. It is now ready for burning. The essential features so far are that the material must be properly proportioned, intimately mixed and very finely ground.

The kilns in which the burning takes place vary from 60 to 150 feet long and 6 to 8 feet in diameter. It consists of a brick-lined steel shell supported at two or more points on heavy rolls. Each kiln is set on an incline with the higher end enclosed in a housing from which the waste gases escape into the stack. At the lower end is a movable brick housing through which the air and coal pipe projects. In operation the kiln is rotated at a speed of about one revolution per minute. The raw material is fed into the kiln from a feed pipe and slowly works its way to the discharge end, during which time the clinkering takes place. To protect the steel shell from the intense heat a fire-brick lining is used. The bricks are 9 inches thick at the firing end and 4 inches at the stack end. Powdered coal blown in with a blast of air is used for burning the clinker. Powdered coal blown through a round pipe forms an axial flame, the hottest part of which is in the center of the kiln. The heat, there-

fore, that does the clinkering is the radiant heat from the axial flame. Attempts to use the more effective impinging flame directly on the material have been abandoned because of too rapid burning of the fire-brick lining.

The reactions taking place in the charge in the kiln are the driving off of the carbon dioxide and the sintering of the rest of the ingredients to form the clinker. This sintering of the residue after the carbon dioxide has been burned off is really the chemical union of lime, silica and alumina, etc., giving out heat in the reaction. By burning a given weight of mix with a coal of known heat value this heat of formation of clinker has been determined. By calculating the heat of decomposition of calcium carbonate and subtracting heat of formation of clinker we find that less than twenty pounds of coal are required theoretically, to burn a barrel of clinker. Since the dissociation of calcium carbonate takes place rapidly at  $700^{\circ}$  to  $800^{\circ}$  C., and clinkering at  $1200^{\circ}$  to  $1300^{\circ}$  C., heat losses, bound to occur while maintaining these high temperatures, bring the amount of fuel required up to many times this amount.

In order to get good combustion an excess of air is blown in with the coal. This excess of air, together with the combustion gases, is introduced into the stack at a temperature ranging from  $600^{\circ}$  C. to  $700^{\circ}$  C. This stack is about four feet in diameter, and the velocity up the stack is something like 1800 feet per minute. Without any scientific data, it is evident that the heat loss here is enormous. The tendency in the newer mills is to cut down this loss by the use of longer kilns. I believe there is one operating on the Hudson 232 feet long.

There is need also of a suitable insulating material to back up the fire-brick lining of the kiln in order to cut down the heat loss by conduction. Asbestos has been tried, but was found to be too yielding in character.

The clinker leaves the kiln at about  $1050^{\circ}$  C. This loss, like others mentioned, has not been as closely watched as one might expect considering the present financial state of the cement industry. Abroad this clinker is run through an undercooler, thereby giving up one-half its heat to the air entering the kiln.

Properly burned Portland cement clinker is greenish black in color and usually when just cooled it is covered with glistening specks. It forms in lumps from the size of a walnut down. The operation of burning requires a workman of experience and good judgment to tell when the kilns are hot enough to burn the material properly. He has the coal feed and air adjustment under his control.

The coal used is a good grade of bituminous coal having a low moisture content.

After the clinker has cooled a clam-shell bucket lifts it into hoppers over the finishing mill crusher. In the process of grinding two sets of machinery are used, the preliminary grinders and the finishing mills. Kent mills crack the clinkers down to the size of wheat and finer. After passing this process the clinker goes through an automatic weighing device which

adds 2 per cent. of plaster of Paris (or gypsum). This mixture is now ground to powder in tube mills when it is ready for the stock-house.

The same mill could, with very little change, be used to make cement from any other raw material.

These mechanical details show the care that is taken that a uniform chemical composition may be obtained. In order to get the best product and a mixture that will burn well, the ratio of the lime to the silica and alumina must be controlled within narrow limits. There must be enough lime present to combine chemically with the acids present and leave no appreciable excess. Uncombined lime combines with water to form calcium hydrate and with carbon dioxide to form calcium carbonate. These reactions, in set cement, cause expansion or blowing and unless such cement is allowed to cure in the air before use, it will not stand the boiling test. On the other hand, if not enough lime is present to take care of the silica and alumina the excess is like so much clay and the tensile strength will be lower than normal.

The chemist has charge of the mixing of these materials, which is simplified by the large units of manufacture. The materials are handled in such large quantities and pass through so many stages of preparation that variations in the mixture are to a great extent eliminated. As a check both on the mixture and the raw material scales, frequent samples are taken and analyzed. The slag is inspected before it leaves the furnaces and only those slags are accepted that have the proper chemical composition. We can therefore calculate our mixture on the lime basis. Silica and alumina are already in the right proportion and it is only necessary to add enough limestone to bring the lime to the required percentage. A formula frequently used in calculating cement mixtures is:  $\text{CaO} = 2.8 \times \text{SiO}_2 + 1.1 \times \text{Al}_2\text{O}_3$ . Having the analysis of stone and the slag, the ratio may readily be calculated as follows:

ANALYSIS.		Limestone.	Slag.
		Per cent.	Per cent.
SiO <sub>2</sub> .....	1.80		35.40
Al <sub>2</sub> O <sub>3</sub> .....	1.30		14.60
CaO.....	52.90		46.30
CALCULATION.			
			Limestone.
SiO <sub>2</sub> .....	$1.80 \times 2.8 =$		5.04
Al <sub>2</sub> O <sub>3</sub> .....	$1.30 \times 1.1 =$		1.43
			6.47
Slag.			
SiO <sub>2</sub> .....	$35.40 \times 2.8 =$		99.12
Al <sub>2</sub> O <sub>3</sub> .....	$14.60 \times 1.1 =$		16.06
			115.18
CaO =	52.90		115.18
	-6.47		-CaO in slag 46.30
	46.43		68.88
Then: $\frac{46.43 \times 1000}{68.88} = 674.$			

Therefore 1000 parts stone require 674 parts slag by weight. This formula is based on the supposed existence of the tricalcium silicate. The best author-

ities on the constitution of Portland cement are agreed that calcareous hydraulic cements do not represent well-defined compounds, but mixtures of calcium silicates and calcium aluminates with varying amounts of uncombined calcium oxide. The prevailing opinion since the time of Le Chatelier that a tri-calcium silicate existed in Portland cement is now definitely discarded by men of science. However, the formula has served as a practical working basis for the manufacture of cement.

As a further check on the composition, frequent tests are made on samples of clinker taken from the kilns.

The percentage of sulphate in the cement is also closely watched. I have already said that an automatic weighing device mixes the gypsum with the clinker in the process of grinding. As mechanical devices are apt to get out of order in this process also, eternal vigilance in the way of frequent tests is the price of a uniform product.

CHEMICAL LABORATORY,  
UNIVERSAL PORTLAND CEMENT CO.,  
BUFFINGTON, IND.

### THE TRAINING OF CHEMICAL ENGINEERS.<sup>1</sup>

By M. C. WHITAKER.

Much attention is properly being centered upon the education of men in the scientific development and management of agricultural production, and the Government not only gives direct financial support to a large number of schools for such training, but also maintains a Department of Agriculture, the function of which is largely educational.

The annual production of the chemical industries is almost equal in value to the agricultural production of the country, and it is therefore proper to compare the facilities now being provided and the means now being adopted for the education of men to develop and manage the widely diversified units of chemical manufacture with the methods and facilities in other educational fields. Obviously the general educational and technical equipment of men to develop and direct processes or works depending upon the applications of chemistry, and usually involving a knowledge of power and mechanical and electrical machinery, is much greater than the technical equipment required for men in agricultural production. While agricultural education has grown and developed at a rate commensurate with the producing power of that industry, and has been fostered by private, State and Federal funds, education in the equally important and essential field of chemical manufacture has been, in some institutions, entirely ignored, in others only indifferently provided, and in no single case supported and equipped on a basis comparable with the wealth-producing power of the industry.

Efficient production and the economic management of our manufacturing plants are essential features to our commercial development, and it is in this field that the greatest results are to be attained in the conservation of our natural resources. The accom-

plishment of these results obviously depends upon the application of scientific knowledge to the solution of all problems, both great and small, in the development, the direction and the management of our factories.

The chemical industries very properly look to the schools for men qualified to produce these results, to improve their production and manage their works. The best evidence that more and better trained men are needed in the chemical industries is the fact that this Institute of Chemical Engineers, composed of men of experience and men now engaged in the direction of great industries, meets twice a year and devotes a large portion of its time to the study of the problem of how to obtain trained men to assist them in the development and administration of their work.

Every employer of chemical talent knows that at best the young graduate is only a vague "prospect" and that much has been left undone in his training.

The problem of proper training and correct methods of teaching chemical engineering is one which must be carefully analyzed and studied from its very foundation and is not one to be remedied by a few trivial changes in existing curricula—by dropping this and substituting that. The subject must be opened up and examined to its foundation and if it is found that the present structure is built on sand we should put some "concrete" under it.

Necessarily, the problem must be solved by the coöperation of the teachers with the employer of chemically trained men, and the writer, having served a term of practically ten years in each of the above fields, begs to submit a few observations and conclusions for the consideration of the Institute Committee.

The chemical industries require for their development and management two classes of men of somewhat different training, natural qualifications and range of service.

FIRST.—*Research Chemists* who are qualified naturally and by training to originate and to develop in new fields. The training of the research man is more advanced, or supplements that of the chemical engineer, and the research results furnish the foundations for the industries which the chemical engineer organizes and administers. In other words, the research chemist works in the new and undeveloped fields of chemical knowledge and produces results calculated to contribute new knowledge and new arts.

SECOND.—*The Chemical Engineer* works in the organization, operation and management of existing or proposed processes with a view to building up a successful manufacturing industry. He uses his classified knowledge of chemistry and the allied engineering branches in developing, perfecting, organizing and administering a plant or a process for the production of a marketable and useful product at a profit to the investor.

Such a field as this requires a man of knowledge, originality and resourcefulness. His fundamental training in chemistry, physics, mathematics, etc., must be thorough and must be combined with a natural

<sup>1</sup>An address presented to the American Institute of Chemical Engineers, December 7, 1910.

engineering inclination and an acquired knowledge of engineering methods and appliances. His originality and imaginative capacity seems to me to be essential and a combination result of natural qualifications and training. Resourcefulness, however, comes as a result of experience in application and the ability to adapt a wide range of methods and practices to new conditions. A man with the natural qualifications, supplemented by the proper training, may become a successful chemical engineer.

The success of the research chemist is measured by his scientific achievements, whereas the success of the chemical engineer is measured by his commercial results. While their work bears a certain mutual and cyclic relation it must be apparent that their natural and educational equipment may be entirely different.

The development of specialized training in certain selected lines of manufacture is not a proper function for an engineering school, but should be left to the trade school or to the industries themselves. Specialized research, on the other hand, should be carefully eliminated from the regular engineering training and provided for in graduate courses.

For convenience in discussion, I have divided training subjects for the chemical engineer into three general classes: Fundamental, Associated and Supplementary. No attempt is made to discuss the details of the curriculum, the general purpose being to get broad subdivisions as a starting point. The question of arrangement of subjects into a curriculum and the proper allotment of time for the course depends upon what is finally determined as proper training for the men under discussion:

Chemistry	}	Fundamental training.
Physics		
Mathematics		
Allied subjects		

Electrical Engineering	}	Associated training.
Mechanical Engineering		
Civil Engineering		
General Engineering		
Business economics		

Study of the <i>applications</i> of the fundamental and associated training in laboratories equipped with the "tools of the trade" and with working plants.	}	Supplementary training.
Training, by "contact" and by "example," in a laboratory managed as an approved business, in the principles and practices of efficient organization and administration.		

**FUNDAMENTAL TRAINING.**—The training in the fundamental subjects need not be materially changed except perhaps more attention should be given to the laboratory facilities and to the selection of instructors for the fundamental work. Profound scholarship and a record for original research are too often made the sole determining factor in the selection of teachers for these subjects. Research qualifications are of secondary importance in the selection of men to give the fundamental training to our chemical engineers. Such teachers might better be chosen from men physically, temperamentally and educationally qualified to present their subjects clearly, logically and enthusiastically to the student, and to present them

in such a way as to quicken and hold his interest. Too often our undergraduates become muddled, discouraged and even give up a subject because of its dry, disconnected presentation or because the instructor "talks over their heads" or lacks the personality and the power to interest them. Research instructors are often permitted to emphasize their "hobbies" or teach their special experiences without regard to the purpose of the course and its relation to the fundamental training. Our instructors should always be chosen to fit the course requirements and should not be permitted to divert the work into special fields not contemplated in the basic formulation.

The training in the fundamental branches should be more thorough and carefully proportioned than at present, keeping in mind that the chemical engineer's knowledge must be classified, complete and accurate in the broad principles and not statistical, encyclopedic, or of the class of deep profundity require for research in new and original fields. The chemical engineer's knowledge is to be used as a basic "tool" of his trade and may be given as such without detracting one iota from its value as mental training.

**ASSOCIATED TRAINING.**—Associated training is for the purpose of placing in the hands of the chemical engineer a working knowledge of the other engineering branches, so that he may utilize them in the development and management of his particular problem. Courses designed primarily as foundational for future advanced study in the same field are not likely to be proper courses for this associated training. Our associated courses should be broad and general and need not carry the student beyond the foundational principles of the subjects with a working knowledge of the existing design, construction, materials, operation and use of engineering appliances.

The existing methods of teaching by lectures, demonstrations and laboratory work, combined with a liberal use of text and reference books, is probably the most effective way of reaching the fundamental and the associated subjects.

Assuming that the student now has a thorough fundamental foundation in the basic principles of his profession and a working knowledge of the associated engineering branches, schools should be equipped for *directed* study of their *application* to the problems of manufacture and production. This applied study is classed as "supplementary training."

In the education of teachers, in the education of doctors, in the study of agriculture and in the education of all other engineers except chemical engineers, training in the *application* of the respective fundamentals, under the direction and with the assistance of experienced teachers, is considered essential. Medical schools without hospitals, teachers' colleges without practice schools, schools of agriculture without experimental farms, or engineering schools without laboratories and shops would hardly be dignified by classification as schools. Such institutions invariably invest large proportions of their resources in facilities for demonstrating the proper practical application of the fundamental theories.

Is there any reason why chemical engineering should not and could not be taught by the tried methods of the normal schools, the medical school, the agricultural schools and other engineering schools? Only with proper chemical engineering laboratories, equipped with real working models of standard appliances to illustrate the basic applications of the industries, and a proper curriculum arrangement to permit the student to study and use these appliances and the principles involved in their application will we be on a basis comparable with the methods and the facilities now existing in other educational fields.

But we can accomplish still more with proper laboratory facilities. We can so construct and administer these laboratories that the student will be surrounded by an "atmosphere" of manufacturing and business efficiency, where he will learn by *example*, by *daily contact*, by "*attrition*" the modern methods and practices of office and works management. Chemical engineers should have this knowledge. It is fundamental to the proper fulfilment of their job. Instances where failure has been converted into success and industries saved by knowledge of proper administrative practices, and the application of business and works efficiency method, are too numerous to mention. Refinements in chemical processes and ingenious mechanical devices are all ineffective and often useless if inefficient organization and management are permitted to absorb the earnings. Successful chemical manufacturing is based upon three general principles: First, chemical and physical facts; second, mechanical applications; third, organization and management.

The first principle is definite and basic and is, therefore, not capable of variation, but the second and third are variable and may be far from perfection. The greatest opportunity for increased profit therefore lies in the possibility of mechanical improvements and improvements in the efficiency of the organization. Instruction is provided in a greater or less degree in existing schools in the two first principles mentioned, but the third equally important and fundamental principle is not even undertaken.

The "contact" system which I am urging for adoption as a method for teaching the principles and the application of chemistry to manufacture, and for imparting a knowledge of the principles and practices of efficiency in organization, management and administration, is the same as the methods which have always obtained, by force of circumstances, in country schools where the small children in the A, B, C classes unconsciously absorb geography, history, arithmetic, etc., by hearing, seeing and being in the "atmosphere" of the more advanced work. This method can be adopted in the training of chemical engineers and can be made infinitely more effective than in the country school.

The contact or "frictional" method would require a laboratory plant larger and more comprehensive than anything yet established and would have to be managed on somewhat different lines than those now obtaining in engineering schools.

If it is proposed to direct the student in the study of the *application of fundamentals of factories, factory appliances, factory processes and manufacturing business* by the "frictional" method, the laboratory should be equipped, organized and administered as a live manufacturing proposition. There should be ground space enough to permit of the erection of one or more complete operating plants in addition to the general laboratories for the study of great applications such as distillation, evaporation, filtration, wet reactions, high temperature oxidation, electrochemistry, etc.

The complete plants should be chosen from some of the important chemical processes of great common interest, which at the same time illustrate a wide diversity of chemical principles and appliances and products—for example, the manufacture of gas.

These plants should be designed and built from the foundation to the roof so that the structure itself, materials used, equipment and arrangement, would illustrate the best known practice and permit of the most economical management and operation. Every structural detail should be provided with a view to *educating by example*. Office appliances, office systems and facilities should be provided and the equipment includes books, trade journals, patent literature, samples, advertising matter, house organs, etc., of the business. Conference facilities should be provided in each laboratory for lectures, discussions, demonstrations of the chemical, mechanical and business features of the process. All such work should be conducted in the special laboratories, and the student from the time he enters until he leaves should be made to "stumble over" the tools of his art and become "saturated" with the "atmosphere" of the business from the raw material to the market.

The classes should "go the rounds" of the laboratories in convenient sized sections for conferences and for "manning" the work.

In connection with the chemical engineering laboratory there should be a "shop organization" consisting of competent mechanics, helpers, and laborers, necessary for the up-keep of the plant, and this organization should be administered that our students would gain actual experience in dealing with works men. Office experience, correspondence, dictation, filing and recording, fundamental costing, etc., may all become familiar knowledge to the student by having these facilities arranged for his use and by incorporating them in his daily "business."

TECHNICAL ADVISERS.—These laboratories of engineering chemistry should be organized with a system of technical advisers to be selected from representative experts in each typical field of industrial chemistry. These advisers should be specially qualified experts or active works managers of live concerns. Their connection with the laboratory should not be merely nominal, but should carry with it a responsibility for the proper equipment of the special laboratory of the industry which they represent. They should also give some lectures upon their specialty, not altogether from the chemical standpoint, which presumably can be covered by the regular instructors,

but from the business, organization, and relative industrial standpoint.

The personal contact and acquaintance between adviser and student is an obvious mutual benefit. The attitude of the leading industries towards such a chemical engineering school would become one of personal interest instead of one of criticism.

The technical advisory system, if properly initiated and administered, will insure modern equipment, methods, and instruction in chemical engineering and will give, through the lectures, first-hand and accurate general information on the scope and magnitude of the typical industries. Furthermore, it will definitely dispose of the frequent reference to obsolete and antiquated methods and equipment. By relying upon the judgment of these experts and managers of live and paying industries we would avoid the equally dangerous extreme of becoming loaded up with impractical untried appliances and uncommercial processes.

**INDUSTRIAL RESEARCH.**—The largest industrial corporations, such as the General Electric Company, the United Gas Improvement Company, the National Electric Lamp Association, etc. have established and are maintaining research laboratories. These laboratories are directed in their chemical and physical research by able and high-priced men and are equipped and maintained at great expense.

Such laboratories are being established because there are no existing equipments, on a suitable scale, for solving the problems necessary for their industrial advancement. The corporations have not undertaken the burden and expense of academic research from choice but from necessity. Our scientific institutions have utterly failed to provide the facilities for industrial research, and as a consequence are being "elbowed" aside from their natural position of technical and scientific leadership.

Under existing conditions the small manufacturer, who can not afford to equip and maintain a research laboratory, has no prospect of solving his industrial problems. Unless the scientific institutions develop modern chemical engineering laboratories, equipped with the tools of the industries, and place their facilities within the range of the small manufacturers, industrial development will be limited to the few concerns whose means will permit the establishment and maintenance of laboratories for private research.

On the other hand, with such laboratories as I have outlined, equipped with every facility for experimentation on a large scale, factory managers, technical laboratories and individuals could be interested in availing themselves of these facilities and in establishing industrial researches for solving industrial problems.

Frequent reference has been made to the cost of such a laboratory of engineering chemistry as has been outlined. We are dealing with a great industry and a great problem and we should therefore exercise our sense of proportion. It is estimated that the minimum *net profit* of chemical manufactures is \$300,000,000 annually. It is also estimated that the

combined investment in chemical engineering equipment in all of the educational institutions of the country is not over \$30,000 or one-hundredth of one per cent. of the net profit of the industry for one year. A thirty thousand dollar investment or even one hundred times that is an absurdly small equipment to be devoted exclusively to instruction in the application of chemistry for such an enormous and profitable industry, not to mention the facilities for research development. If the plan outlined will produce men better qualified to enter this field of industry and men who can "deliver the goods," I have no fear that the question of cost will ever prove an obstacle to the development of such laboratories of chemical engineering.

#### THE DEVELOPMENT OF PAINT FORMULAE.<sup>1</sup>

By L. S. HUGHES.

Until very recent years there was no technology of paints worthy of the name; in fact, it is not too much to say that there was no understanding of the causes of success or failure of any formula. It was recognized in a vague way that a zinc paint was likely to peel and that the addition of non-drying oils led to difficulties; and certain pigments were accepted as valuable, but the art of combining the various available materials was purely empirical; each formula was tried out without co-ordination of its results with the results of other mixes.

The reasons for the long persistence of this condition are not hard to recognize: first, there were no comprehensive or reliable methods for the testing of either pigments or paints. Chemical analyses, even when correct, failed to account for the wide discrepancies observed in the behavior of paints of similar chemical composition, and this method of examination fell into total disrepute among a majority of painters and paint manufacturers. And, second, there was a wide-spread feeling that the value of a paint was in some occult way proportionate to the cost of the raw materials. Indeed, this curiously illogical idea is, even to-day, so widely spread that it is the basis of advertising by many large manufacturers. Third, and last of the important factors in delaying the development, was the very general fraud practiced for the purpose of taking advantage of the belief just mentioned, that is, the manufacture and sale of paints under secret formulae and their sale under guarantee of containing nothing but recognizedly expensive pigments. As some of these mixtures, very largely cheapened in cost by the addition of native mineral pigments, were far superior to their nominal composition it necessarily followed that the latter obtained the credit and so the advantage of "purity;" *i. e.*, freedom from anything except white lead and zinc oxide became a very general criterion of excellence.

So long as this general misrepresentation continued and there was no certain method for testing a paint save by using, it is not unnatural that paint-making failed to become subject to proper technical control.

<sup>1</sup> An address read before the Chicago Section, *American Chemical Society*, December 16, 1910.

At last, however, some large manufacturers, especially those who manufactured paint for their own use, and some independent chemists began the practice of subjecting all raw materials to regular and thorough examination. At first the data were of little value except in securing uniformity in supply, but as the microscope came more and more into use conjointly with improved chemical methods it became apparent that structure and size of particle were of no less importance than chemical composition; further, the fact began to receive recognition that all of the natural pigments suitable for use alone (or "straight") were heterogeneous in size and almost invariably so in structure. This was at first misinterpreted into a rule which, while it contained the elements of an important truth, was nevertheless inexact as stated. The rule at first was that the finer the pigment portion of a paint the better. To prevent possible misunderstanding it is perhaps advisable to anticipate a little and to say here that the more modern form of this dictum is that the finer the major pigments in a paint the better, but that there is advantage in the presence of a moderate portion of distinctly coarser particles.

The apparently mysterious fact that the addition of transparent crystalline ingredients to most of the opaque pigments improved the hiding power of the latter proved a stumbling-block for a long time but was finally elucidated by a demonstration that showed this to occur only when the transparent materials were coarse enough to afford points for capillary action, thus increasing the thickness of the coat. It naturally followed and, indeed, was proven that the diameter of the larger particles was coincident with the thickness of the coat.

These two points were of no little importance because they established a sharp differentiation between "opacity" and "hiding power," two characteristics which had been badly confused and generally regarded as identical.

These investigations were accompanied by coincident interpretation of the chemical behavior of the various ingredients. At first this concerned itself only with the behavior of the straight pigments and the results found expression in many hopeless contradictions. As an instance: because silica, barytes and other crystalline earths of manifest chemical inertness failed entirely when used alone the erroneous idea grew up that unless a pigment were sufficiently basic to react with the oil of the coat it was of doubtful value. As a matter of fact the preponderance of evidence was enormously on the other side from the recognized superiority in wear of the demonstrably stable iron oxides, many dry colors and especially of the totally non-reactive carbon pigments. The difference in color of these from the white pigments was apparently the reason for their lack of consideration—a thing which to-day seems so totally inadequate as to approach the incredible.

Many paint men were never satisfied of the correctness of this belief but it was so generally accepted as to lead to legislative action by one state in the form of a law which directly encouraged paints made only

from basic lead carbonate and zinc oxide, two highly reactive pigments. The phrasing of this act indirectly stigmatized all other ingredients as adulterants.

Even at the time of the passage of this law a consideration of the previously disregarded data of the wear of inert colors and a recognition of the value of the comparatively new basic sulphate white lead had led to a grave suspicion that saponification and analogous reactions were not only of no benefit but were emphatically destructive. This view spread rapidly because the great spread of micrographic study of paints furnished a complete explanation of the failure of the stable crystalline pigments when used alone. Their noticeable coarseness and the universality with which their amorphous analogues proved successful needed little interpretation to show that it was not the chemical stability of the crystalline materials which caused their failure when used alone but that their angular outline and absence of small particles gave a coat possessing interstices of appreciable dimensions, and these being filled with nothing but the easily perishable "linoxin" afforded little resistance to weather attack. Addition of impalpable amorphous substances entirely remedied the weakness of the crystalline pigments except in so far as their undue proportion limited the area covered by the paint.

The work of the late Dr. Dudley and others outlined the general means by which the permeability of a paint coat by moisture and gases may be controlled and the necessity for heterogeneity of structure and composition became very generally recognized.

Satisfactory demonstration of the applicability of these various principles proved of no little difficulty, largely because there was little co-operation between the different experimenters and partly because of what appeared to be hopeless discrepancies between the record of exposure test of analogous formulae in different localities. In a general way it had been acknowledged that a given formula was better adapted to certain classes of work and locality, but there was a strong underlying opinion that a really good paint would be successful under any conditions.

It is easy to be wise after the fact but in the present light of the very comprehensive and valuable records of the co-operative test fences the local success of many paints contrasted with their failure outside of the range of the climatic condition prevailing at the factory where they were tested and developed would seem necessarily to have suggested the necessity or at least the desirability of adjusting formula to climate. It is true that suggestions toward this end have been made but they are merely tentative.

It remained for Mr. John Dewar in his valuable review of test fence records to make the declaration that no one formula can prove satisfactory under all climatic conditions. This dictum is the latest in paint development and with it we may properly close a recital of the gradual development of paint-making rules and turn briefly to a consideration of their application to the use of those pigments which are in general use.

First, a citation of the records of condition of the



white pigments used straight as developed by their exposure at Atlantic City is instructive in illustrating the fallacy of the doctrine of "purity" as a criterion of reliability.

Basic lead carbonate: type A.....	Condition bad.
Basic lead carbonate: type B.....	Condition bad
Basic lead carbonate: type C.....	Condition bad.
Zinc oxide.....	Condition fair.
Zinc oxide (another test).....	Condition not stated.
Sublimed or basic sulphate white lead.....	Condition good.
Zinc lead.....	Condition good.

These tests were closely confirmed by the exposures at Pittsburgh although the character of wear in the two sets of tests was naturally quite different.

The remarkable consistency with which the fumiform or sublimate pigments outlasted their pulverized and precipitated competitors is strikingly indicative of the benefit of impalpable fineness and amorphous structure in the major pigment of a mix.

Without exception the individual pigments showed improvement in behavior when employed mixed with others; the prohibitive hardness of the zinc oxide coat was greatly modified by addition of either of the white leads; the checking of the lead carbonates and their tendency towards discoloration were diminished by large admixtures of either zinc oxide or crystalline ingredients, while the sublimed or basic sulphate white lead, which (like all the straight leads) exhibited a soft coat, was satisfactorily hardened when tempered by the addition of zinc oxide.

The recognized difficulty of securing satisfactory brushing with fumiform pigments only, proved easy of elimination by the employment of small amounts of coarser and crystalline pigments. Most satisfactory of all, perhaps, was the demonstration that the characteristics of a pigment persist in mixtures and are manifested proportionately to its amount therein.

A complete demonstration of the advantage of modifying the faults of one pigment by mixing it with others of different qualities is at least strongly indicated by the record of six out of seven successful exposures of paints containing four pigments each.

So consistent was the improvement noted with increasing heterogeneity that the committees in charge of the experiment have made unqualified declaration of the superiority of formulae containing both lead and zinc in addition to mineral crystals.

Attention so far has been given only to the tests at Atlantic City and Pittsburgh because the climatic conditions to which they were exposed are representative of much more important areas than the other series of public tests—those at Fargo, North Dakota.

That the latter have confirmed the generalizations of the Eastern tests is best shown by quotation from a report on the Fargo fences:

"It was conclusively demonstrated that mixtures of white lead and zinc oxide properly blended with moderate percentages of reinforcing pigments, such as asbestine, barytes, silica and calcium carbonate, have proved most satisfactory from every standpoint and are superior to mixtures of prime white pigments not reinforced with inert pigments.

"The white leads painted out on the 1908 fence exhibited different degrees of checking: the mild process lead and sublimed white lead which presented the best surfaces, were free from checking, while the old process leads seemed to be showing very deep and marked checking, even after one year's wear."<sup>1</sup>

While the generalizations were thus borne out by the Dakota tests it must be said that the limits of usefulness of the various "prime" (or opaque) pigments were differently indicated. In the sea coast and Pittsburgh tests very little trouble was noted in securing satisfactory adherence to the painted surface; the difficulty seemed to be to prevent undue permeation of the film by destructive gases and vapors—a problem most satisfactorily solved by the employment of the excessively fine fumiform pigments. As the humidity was always fairly high in these exposures the brittleness, due to hard coats with consequent splitting or peeling, was not noticeable.

In North Dakota, however, the aridity and wide range of temperature almost reversed the problem, and while very few coats perished by disintegration many paints failed through lack of adherence and through undue hardness. The high lead mixes with their consequent softness proved best and the advantage of reducing the zinc oxide content for this region was demonstrated.

A universal improvement in wear was observable in the tinted paints over the untinted made from the same "white base" in all tests without regard to locality—a difference so marked that it is doubtful whether it can be entirely accounted for by consideration only of the increased proportion of chemically stable pigments and the necessary increase in heterogeneity of structure. It appears probable that explanation must await a better understanding of the effect of light within the paint film.

These various tests, confirming, as they do, previous research, bid fair to put paint compounding upon a proper technical basis.

The formulae of to-day can be compounded to secure definite permeability, definite hardness (by proportioning the lead and zinc pigments) and certain attachment to a surface, either by use of a chemically stable fumiform pigment of sufficient fineness to enter the pores of wood or through insuring a soft coat by avoidance of zinc or other hardening agents. Thickness of coat can be accurately controlled by the amount and size of crystalline pigments employed, and checking or internal disintegration can be avoided by the selection of non-reactive and insoluble pigments. Indeed, it is not too much to say that the major functions, at least, of our available pigments have been accurately catalogued.

While much remains to be done (especially in improving the vehicle) the rapid progress that has been made in developing a scientific basis for paint compounding must be regarded not only as satisfactory but as gratifying.

<sup>1</sup> Page 9, *Bulletin 25*, Scientific Section P. M. A.

## NOTES AND CORRESPONDENCE.

## DETERMINATION OF TIN AND ANTIMONY IN SOFT SOLDER.

The following details for the rapid volumetric determination of tin and antimony in soft solder are adapted from A. H. Low's method.<sup>1</sup>

*Antimony.*—On a counterpoised watch glass weight exactly 2 grams of filings, which should be fine enough to pass a 30-mesh sieve. With a quill brush transfer the filings through a stemless funnel into a 300 cc. Jena Erlenmeyer flask. Add 5 grams of  $\text{KHSO}_4$  crystals and 10 cc. of sulphuric acid, specific gravity 1.8. By means of cork-lined tongs or test tube holder manipulate the flask over a bare Bunsen flame until most of the free acid is expelled and no sulphur remains on the walls of the flask nor in the liquid. Do not attempt to take to dryness. Place the hot flask on a piece of asbestos. The tin is now all a stannic and the antimony all an antimonous salt. When the flask cools sufficiently add 25 cc. of cold water and 5 cc.<sup>2</sup> of hydrochloric acid, specific gravity 1.2. Manipulate over a free flame for half a minute to complete the solution of the tin and antimony salts and to expel any sulphuric dioxide. Cool the flask under running water. Add 100 cc. of cold water and titrate rapidly with  $N/20$  potassium permanganate. From the volume of the latter required to give the first pink color calculate the per cent. of antimony. Dry to constant weight some highest purity sodium oxalate, made according to Sorensen, and use this to standardize the  $N/20$  potassium permanganate solution.

*Tin.*—Weigh exactly 0.2 gram of the filings and transfer as before to a 300 cc. Jena Erlenmeyer flask. Add 5 cc. of 15 per cent. sodium carbonate solution. Add 20 cc. of hot water. Add 25 cc. of hydrochloric acid, 1.2 specific gravity. Add one drop of 5 per cent. antimony chloride solution from a dropping bottle. This solution should be strongly acid with  $\text{HCl}$ . Close the flask with a 1-hole rubber stopper carrying a capillary U-tube of 1 mm. bore. The short arm of the U-tube should just reach through the stopper while the long arm should almost reach the surface on which the flask stands. Place the flask on a hot plate where it will boil very slowly but not suck air back through the tube. The solder will dissolve in about 15 minutes, leaving a small black precipitate of antimony. As soon as this occurs and without interrupting the slow boiling bring a test tube of 15 per cent. sodium carbonate solution under the U-tube. Carry to the sink and cool the flask under running water, allowing the carbonate solution to suck back into it. When cold add 5 cc. of 15 per cent. sodium carbonate solution and 5 cc. of cold, fresh starch liquor and titrate immediately with  $N/20$  iodine solution. From the volume of the latter required to give the first deep blue color calculate the per cent. of tin. Standardize the  $N/20$  iodine solution by titrating in the same way 0.1 gram portions of filings made from a stick of Kahlbaum's highest purity tin.

<sup>1</sup> *J. Am. Chem. Soc.*, 29, 66.

<sup>2</sup> P. H. Walker and H. A. Whitman also use less hydrochloric acid than A. H. Low, *THIS JOURNAL*, 1, 519.

This method can be used to advantage for soft solder containing 0 to 2 per cent. of antimony, 30 to 60 per cent. of tin, 40 to 70 per cent. of lead and not more than traces of any other metals. Duplicate determinations of tin and antimony can be made in one hour.

J. H. GOODWIN.

## THE USE OF ALUNDUM CRUCIBLES IN FATTY ACID DETERMINATIONS.

Recently the writer has had some opportunities of making separations and determining fatty acids from soaps and soap powders.

These separations were, at first, made by the usual methods, as taking up with beeswax, or upon a balanced filter.

The porous alundum crucibles, manufactured by the Norton Co., were then used as a Gooch crucible, by placing the crucible into a Gooch funnel, using a filtering bottle and a pump for suction.

The method used was by acidifying the soap solution, as usual, with an acid, allowing it to stand for some time, to give the fatty acids enough time to thoroughly coagulate. The solution was then run through this crucible, which was weighed, and the acids remaining in the crucible washed once or twice with cold water. It was then dried and weighed.

The writer finds this method to be very rapid and accurate. When the determinations are completed the fatty acids can be burned out very readily, leaving the crucible as clean as before filtering, and may be used again for a considerable number of determinations.

As the crucible is not acted upon, or contaminating the solutions with any foreign matter, but leaving it in a perfectly clear state, the filtrate passing through may be used for other determinations if so desired.

As this method is found to be more rapid and fully as accurate as the two former methods, also owing to the fact that the crucible can be used for numerous determinations, the writer can say that the use of these crucibles excel any methods, for this separation.

H. O. ANDERSON.

## DISSOLVING SILICON ALLOYS.

*Editor Journal of Industrial and Engineering Chemistry:*

In working on some silicon alloys recently I found they may be readily decomposed by a mixture of strong hydrofluoric with hydrochloric or sulphuric acid.

The alloys so far tried include samples of 50 per cent. ferro-silicon and one of silico-spiegel (21 per cent. Si, 39 per cent. Mn and 42 per cent. Cr). The sample is placed in a large platinum crucible, conc. hydrofluoric acid added and then hydrochloric or sulphuric as desired. The solution starts at once and is complete in a few minutes at a low heat. The sample does not even have to be finely powdered for I have dissolved ordinary crushed ferro-silicon in pieces as large as 10 mesh.

For determination of iron or manganese this method is much more rapid and far simpler than either of the fusion methods.

These facts do not appear to be widely known and are not mentioned in several of the best known books on metallurgical analyses which I have consulted. The ordinary method is to fuse with sodium peroxide in a nickel crucible or with sodium carbonate and potas. nitrate in a platinum crucible. Both these methods have well-known objections which need not be discussed here.

After doing this work in looking up methods for analyses I found that the method of decomposing silicon alloys had been used by at least one concern making ferro-silicon.

But in view of the fact that this method has not been widely published I thought this note might be of interest to the readers of the Journal.

GEORGE C. DAVIS.

#### THE DETERMINATION OF FREE SULPHUR IN CONDIMENTAL FEEDS, STOCK TONICS AND CONDITIONERS.

In the examination of condimental feeds, stock and poultry tonics, etc., under the recently enacted Condimental Feed Law of North Carolina<sup>1</sup> it was found to be a very important point to know exactly how much free sulphur the various preparations contained. Accordingly, a considerable amount of time was spent in trying various methods for the determination of free sulphur, and as none of them proved entirely satisfactory for the material in hand a method was finally worked out which gave satisfactory results and answered all the requirements for this class of work.

The condimental feeds,<sup>2</sup> conditioners, etc., to which this method was applied usually consist of a base material, such as wheat bran, middlings, oil meal or cotton-seed meal to which has been added various condiments and drugs. The most common vegetable drugs are pepper, fenugreek, ginger, turmeric, gentian, and licorice. The most common mineral drugs are salt, Glauber's salt, Epsom salts, calcium carbonate, sodium bicarbonate, saltpeter, sulphur, oxide of iron and black antimony. From this it will be seen that a method for determining free sulphur in these preparations must eliminate both the combined sulphur in the base material and the vegetable drugs and the combined sulphur in the mineral drugs in the form of sulphates and sulphides. These difficulties are best overcome by dissolving out the free sulphur by carbon bisulphide, which was used in the method as finally worked out. Quite a number of methods were tried applying them to the original sample and also to the sulphur after it had been extracted with carbon bisulphide. The accuracy of the methods was tested by applying them to a wheat feed to which 10 per cent. flowers of sulphur had been added, and after the present method had been worked out further tests were made with the various methods using the results as checks.

The first method tried was the Pozzi-Escot<sup>3</sup> method.

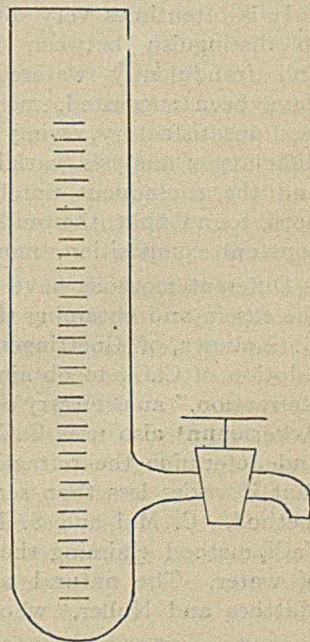
This method depends on the oxidation of the sulphur by chromic acid. Unsatisfactory results were obtained when the method was tried on flowers of sulphur and a composite sample so that it was not tested further.

The Avery<sup>1</sup> method for determining sulphur in insecticides was tried out fully. This method consists, briefly, in putting the sulphur in solution in sodium hydroxide solution (100 grams in 100 cc. water), then oxidizing with hydrogen peroxide and precipitating the sulphates with barium chloride. When applied to the composite sample and to two stock tonics of varying composition this method gave results too low to permit its being used. When applied to the sulphur extracted from these samples by carbon bisulphide the results were nearer correct, but were still too low. In this case the low results were attributed to the error introduced by the frothing of the solution and not to incomplete oxidation.

Oxidation with bromine was then tried in a somewhat similar manner to Eschka's<sup>2</sup> method for determining sulphur in coal. The sulphur was first taken up with sodium hydroxide solution and then oxidized by treating with saturated bromine water and the sulphates precipitated with barium chloride. This gave low results both on the original sample and the sulphur extracted from the samples.

Oxidation with chlorine gas, according to the method of Rivot, Beudant and Daguin,<sup>3</sup> when applied to the original samples gave high results. Further tests showed that the high results were caused by the oxidation of part of the sulphur of the base material.

The method as finally worked out is as follows: One gram of the sample is weighed into a side neck tube (see figure), 50 cc. carbon bisulphide added, the tube stoppered tightly, placed in a shaking machine and shaken for five hours. The tube is then taken out of the machine and allowed to stand overnight, thus giving a perfectly clear solution. 20 cc. of the solution = 0.4 gram of the sample are then drawn off, by means of the side neck, into a flask, the carbon bisulphide evaporated off and the flask dried in a water oven. The sulphur is then taken up with sodium hydroxide solution as in the Avery method, the solution diluted and the sulphur oxidized by passing in a stream of chlorine, the solution made acid and heated to expel chlorine, filtered and the sulphates precipitated with barium chloride. On



<sup>1</sup> Public Laws of North Carolina, 1909.

<sup>2</sup> A complete report of this work will be published in a bulletin of this Department at a later date.

<sup>3</sup> This method, published in *Rev. gen. chim. Appl.*, April 7, 1904, was used by J. P. Street, New Jersey Expt. Sta. *Bull.* No. 184, and the general procedure was very kindly furnished the author in a personal communication.

<sup>1</sup> Bureau of Chemistry, *Bull.* 90 and *Bull.* 107 (revised).

<sup>2</sup> *Z. anal. Chem.*, 13, 344. Fresenius "Quant. Anal.," Vol. II, revised, 1908.

<sup>3</sup> Fresenius "Quant. Anal.," Vol. I, revised, 1908.

the composite sample containing 10 per cent. sulphur this method gave 9.94 per cent. sulphur. Several duplicates made at the same time gave closely agreeing results. A number of determinations on stock tonics of varying composition gave satisfactory results with closely agreeing duplicates.

The side neck tubes used in the method, shown in the figure are heavy graduated glass tubes 16.4 cm. tall and 3.0 cm. in diameter with a side neck carrying a stopcock fused in about 5.0 cm. from the bottom of the tube. The use of this side neck was found to be the most satisfactory means of drawing out the aliquot portion. When the tubes are put in the shaking machine they are closed with tight-fitting cork stoppers. No trouble has been experienced by evaporation from this source. Settling the suspended particles in the tube by means of a centrifugal machine was tried, but with only a fair amount of success and it was found better, when time will permit, to allow the tubes to stand overnight before drawing off the aliquot, thus giving a perfectly clear solution. It was found most satisfactory to draw off the aliquot into an Erlenmeyer flask of about 450 cc. capacity. Then during the oxidation with chlorine the flask is closed with a two-hole stopper. One hole is used for the tube from the generator and the other is used for a waste tube to carry off the excess of chlorine gas.

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#### A COMPARISON BETWEEN THE REFRACTION AND THE SPECIFIC GRAVITY OF MILK SERUM FOR THE DETECTION OF ADDED WATER.

It is oftentimes very difficult for the food chemist to distinguish between honest low-standard milk and fraudulently watered milk. Various methods have been suggested, most of them being more or less unsatisfactory, owing to the time involved and difficulty of analysis, variability of the milk constants, and the consequent unreliability of results. It has been found that the milk serum possesses a fairly constant composition, more so than the milk itself.

Different methods have been used for precipitating the casein and obtaining the serum. G. Wiegner and G. Yakuwa, of Goettingen University,<sup>1</sup> use a dilute solution of CaCl<sub>2</sub> to obtain the serum. The "Specific Refraction," an arbitrary constant, is then determined. Ackermann<sup>2</sup> also uses CaCl<sub>2</sub> to precipitate the casein and determine the refraction of the serum, claiming that it varies less than serum obtained by any other method. C. Mai and S. Rothenfusser,<sup>3</sup> also use the CaCl<sub>2</sub> method, claiming they can detect four per cent. of water. The natural souring method is used by Matthes and Nuller,<sup>4</sup> who get very uniform results.

<sup>1</sup> "The Extent of Refraction and Specific Gravity of Calcium Chloride Serum of Milk," *Milchwirtsch. Zentr.*, 5, 473.

<sup>2</sup> "The Refractometric Detection of Added Water in Milk," *Z. Nahr.-Genuss.*, 16, 586.

<sup>3</sup> "The Refraction of Calcium Chloride Milk Serum," *Z. Nahr.-Genuss.*, 18, 737.

<sup>4</sup> "Über die Untersuchung des Milch Serums mit dem Zeiss'schen Eintansch-Refraktometer," *Z. für öffent. Chem.*, 3, 173.

The "Asaprol Method" is used by Baier and Neumann, but, owing to the dilution of the serum, is not regarded by some as accurate. Leach,<sup>1</sup> and Lythgoe and Nurenberg,<sup>2</sup> express preferences for the acetic acid method. As it is the method used in the following determinations, it is described in detail. To 100 cc. of milk add 2 cc. of 25 per cent. acetic acid (sp. gr. 1.035). Heat at 70° C. for 20 minutes in a beaker covered with a watch glass on the water bath. Then cool for 10 minutes in ice water and filter. If the first part of the filtrate is cloudy, it will usually clear up if refiltered through the same filter paper.

The serum being obtained in the above manner, the refraction at 20° C. is determined by the Zeiss immersion refractometer and the specific gravity at 15° C. by the Westphal balance accurately graduated to four places.

As a preliminary, the refraction and fat content of different milk samples from individual cows were determined, the fat being determined by the Babcock method.

TABLE 1.

Milk.	Refraction.	Per cent. fat.
Holstein, pure bred.....	39.8	3.4
Holstein, pure bred.....	39.2	3.4
Holstein, pure bred.....	43.0	3.0
Guernsey, pure bred.....	42.5	...
Guernsey, pure bred.....	47.3	4.7
Guernsey, pure bred.....	44.8	5.2
Guernsey, pure bred.....	42.7	3.3
Red Poll, pure bred.....	43.8	3.7
Red Poll, pure bred.....	41.9	6.2
Red Poll, pure bred.....	43.5	...
Jersey, pure bred.....	44.8	5.0
Jersey, pure bred.....	45.5	4.8
Angus, pure bred.....	43.2	4.2
Angus, pure bred.....	43.4	3.5
Short Horn, pure bred.....	44.0	4.1
Short Horn, pure bred.....	42.0	4.3
Devon, pure bred.....	43.2	4.6
Kerry, pure bred.....	42.7	5.2
Grade Red Poll, pure bred.....	41.3	4.4
Average.....	43.1	4.3
Highest (Guernsey).....	47.3	(Red Poll) 6.2
Lowest (Holstein).....	39.2	(Holstein) 3.0

This table shows variation in refraction from 39.2 to 47.3 and also shows there is no relation between the refraction and the fat content in the sample used.

Table 2 shows that milk serum from the same cow will vary in refraction if taken at different times. Hence it would seem impossible to estimate absolutely the amount of added water in a sample even when the original source of the milk is known unless the milk came from a large herd when it might be possible as the composite serum will vary less than the individual serum.

TABLE 2.

Milk.	First sample.	Two weeks later.
Guernsey.....	44.8	43.7
Holstein.....	39.2	40.8
Holstein.....	39.8	41.2
Short Horn.....	44.0	44.1
Guernsey.....	47.3	42.2
Red Poll.....	43.8	43.9
Angus.....	43.4	43.9

Table 3 shows milk systematically adulterated

<sup>1</sup> "Food Inspection and Analysis."

<sup>2</sup> "A Comparison of Methods for the Preparation of Milk Serum," THIS JOURNAL, 1, 38.

and shows the decrease in refraction and specific gravity as water is added.

TABLE 3.

Milk "A"	Refraction at 20° C.	Sp. gr. at 15° C.
0 per cent. H <sub>2</sub> O.....	41.9	1.0292
5 per cent. H <sub>2</sub> O.....	40.3	1.0269
10 per cent. H <sub>2</sub> O.....	39.4	1.0262
15 per cent. H <sub>2</sub> O.....	38.4	1.0247
20 per cent. H <sub>2</sub> O.....	36.6	1.0233
Milk "C"		
0 per cent. H <sub>2</sub> O.....	43.7	1.0313
5 per cent. H <sub>2</sub> O.....	42.2	1.0285
10 per cent. H <sub>2</sub> O.....	41.4	1.0280
15 per cent. H <sub>2</sub> O.....	39.4	1.0262
20 per cent. H <sub>2</sub> O.....	38.8	1.0251
25 per cent. H <sub>2</sub> O.....	36.5	1.0234
Milk "D"		
0 per cent. H <sub>2</sub> O.....	40.8	1.0275
5 per cent. H <sub>2</sub> O.....	38.9	1.0247
10 per cent. H <sub>2</sub> O.....	37.4	1.0237
15 per cent. H <sub>2</sub> O.....	35.8	1.0224
20 per cent. H <sub>2</sub> O.....	34.3	1.0205
25 per cent. H <sub>2</sub> O.....	33.8	1.0195
Milk "E"		
0 per cent. H <sub>2</sub> O.....	43.0	1.0280
5 per cent. H <sub>2</sub> O.....	40.7	1.0263
10 per cent. H <sub>2</sub> O.....	..	..
15 per cent. H <sub>2</sub> O.....	39.3	1.0243
20 per cent. H <sub>2</sub> O.....	37.0	1.0220
25 per cent. H <sub>2</sub> O.....	35.9	1.0209
Milk "F"		
0 per cent. H <sub>2</sub> O.....	41.2	1.0320
5 per cent. H <sub>2</sub> O.....	39.6	1.0259
10 per cent. H <sub>2</sub> O.....	37.9	1.0231
15 per cent. H <sub>2</sub> O.....	36.2	1.0219
20 per cent. H <sub>2</sub> O.....	35.9	1.0202
Milk "G"		
0 per cent. H <sub>2</sub> O.....	44.2	1.0306
5 per cent. H <sub>2</sub> O.....	41.2	1.0277
10 per cent. H <sub>2</sub> O.....	39.4	1.0251
15 per cent. H <sub>2</sub> O.....	38.7	1.0238
20 per cent. H <sub>2</sub> O.....	36.4	1.0220
25 per cent. H <sub>2</sub> O.....	35.8	1.0217

The average decrease in refraction due to every 10 per cent. of added water is 2.7. The average refraction of all the pure samples used is 42.8, the refraction of water 15.0. By a mathematical calculation it is determined that 10 per cent. added water should lower the refraction 2.8, corresponding very closely with the results found.

100 per cent. milk.....	42.8
100 per cent. H <sub>2</sub> O.....	15.0
90 per cent. milk.....	38.5
10 per cent. H <sub>2</sub> O.....	1.5
90 per cent. milk, 10 per cent. H <sub>2</sub> O.....	40.0
42.8 — 40.0 = 2.8, decrease due to 10 per cent. water.	

The average decrease in specific gravity due to every 10 per cent. added water is 0.0031. The average specific gravity of all pure samples is 1.0291 at 15° C. The specific gravity of water at 15° C. is 0.9991. By calculation it is determined that 10 per cent. of added water should decrease the specific gravity of the serum 0.0030, corresponding within 0.0001 of the results found.

100 per cent. milk.....	1.0291
100 per cent. H <sub>2</sub> O.....	0.9991
90 per cent. milk.....	0.92619
10 per cent. H <sub>2</sub> O.....	0.09991
90 per cent. milk, 10 per cent. H <sub>2</sub> O.....	1.0261
1.0291 — 1.0261.....	0.0030

Woodman<sup>2</sup> finds that 10 per cent. added water lowers the specific gravity of the serum 0.0031 and

<sup>1</sup> *J. Am. Chem. Soc.*, 21, 503 (1899).

attempts to show that he can accurately estimate the amount of water added by taking that figure. Owing to the variability of the specific gravity of various milk serums it would not seem feasible. The pure samples examined by the author vary from 1.0270 to 1.0320.

Radulescu<sup>1</sup> and König<sup>2</sup> both state that 10 per cent. of added water decreases the specific gravity of the serum 0.0003-0.0010. All other results point toward 0.0031 as nearer the exact figure.

Most authorities take the lowest limit of refraction for pure milk serum as 39.0 regarding samples under 40.0 as suspicious. This corresponds to the results found by the author. Two Holstein samples were found under 40.0 but it is very unlikely that the composite milk of the herd, even of Holsteins, would run under 40.0. Of fourteen systematically adulterated, individual samples, 5 per cent. added water (by volume) was distinguishable in four cases, taking 39.0 as the limit of pure milk, and the milk would be regarded as "suspicious" in three more cases. 10 per cent. added water was distinguished in six cases and was "suspicious" in three cases. 15 per cent. added water is distinguishable in nine cases and was "suspicious" in five cases. 20 per cent. added water was distinguishable in every sample.

1.0270 is regarded by most authorities as the low limit for the specific gravity of pure milk serum at 15° C. Leach and Lythgoe<sup>3</sup> present figures showing pure Holstein milk running as low as 1.0253 but in every case the milk itself had a specific gravity under the legal standard, 1.0290. The author has been unable to find any other authorities presenting authentic figures as low. Milks "M" and "N" were taken from the first milkings of Holstein cows but did not run under the limit, 1.0270. Hence, 1.0270 has been taken as the low limit for pure milk serum.

The specific gravity of the serums of the 14 individual samples (Table 3, part) was determined on the same serum as the refraction, with the result that 5 per cent. added water is distinguishable in 8 cases. 10 per cent. added water is distinguishable in twelve cases and 15 per cent. of water in fourteen cases.

From the above results it would appear that the specific gravity of the serum is a much more delicate test for added water than the refraction, but owing to the fact that all authorities are not agreed as to the low limit of the specific gravity of pure milk serum, the author would say that it is not as reliable in all cases as the refraction. Both methods combined should furnish both a delicate and reliable guide to the detection of added water in milk. As both the methods may be used on the same serum, and as the determinations are easily made after the serum has been obtained, it appears that a combination of the two methods would insure the certain

<sup>1</sup> "Mittl. ans dem pharm. Ins. und Laboritorium für ang. chem. der Univ. Erlangen (1890)" 3, 93.

<sup>2</sup> "Die Untersuchung landwirtschaftlich und gewerblich wichtiger Stoffe," Ed. (1898), 36.

<sup>3</sup> "The Detection of Watered Milk," *J. Am. Chem. Soc.*, 26, 1195 (1904).

detection of added water, if in any quantity as would be used in fraudulently adulterated milk.

SLEETER BULL.

OHIO STATE UNIVERSITY,  
COLUMBUS, OHIO.

## BOOK REVIEWS AND NOTICES.

**High Speed Steel.** The Development, Nature, Treatment, and Use of High Speed Steels, together with some suggestions as to the Problems Involved in Their Use. By O. M. BECKER, Industrial Engineer. Cloth, pp. v + 344. McGraw-Hill Book Company, 1910. Price, \$4.00 net.

A very good book from both practical and theoretical standpoints. In a general way the development of high-speed steel and the marvelous advance it has caused in machine operation and output are known, but one begins to understand the real magnitude of that advance as he turns the pages of this book.

The first chapters give a short history of the development of metal cutting from earliest times and methods of manufacture of the ancient steels, including the famous Wootz and Damascus brands, the later crucible, open-hearth, Bessemer and electric furnace processes, relate the discovery of Mushet—the forerunner of the high-speed steels, and the extensive experiments of Taylor and White which resulted in the wonderful steels which we have to-day. Tables are given of the chemical composition of the various types, and their properties and requirements for hardening explained according to the latest and accepted theories of metallurgy. The author has had the aid of such well-known metallurgists as Carpenter, Taylor, Stoughton, and others, in ways of suggestion, criticism, use of material, proof-reading, etc. The metallographical explanations and photomicrographs are good and make clear the theories.

The balance and larger part of the book is devoted to the practical part of the subject: the making of the steel, forging the tools, hardening, tempering, annealing, grinding, etc. The descriptions of the various types of hardening and annealing furnaces, pyrometers, machines, etc., are very complete, and apparently no usable type is omitted. Chapters are given on speeds and feeds, new requirements for machines, notes on remodeling old equipment and the problems involved. The book is well illustrated. In the appendix are given several practical tables. The volume should be of much assistance to the superintendent, metallurgist or practical tool man.

I. M. BREGOWSKY,  
L. W. SPRING.

**Der Kautschuk und seine Prüfung.** By F. W. HINRICHSSEN and K. MEMMLER. 8vo, pages x + 263. Leipzig: S. Hirzel, 1910. Price: Paper, 8 marks; cloth, 9 marks

This is, doubtless, the most comprehensive work that has been published up to date on rubber and is particularly valuable in the rubber industry to those interested in the physical testing of vulcanized rubber. A glance over the table of contents gives the

best idea of the scope and thoroughness with which the work has been carried out. (I) *General Part*, by F. W. Hinrichsen. (A) Introduction, (B) Occurrence of Rubber, (C) Properties of the Latex, (D) Constitution of the Rubber Hydrocarbon, (E) Other Substances Associated with the Rubber Hydrocarbon in Crude Rubber, (F) Physical Properties of Crude Rubber, (G) Chemical Properties of Crude Rubber, (H) Theory of Vulcanization of Rubber, (I) Technical Handling of Rubber Materials, (J) The Properties of Vulcanized Rubber. (II) *Chemical Analysis of Rubber*, by F. W. Hinrichsen. (A) Analysis of Crude Rubber, (B) Analysis of Vulcanized Rubber, (C) Life Tests of Finished Rubber Articles. (III) *Mechanical Testing of Rubber*, by K. Memmler. (A) The Practical Carrying Out of Strength Tests on Soft Rubber. (B) Results of Strength Tests on Soft Rubber according to the Older and More Recent Publications.

The authors have compiled and arranged very excellently the work of the older and modern investigators in the field of rubber testing. Of particular interest is the attention given to the physical testing of vulcanized rubber, a division of the subject in most other works that has been given but slight attention. Nevertheless, from the standpoint of our knowledge of rubber as a material of construction it is one of the most important. The discussion of tensile tests, the pressure tests, the machines and apparatus, the elongation curves, the hysteresis curves, is very admirably written.

W. C. GIN.

**Die Chemie der Cellulose.** By CARL G. SCHWALBE. First Half. 8vo. pp. 272. Berlin: Gebrüder Borntraeger, 1910.

This work is unquestionably the best on the chemistry of cellulose which has as yet been published. While it is largely bibliographic in its text, its construction and method of handling is excellent. This first half deals with cotton cellulose as a type, and considers its behavior and relation towards water, heat, alkalis, acids, salts, dyes, oxidation and reducing agents, solvents and ferments. The cellulose products produced by hydrolysis and oxidation are treated at some length. The conclusion of the first half commences the consideration of the esters of cellulose which, as stated, are to be handled fully in the second half to be published very soon.

H. S. MORK.

**Die Unterscheidung der Natürlichen und Künstlichen Seiden.** By DR. ALOIS HERZOG. Paper, 12mo., pp. 78. Dresden: Theodor Steinkopff, 1910. Price, 75 cents.

This small pamphlet, containing fifty excellent microphotographs and illustrations, treats in a full and complete manner of the methods of differentiating the various artificial silks from each other and from the natural product. While both chemical and optical methods are given, the latter receive the greater attention. Excellent photographs are shown of the appearance of the fibers under the ultramicroscope at a magnification of 2500.

H. S. MORK.

**Testing for Metallurgical Processes.** By JAMES A. BARR. 12mo. Cloth, pp. 208. San Francisco: Mining and Scientific Press, 1910. Price, \$2.00.

This book is based upon notes and experiments made by the author, while instructor at the Michigan College of Mines, and aims to describe laboratory experiments and methods of testing ores which will enable the student to secure definite data upon which to base an opinion as to the most available method for the extraction of a metal from its ore. It deals with the ores of gold, silver, copper and zinc, and describes the principles upon which depend the effective application of the various well-known processes, including amalgamation, chlorination, cyanidation, roasting, refining of lead bullion, zinc smelting, and smelting of lead silver ores. An interesting chapter on the properties of slags is especially worthy of mention. The illustrations of this book are simple and clear. The book presupposes at least an elementary knowledge of chemistry, but its style is extremely practical. This publication should prove of value not only to students but also to those interested in the mining or the treatment of the metals mentioned.

WM. HOSKINS.

**Practical Stamp Milling and Amalgamation.** By H. W. McFARREN. 12mo. Cloth, pp. 165. San Francisco: Mining and Scientific Press, 1910. Price, \$2.00.

This is a practical book and does not pretend to be anything else. The author has evidently told what he has learned in the practice of milling and amalgamation, and tells it as one who knows little of the subject would like to have it told, in sufficient detail. The book can be recommended to those employed in the stamp mill or having to do with the treatment of gold ores by the ordinary milling processes. The book is particularly valuable to a person about to engage in the mining or milling of gold ores.

WM. HOSKINS.

## SCIENTIFIC AND INDUSTRIAL SOCIETIES.

### ASSOCIATION OF FEED CONTROL OFFICIALS.

The second annual meeting of the Association of Feed Control Officials was held at the Raleigh Hotel, Washington, D. C., November 14-16th. There were in attendance at the meeting some eighty feed control officials, manufacturers and their representatives, representing practically all sections of the United States and all phases of the feeding-stuff trade.

The most important subject before the convention was the adoption of a draft for a uniform feeding-stuff law for the states and uniform definitions.

The program was carried out as follows:

#### FIRST DAY—MORNING SESSION.

Monday, November 14, 1910, 10 o'clock.

Raleigh Hotel, Washington, D. C.

1. Convention called to order by the President, Benj. L. Purcell, Virginia.
2. Roll Call.
3. Appointment of Committees.
4. President's Address—Benj. L. Purcell, Virginia.
5. Report of Executive Committee—L. F. Brown, *Chairman*, New York.
6. Report of Committee on Credentials.
7. New Business.

#### Recess.

#### AFTERNOON SESSION, 2 O'CLOCK.

Discussion of that part of report of the Executive Committee relating to a Uniform Law and Definitions for Feeds.

By Feeders, Individual Manufacturers and Representatives of Trade Associations.

#### Executive Session.

#### SECOND DAY—MORNING SESSION.

Tuesday, November 15, 1910, 10 o'clock.

1. Reports of Committees.
2. Address—Importance of Making Feed out of Sound Material—Dr. H. W. Wiley, Chief U. S. Bureau Chemistry.
3. Address—Coöperation between Feed Dealer and Executive of the Law—Dr. C. D. Woods, Maine.
4. Address—The Manufacturers' Position and Needs—Robt. W. Chapin, Buffalo, N. Y.
5. Discussion of the above addresses.
6. Unfinished Business.

#### SECOND DAY—AFTERNOON SESSION, 2 O'CLOCK.

#### EXECUTIVE SESSION.

Discussion of Uniform Feeding Stuff Law and Definition for Feeds.

Open to Members of this Association only.

#### THIRD DAY.

Wednesday, November 16, 1910, 10 o'clock.

1. Reports of Committees.
2. Continued discussion of a Uniform Feeding-Stuff Law and Definitions for Feeds.
3. Election of Officers and Executive Committee for ensuing year.
4. Unfinished business.

#### Adjournment.

The meeting was a very profitable and valuable one to all concerned and resulted in definite steps being taken toward the adoption of a uniform law. After a full and free discussion by the feed control officials and manufacturers present, the draft for a proposed uniform law (see below) was adopted. On motion the Committee on Definitions was continued. Definitions prepared by the committee covering some fifty terms used in the feeding-stuff trade were tentatively adopted and ordered published for the information of the trade and to elicit criticism. The Executive Committee was instructed to consider the advisability of amalgamating with some other association engaged in work similar to that of the feed control. The report of the Nominating Committee was unanimously adopted and the following officers were elected:

*President*, L. F. Brown, New York; *Vice-President*, W. P. Hand, Mississippi; *Secretary and Treasurer*, J. D. Turner, Kentucky; *Executive Committee*, W. D. Woods, Maine, J. K. Haywood, U. S. Department of Agriculture, and W. J. Jones, Jr., Indiana.

Association adjourned at noon, November 16th, subject to call of Executive Committee.

#### PROPOSED UNIFORM FEED LAW.

SECTION 1.—The term "Commercial Feeding-Stuffs" shall be held to include all feeding-stuffs used for feeding live stock and poultry, except whole seeds or grains; the unmixed meals made directly from the entire grains of corn, wheat, rye, barley, oats, buckwheat, flaxseed, kaffir and milo; whole hays, straws, cottonseed hulls and corn stover when unmixed with other materials. Together with all other materials containing 60 per cent. or more of water.

SEC. 2.—Every lot or parcel of commercial feeding-stuffs sold, offered or exposed for sale or distributed within this state shall have affixed thereto a tag or label, in a conspicuous place on the outside thereof, containing a legible and plainly printed statement in the English language, clearly and truly certifying:

- (a) the net weight of the contents of the package, lot or parcel;
- (b) the name, brand or trade mark;
- (c) the name and principal address of the manufacturer or person responsible for placing the commodity on the market;

- (d) the minimum per centum of crude protein;
- (e) the minimum per centum of crude fat;
- (f) the maximum per centum of crude fiber;
- (g) the specific name of each ingredient used in its manufacture.

The crude protein, crude fat and crude fiber shall be determined by the methods in force at the time by the Association of Official Agricultural Chemists of the United States.

SEC. 3. Before any manufacturer, importer, jobber, firm, association, corporation or person shall sell, offer or expose for sale or distribute in this state any commercial feeding-stuffs, he or they shall file with . . . . . a certified copy of the statement specified in Section 2 for each brand of commercial feeding stuffs; said certified copy to be accompanied, when the . . . . . shall so request, by a sealed package containing at least one pound of the commercial feeding-stuffs to be sold, offered or exposed for sale or distributed in this state, and the company or person furnishing said sample shall thereupon make affidavit that the said sample is representative of the commercial feeding-stuffs offered for registration.

SEC. 4.—(The provisions of this section are proposed for the benefit of those states who may not secure a direct appropriation from the legislature to cover the expenses enforcing the law.) Each and every manufacturer, importer, jobber, firm, association, corporation or person manufacturing or selling any commercial feeding-stuffs as defined in Section 1 of this act shall pay to the . . . . . an inspection tax or fee of . . . . . per . . . . . for each brand of commercial feeding-stuffs sold, offered or exposed for sale or distributed in this state, and shall affix to, or accompany, each lot shipped in bulk, and to each parcel of such commercial feeding-stuffs a tag, stamp or label to be furnished by the . . . . . stating that all charges specified in this section have been paid. Whenever any commercial feeding-stuff as defined in Section 1 is offered or exposed for sale in bulk or otherwise stored, the manufacturer, importer, jobber, firm, association, corporation or person keeping the same for sale shall keep on hand cards upon which shall be printed the statement required by the provisions of Section 2, and when such feeding-stuff is sold at retail in bulk or in packages belonging to the purchaser, the manufacturer, importer, jobber, firm, association, corporation or person shall furnish the purchaser with sufficient tax tags or stamps to cover the sale, and, upon request, with a card or cards upon which appears the statement required by the provisions of Section 2.

SEC. 5.—The . . . . . shall have power to refuse to register any commercial feeding-stuffs under a name, brand or trade mark which would be misleading or deceptive, or which would tend to mislead or deceive as to the materials of which it is composed, or when the specific name of each and all ingredients used in its manufacture are not stated. He shall also have the power to refuse to register more than one commercial feeding-stuff under the same name or brand when offered by the same manufacturer, importer, jobber, firm, association, corporation or person. Should any commercial feeding-stuffs be registered in this state, and it is afterward discovered that such registration is in violation of any of the provisions of this act, the . . . . . shall have the power to cancel such registration. The . . . . . shall have the power to refuse to allow any manufacturer, importer, jobber, firm, association, corporation or person to lower the guaranteed analysis or change the ingredients of any brand of his or their commercial feeding-stuffs during the term for which registered, unless satisfactory reasons are presented for making such change or changes.

SEC. 6.—Whenever a manufacturer, importer, jobber, firm, association, corporation or person manufacturing or selling a

brand of commercial feeding-stuffs shall have filed the statement required by Section 3, and paid the inspection tax or fee, as required by Section 4, of this act, no other agent, importer, jobber, firm, association, corporation or person shall be required to file such statement or pay such tax or fee upon such brand.

SEC. 7.—The . . . . . is authorized in person or by deputy to have free access to all places of business, mills, buildings, carriages, cars, vessels, and parcels of whatsoever kind used in the manufacture, transportation, importation, sale or storage of any commercial feeding-stuffs, and shall have the power and authority to open any parcel containing or supposed to contain any commercial feeding-stuffs, and upon tender and full payment of the selling price of said sample, to take therefrom, in the manner prescribed in Section 8, samples for analysis, and said . . . . . shall annually cause to be analyzed at least one sample so taken of every commercial feeding-stuff that is found sold, offered or exposed for sale or distributed in this state.

SEC. 8.—A representative sample of each brand of commercial feeding-stuffs found, sold, offered or exposed for sale shall be taken by the said . . . . . or his duly authorized representative in the presence of at least one witness. No action shall be maintained for a violation of the provisions of this act, based upon an analysis of a sample from less than five separate original packages, unless there be less than five separate original packages in the lot, in which case portions for the official sample shall be taken from each original package; if the commercial feeding-stuffs are in bulk, portions shall be taken from not less than five different places in the lot, provided that this does not exclude sampling in bulk when not exposed sufficiently to take portions from five different places, in which case portions are to be taken from as many places as practicable. If the sample thus secured is larger than is required, it shall be mixed and quartered until a sample of suitable size remains. Said sample shall be divided into two parts, and shall be placed in packages and sealed in the presence of said witness; one of said packages so sealed shall be tendered, and if accepted, delivered to the person apparently in charge of such feeding-stuffs; the other package the said . . . . . shall analyze or cause to be analyzed and the result, of such analysis, together with such additional information as the said . . . . . may deem advisable, shall be promptly transmitted to the manufacturer or person responsible for the placing of the commodity on the market, and shall be published in reports or bulletins from time to time. If the manufacturer or person responsible for the placing of any commodity so sampled upon the market be unable to secure the sample delivered to the person apparently in charge of the feeding-stuffs sampled, he shall upon request to the . . . . . be furnished with a portion of the official sample referred to in this section. The methods of analysis shall be those in force at the time by the Association of Official Agricultural Chemists of the United States.

SEC. 9.—If it appear that any of the provisions of this act has been violated, the . . . . . shall certify the facts to the proper prosecuting attorney and furnish that officer with a copy of the results of the analysis or other examination of such feeding-stuffs duly authenticated by the analyst or other officer making the determination, under the oath of such officer, provided that if it shall appear from any such examination that any of the provisions of this act have been violated the . . . . . shall cause notice to be given to the manufacturer or dealer from whom said sample was taken; any party so notified shall be given an opportunity to be heard in his defense under such rules and regulations as may be prescribed by the . . . . . before the facts shall be certified to the proper prosecuting attorney. In all prosecutions arising under the provisions of this act, certificates of the analyst or



other officer making the examination or analysis, when duly sworn to by such officer, shall by *prima facie* evidence of the fact or facts therein certified.

SEC. 10.—Any manufacturer, importer, jobber, firm, association, corporation or persons who shall sell, offer or expose for sale, or distribute in this state, any commercial feeding-stuffs without having attached thereto or furnished therewith such tax stamps, labels or tags as required by the provisions of this act, or who shall use the required tax stamps, labels, or tags a second time, or use a counterfeit of such tax stamps, labels, or tags, or who shall impede, obstruct, hinder or otherwise prevent or attempt to prevent said . . . . . or his authorized agent in the performance of his duty in connection with the provisions of this act, or who shall sell, offer or expose for sale or distribute in this state any commercial feeding-stuffs as defined in Section 1, without complying with the requirements of the provisions of this act, or who shall sell, offer or expose for sale or distribute in this state any commercial feeding-stuffs which contain a small per centum of crude protein or crude fat or a larger per centum of crude fiber than is certified to be contained therein, or who shall fail to properly state the specific name of each and every ingredient used in its manufacture shall be deemed guilty of a violation of the provisions of this act and upon conviction thereof shall be fined not more than one hundred dollars (\$100.00) for the first violation and not less than one hundred dollars (\$100.00) for each subsequent violation. Any manufacturer, importer, jobber, firm, association, corporation or person who shall mix or adulterate any feeding-stuffs with any substance or substances injurious to the health of live stock or poultry shall be deemed guilty of a violation of the provisions of this act, and in addition to the penalty provided in this section, the lot of feeding-stuffs shall be subject to seizure, condemnation and sale as the court may direct, the proceeds from such sale to be covered into the state treasury. The court may in its discretion release the feeding-stuffs so seized when the requirements of the provisions of this act have been complied with, and upon payment of all costs and expenses incurred by the state in any proceedings connected with such seizure. (Proceedings in *rem*. . . . . Seizure of goods believed to be shipped or sold in violation of law does not work a forfeiture of them; this can only be declared by a court of competent jurisdiction. The general rule is that a court proceeding in *rem* must have the custody of the *res* in order to pronounce a valid judgment. The goods cannot be condemned without giving the defendant opportunity to be heard. He is not entitled to personal notice before the court can adjudge a forfeiture of his property, but he must have noticed, either actual or constructive, or the proceeding will be void. The title to property as to which an act of forfeiture has been committed is not divested *co instanti* by the offense, but only by the judgment or decree of a court having jurisdiction; and if after the seizure possession is abandoned and forfeiture not decreed, the title and right of possession is in the original owners.

Legal advice to committee is to the effect that no addition can be made to proposed law which would satisfactorily meet the requirements of different states relative to proceedings in *rem*. Some states will require no additional legislation. States which will require additional legislation must so word such legislation as to meet the requirements of the different conditions existing in each individual state.

SEC. 11.—The . . . . . is hereby empowered to enforce the provisions of this act and to prescribe the form of tags, stamps or labels to be used to show that the inspection tax or fee has been paid, and to prescribe and enforce such rules and regulations relating to the sale of commercial feeding-stuffs as he may deem necessary to carry into effect the full intent and meaning of this act.

SEC. 12.—All laws or parts of laws in conflict with the provisions of this act are hereby repealed.

The following resolution was presented by the Committee of the Whole and adopted by the Association.

"This committee report to the convention that they recommend that the Committee on Definitions be continued one year and that these tentative definitions be published as they stand to-day, for the information of the trade and to elicit criticism."

*Meal* is the clean, sound, ground product of the entire grain, cereal or seed which it purports to represent, provided, that the following meals, qualified by their descriptive names, are to be known, as *viz.*, *corn germ meal* is a product in the manufacture of starch, glucose and other corn products and is the germ layer from which a part of the corn oil has been extracted. *Cottonseed meal* is the meal obtained from the cottonseed kernel after extraction of part of the oil and contains not less than 38.50 per cent. of crude protein. *Linseed meal* is the ground residue after extraction of part of the oil from ground flax seed. *Bolted corn meal* is the entire ground product of corn, bolted.

*Grits* are the hard, flinty portions of Indian corn.

*Hominy meal, feed or chop* is the bran coating and germ of the corn kernel and may contain a part of the starchy portion of the kernel.

*Corn feed meal* is the siftings obtained in the manufacture of cracked corn and table meal made from the whole grain.

*Gluten meal* is a product obtained in the manufacture of starch and glucose from corn and is the flinty portion of the kernel which lies in its outer circumference just beneath the hull. If the meal is derived from any other cereal, the source must be designated.

*Corn bran* is the outer coating of the corn kernel.

*Gluten feed* is a product obtained in the manufacture of starch and glucose from corn and is a mixture of gluten meal and corn bran to which may be added the residue resulting from the evaporation of the so-called "steep-water." If derived from any other cereal, the source must be designated.

*Wheat bran* is the coarse outer coating of the wheat berry.

*Shorts or standard middlings* are the fine particles of the outer bran as well as the inner or "bee-wing" bran separated from the wheat bran and white middlings.

*Shipstuff or wheat mixed feed* is a mixture of the by-products from the milling of the wheat berry.

*White wheat middlings* are that part of the offal from wheat left after separating it from the bran and the shorts or standard middlings.

*Red dog* is a low-grade wheat flour containing the finer particles of bran.

*Oat groats* are the kernels of the oat berry with the hulls removed.

*Oat shorts or oat middlings* are the starchy portion of the oat groats obtained in the milling of rolled oats.

*Oat hulls* are the outer covering of the oat grain.

*Oat clippings* are the small hairs, dust and ends of oats separated from the oats in the clipping process and may contain light oats and oat hulls.

*Rice bran* is the inner cuticle of the rice hull.

*Rice polish* is the flour secured from the surface of the rice kernels in polishing.

*Rice meal or flour* is the clean ground rice.

*Rice hulls* are the outer covering of the rice grain.

*Flax seed meal* is the entire flax seed ground.

*Flax plant refuse* is the flax shives, flax pods, inferior flax seeds and the woody portion of the flax plant or any of the above materials.

*Buckwheat shorts or middlings* are that portion of the buck-

wheat grain immediately inside of the hull after separation from the flour.

*Blood meal* is finely ground dried blood.

*Meat meal* is finely ground beef scraps. If it bears a name descriptive of its kind, composition or origin, it must correspond thereto.

*Cracklings* are the residue after extracting the fats and oils from the animal tissue. If it bears a name descriptive of its kind, composition or origin, it must correspond thereto.

*Digester tankage* is meat scraps from edible carcasses which have been inspected and passed as satisfactory for human consumption, especially prepared for feeding purposes through tanking under live steam, drying under high heat and suitable grinding.

*Distillers' dried grains* are the dried residue from cereals obtained in the manufacture of alcohol and distilled liquors. The product shall bear a designation indicating the cereal predominating.

*Brewers' dried grains* are the dried residue from cereals obtained after "mashing and sparging" the malt.

*Malt sprouts* are the sprouts of the barley grain. If the sprouts are derived from any other mated cereal, the source must be designated.

*Cottonseed feed* shall be a mixture of cottonseed meal and cottonseed hulls containing less than 38.50 per cent. of crude protein and shall be plainly marked "mixture of cottonseed meal and cottonseed hulls."

*Alfalfa meal* is the entire alfalfa hay ground and does not contain an admixture of ground alfalfa straw or other foreign materials.

*Chop* is a ground or chop feed composed of one or more different cereals or by-products thereof.

*Screenings* are the smaller imperfect grains, weed seeds and other foreign materials having feeding value, separated in cleaning the grains. They shall be designated by the name of the seed from which they are derived.

*Barley bran* is a misnomer.

*Cottonseed bran* is a misnomer.

*Elevator feed* is a misnomer.

*Cottonseed meal feed* is a misnomer.

*Cottonseed feed meal* is a misnomer.

*Oat feed* is a misnomer unless applied to whole ground oats.

*Flax seed* is a misnomer unless applied to whole ground flax seed.

*Flax bran* is a misnomer.

*Oat nubbins* is a misnomer.

*Buckwheat feed* consisting of buckwheat middlings and hulls is a misnomer.

*Gluten feed* as applied to distillers' grains is a misnomer.

#### LAKE MICHIGAN WATER COMMISSION.

##### PROGRAM OF THE EIGHTH MEETING, CHICAGO, DECEMBER 17, 1910.

12 noon. Informal luncheon, Drexel Café, 39th St. and Cottage Grove Avenue.

1.30 P.M. Meeting at the Pumping Station, Sanitary District of Chicago, 39th St. and Lake Michigan.

"Sanitary Conditions of the Calumet River in Indiana," J. H. Brewster, chemist, Indiana State Board of Health.

"Disposal of Starch Factory Wastes," T. B. Wagner and O. H. Sjostrom, Corn Products Refining Co., Chicago.

"Sewage Experiment Station, Sanitary District of Chicago," Langdon Pearse and Dr. Arthur Lederer, Sanitary District of Chicago.

W. A. EVANS, M.D., *President*,  
EDWARD BARTOW, *Secretary*.

#### NATIONAL COMMERCIAL GAS ASSOCIATION.

SIXTH ANNUAL CONVENTION, BOSTON, DECEMBER 6-9, 1910.

The National Commercial Gas Association convened in Boston, Mass., on the above-mentioned dates and carried out a long and interesting program. A prominent feature of the convention was an exhibition of gas appliances and apparatus of all types which was open to the general public from December 7-13. A most interesting part of the exhibit was a complete operating plant showing the manufacture of incandescent gas mantles. The process was carried out from the knitting of the fabric to the packing of the final product and occupied the entire stage of the Mechanics Hall where the convention was held. The exhibition was made by the Welsbach Company and proved of the greatest interest both to the gas men and members in attendance at the convention and the public.

#### AMERICAN CHEMICAL SOCIETY.

##### METHODS OF ANALYSIS AND TESTS OF FATS AND OILS SUGGESTED BY THE SPECIAL COMMITTEE OF COMMITTEE ON THE UNIFORMITY OF ANALYSIS OF FATS AND FATTY OILS.

(These methods are proposed tentatively with the object of inviting criticism and discussion.)

###### 1. MOISTURE AND VOLATILE MATTER.

*Weighing Out Sample.*—By the application of gentle heat soften, but do not melt, the sample, and emulsify thoroughly by means of a mechanical egg beater (or other suitable device). Of the thoroughly emulsified sample weigh out for the standard methods from 5 to 20 grams according to the method used from weighing bottle into a watch glass or shallow glass dish whose sides are not more than 1 cm high.

*Standard Method No. 1, Moisture and Volatile Matter at 110° C.*—A 5-10 gram sample weighed out as above is heated in an oven held at a constant temperature of 110° C. until constant weight is attained. Constant weight is attained when successive weighings thirty minutes apart show a loss of not more than 0.05 per cent.

*Standard Method No. 2, Moisture and Volatile Matter.*—A 5-10 gram sample weighed out as above is heated in a vacuum oven held at 50° C. under a pressure of not more than 30 mm. of mercury for four hours. (The tension of water vapor at 50° C. is 92 mm.)

*Routine Method, Moisture and Volatile Matter.*—The sample weighed out in a glass or aluminum beaker as above is heated on a heavy asbestos board over burner or hot plate, the sample at no time being allowed to reach a temperature greater than 130° C. During the heating the beaker is rotated gently on the board by hand to avoid sputtering or too rapid evolution of moisture. The proper length of time of heating is judged by absence of condensation on a cold watch glass held over the beaker, by the absence of rising bubbles of steam, by the absence of foam or by other signs known to the operator. Cool in desiccator and weigh. Report loss as moisture.

###### 2. MOISTURE.

The term "moisture," as here used, refers to the chemical substance "water" physically incorporated in the fats and fatty oils.

*Standard Method.*—(Similar to that mentioned by Ubbelohde.)

100 grams of the sample are mixed with 100 cc. of xylene in a suitable distilling flask, and about 50 cc. slowly distilled off over a free flame. The distillate containing the water is collected in a tube 0.75 cm. diameter graduated in 1/10 cc., and the percentage of water read off directly from the volume of

water contained in the tube. Correction is to be made for the solubility of water in xylene. Details to be supplied.

Note: The boiling point of xylene is 138° C.

### 3. SUSPENDED IMPURITIES.

*Definition*—Suspended impurities in fats and fatty oils are those non-fatty solid substances physically incorporated therewith and insoluble in hot petroleum ether, such as particles of wood, coal, fibers, and mineral matter. They are determined by the standard method given below.

*Determination: Standard Method*.—A sufficiently large sample to be representative should be weighed out and dried, or the residue from a moisture and volatile matter determination may be used. Usually from 5–20 grams should be used. The sample is dried in a beaker over asbestos board, keeping the beaker in motion by hand to prevent sputtering. The sample is then dissolved in hot petroleum ether (B. P. 50–70° C.) by gentle boiling on a water bath, filtered on a Gooch crucible or porous crucible, washed thoroughly with a boiling petroleum ether (B. P. 50–70° C.), dried to constant weight and weighed.

### 4. FREE FATTY ACIDS.

*Preparing Neutral Alcohol*.—Take commercial 95 per cent. alcohol, add 50 grams powdered caustic soda per liter, boil with reflux condenser for a period of six hours, allow to stand for twenty-four hours, and then distil. Alternate method.

*Determination*.—From 5–15 grams of the sample are weighed into an Erlenmeyer flask (100 cc. capacity) and melted on the steam bath, if solid at ordinary room temperature. Add 100 cc. of hot neutral alcohol. Titrate with N/2, N/4 or N/10 sodium hydrate, using phenolphthalein as indicator. Where the fat is known to have a mean molecular weight of 282 or thereabouts, that figure is to be used in calculating the percentage of free fatty acids. Report also the acid number: milligrams KOH required to neutralize 1 gram. The percentage of free fatty acids is to be calculated on the basis of sample freed from moisture and volatile matter.

### 5. TITER.

Bureau of Chemistry, Bulletin 107, Revised.

*Method Proposed by L. M. Tolman as Follows*.—Weigh 75 grams of fat into a metal dish, and saponify by using 60 cc. of 30 per cent. sodium hydrate (36° Beaumé caustic soda) and 75 cc. of 95 per cent. by volume alcohol, or 120 cc. of water. Boil down to dryness, with constant stirring, to prevent scorching. This should be done over a very low flame or over an iron or asbestos plate. Dissolve the dry soap in a liter of boiling water, and if alcohol has been used boil for forty minutes in order to remove it, adding sufficient water to replace that lost in boiling. Add 100 cc. of 30 per cent. sulphuric acid (25° Beaumé sulphuric acid) to free the fatty acids, and boil until they form a clear transparent layer. Collect the fatty acids in a small beaker and place on the steam bath until the water has settled, then decant them into a dry beaker, filter, using a hot-water funnel, and dry twenty minutes at 100° C. When dried, cool the fatty acids to 15° or 20° C. above the expected titer and transfer to the titer tube, which is 25 mm. in diameter and 100 mm. in length (1 by four inches) and made of glass about 1 mm. in thickness. This is placed in a sixteen ounce, salt-mouth bottle of clear glass, about 70 mm. in diameter and 150 mm. high (2½ × 6 inches), fitted with a cork which is perforated so as to hold the tube rigidly when in position. The thermometer, graduated to 0.1° C., is suspended so that it can be used as a stirrer, and the mass is stirred slowly until the mercury remains stationary for thirty seconds. The thermometer is then allowed to hang quietly with the bulb in the center of the mass, and the rise of the mercury observed. The highest point to which it rises is taken as the titer of the fatty acids

“The fatty acids are tested for complete saponification as follows: Three cc. of the fatty acids are placed in a test tube and 15 cc. of alcohol (95 per cent. by volume) added. The mixture is brought to a boil and an equal volume of ammonia (0.96 sp. gr.) added. A clear solution should result, turbidity indicating unsaponified fat. The room temperature must be reported”

*Proposed Exceptions*.—The fat is to be saponified in an iron or porcelain dish, and fatty acids set free in porcelain, fatty acids to be dried twenty minutes at 105° C. instead of at 100° C.

### 6. UNSAPONIFIABLE MATTER.

*Definition*.—The non-fatty acid constituents of fats and fatty oils, soluble in petroleum ether (B. P. 35–50° C.).

#### DETERMINATION.

*Standard Wet Method*.—Three grams of the sample, free from moisture and volatile matter, are weighed into a 150 cc. flask, and a 30 per cent. excess of strong, colorless or nearly colorless alcoholic potash solution added. The contents are boiled for one hour under a reflux condenser, and then transferred to a stoppered 100 or 150 cc. cylinder and made up to 50 cc. with cold water. Add 30 cc. of redistilled petroleum ether (boiling point 35–50° C.) and agitate vigorously. Draw off the petroleum ether layer by means of slender glass siphon. Repeat this operation with five separate portions of petroleum ether. Place the 150 cc. of petroleum ether into a Squibb's pear-shaped separatory funnel (250 cc.) and wash three times with 20 cc. of 50 per cent. alcohol. Pour the contents of the funnel into a tared flask and distil off the greater part of the petroleum ether and complete the drying on a steam bath and in an oven, the latter held below 105° C.

*Standard Dry Method*.—Approximately 5 grams of fat or oil are weighed into a 200 cc. capacity Soxhlet or Erlenmeyer flask, and saponified with sufficient alcoholic sodium hydrate solution to give 50 per cent. excess of sodium hydrate by boiling under a reflux condenser for ½ hour to one hour or until saponification is complete. The solution is then transferred to a four-inch porcelain evaporating dish (the flask being rinsed with hot alcohol) and dried on a water bath. The drying is completed in the oven at 120° C. for one to two hours. Grind the dried soap in an agate mortar with 10–15 grams granular, anhydrous sodium carbonate and place the whole in a 33 × 80 mm. S. & S. extraction thimble, using a fat-free plug of cotton to cover the charge. Place the thimble and contents in oven and redry for one hour at 110–120° C. The extraction is made with redistilled light petroleum ether boiling from 35–50° C. During the extraction if a Soxhlet or Knorr apparatus is used the open end of condenser must be protected against atmospheric moisture by a CaCl<sub>2</sub> tube. All connections of the apparatus must be tight. The extraction is allowed to proceed for about ten hours (if a Soxhlet apparatus is used at least 50 discharges). Transfer the extract to a weighed beaker, evaporate solvent on the water bath and dry in an oven to constant weight. Test the extract by redissolving in light petroleum ether: a clear solution should be obtained if the determination has been properly carried out.

### 7. METALLIC SOAPS.

*Definition*.—The insoluble metallic soaps in the present sense are the fatty acid compounds of bases other than the alkalis. They are insoluble in water.

#### DETERMINATION.

*Standard Method No. 1*.—The filtrate from the suspended impurities determination (including the hot petroleum ether washings) is evaporated to a bulk of about 200 cc., and allowed to stand over night or 12 hours in a cool place (18–20° C.). It is then filtered from the separated insoluble metallic soaps on a Gooch crucible, washed with cold petroleum ether (B. P. 35–50° C.), dried and weighed.

*Standard Method No. 2.*—The filtrate from the suspended impurities determination is evaporated, burned and ignited to constant weight. (a) The weight of the ash from metallic soaps thus obtained is to be reported as such. (b) Considering the ash to consist entirely of calcium oxide, it is to be calculated to normal soap, using 281 as molecular weight of fatty acid and reported as lime soap.

#### PROPOSED DISCUSSION OF METHODS.

Correspondence in regard to the above methods should be addressed to W. D. Richardson, 4215 Prairie Ave., Chicago, Ill.

### PERSONAL NOTES.

On November 9, 1910, the City of Philadelphia, on the recommendation of the Franklin Institute, awarded the John Scott Legacy Premium and Medal to Dr. L. H. Baekeland, of Yonkers, New York, for his invention of Bakelite, in accordance with the report of the Institution's Committee on Science and Arts, adopted May 4, 1910.

Seven eminent scientists and technologists have been honored by the Franklin Institute of Philadelphia in being awarded Elliott Cresson medals for "distinguished, leading and directive work" in their respective fields of endeavor. The medals are the highest awards in the gift of the institution. The recipients are:

Dr. Harvey W. Wiley, chief chemist to the department of agriculture, Washington, for his work in agricultural and physiological chemistry.

John Fritz, Bethlehem, Pa., for his work in the development of the iron and steel industries.

John A. Brashear, Pittsburg, Pa., for his work in the production and perfection of instruments for astronomical research.

Edward Weston, Newark, N. J., for his work in electrical discovery and in the advancement of electrical application.

Ernest Rutherford, professor of physics, Owens College, Victoria University, Manchester, England, for his work in the advancement of the knowledge of electrical theory.

Sir Joseph John Thomson, Cavendish professor of experimental physics, Cambridge University, England, for his work in the advancement of knowledge of the physical sciences.

Sir Robert A. Hadfield, Sheffield, England, for his work in the advancement of knowledge of metallurgical science.

Elliott Cresson medals have been awarded by the Franklin Institute at infrequent intervals during the last sixty or seventy years.

### RECENT INVENTIONS.

The following patents relating to Industrial and Engineering Chemistry are reported by C. L. Parker, Solicitor of Chemical Patents, McGill Building, 908 G St., N. W., Washington, D. C.

Only a few patents which are deemed of greatest importance are abstracted in this department. ¶

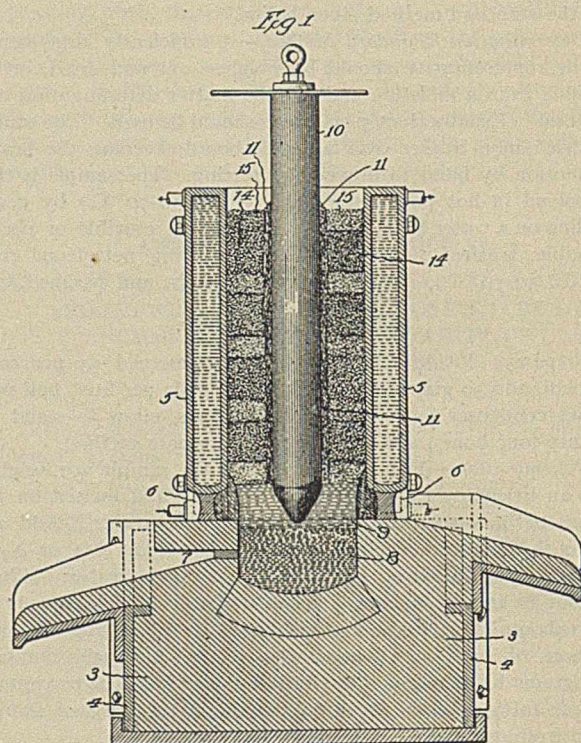
Abstracts of all patents appear regularly in *Chemical Abstracts*, to which publication the reader is referred.

**974,608.** Process of Smelting Ore. FREDERICK T. SNYDER, Oak Park, Illinois. Patented November 1, 1910.

This invention relates to a process of smelting ore, with especial reference to the treatment of iron ore, for the direct production of steel therefrom.

Previous attempts to produce steel directly from iron ore by electric smelting have met with practical difficulties, one of which has been the rapid destruction of the furnace walls by corrosive slags. Attempts to overcome this by making the crucible of carbon result in impairing the product because the carbon combines with the molten metal and produces pig iron instead of steel.

In accordance with this invention, only sufficient carbon is mixed with the furnace charge to secure reduction of the metal from the ore and to produce steel; and the molten metal when produced is collected in a crucible of refractory, and preferably basic, material, such as dolomite, while the slag is confined by a fluid, cooled wall in contact therewith, which freezes the outlying portions of the slag bath to form a lining or container composed of solid slag. The necessary heat is produced by passing



an electric current between carbon electrodes which dip into the molten slag from the top, but do not extend downward deep enough to reach and contaminate the steel in the crucible. Two or more electrodes are provided, for taking the current both into and out of the furnace through the top, in order to avoid having any carbon in the crucible or as a part thereof.

The water-jackets protect the masonry crucible on which they rest to a depth of several inches, and the metal level in the crucible is kept high enough so that the slag cannot reach a low enough level to cut through the crucible under the water-jackets. The metal, however, is not allowed to accumulate in the crucible to such an extent that it would come into contact with the water-jackets, as this would freeze the metal solidly upon the jackets, and result in a very great heat-loss. This loss is prevented, and the steel kept from contamination by keeping it in the refractory crucible, the material of which also serves to actually purify the steel by taking up small amounts of phosphorus and sulfur therefrom.

**975,076.** Process of Carbonizing. ALBERT F. ROCKWELL, Bristol, Conn. Patented November 8, 1910.

In carrying out this invention a carbon-bearing gas is first brought to a heat as great as that of the material being treated and is at such temperature then introduced into contact with the said material. In this way the incoming gas does not interfere with the carbonizing operation by chilling the material. Indeed, at the beginning of the operation, the gas is generally at a temperature greater than that of the said material, in which event said incoming gas not only does not chill the material but assists in heating the same.

The patentee employs a heating chamber separate from the

flask which contains the material to be treated but communicating with said flask, such heating chamber being of a temperature at least equal to (and sometimes greater than) that of the flask, and to introduce a carbon-bearing liquid, such as hydro-

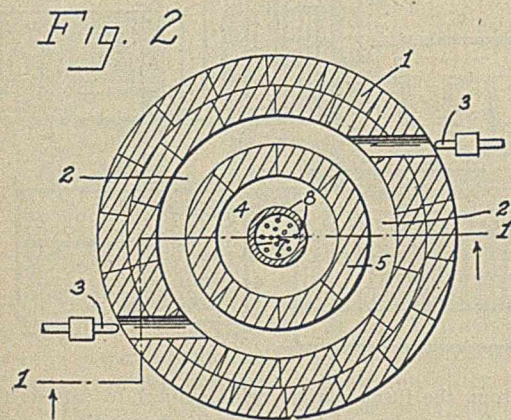
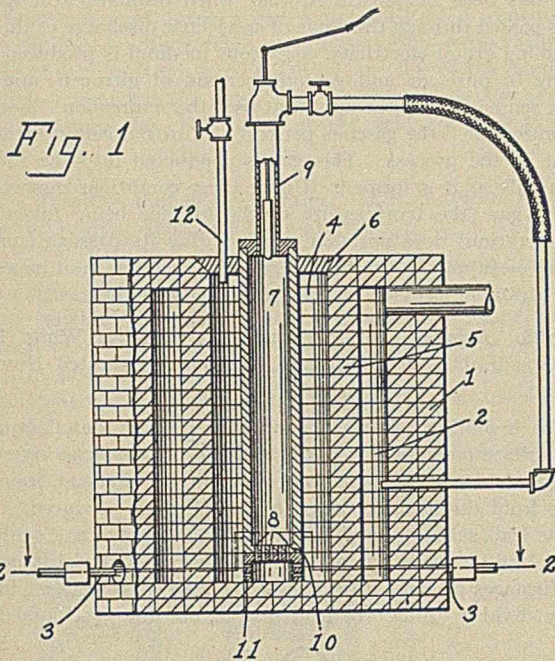
carbon oil, into said heating chamber in small quantities, whereby said oil is converted into gas and heated, the heated gas then passing into said flask. The gas thus creates its own pressure in the heating chamber whereby said gas is forced into said flask and into intimate contact with the material therein.

the removable cover put in place to close the heating chamber and the furnace heated. Preferably, a small amount of the hydrocarbon oil is now introduced into the heating chamber 4, the resulting gas flowing into the flask 7 and driving off the air therein to prevent oxidation as above explained. When the proper temperature has been attained, say a red heat, oil is again admitted through the inlet 12, and such oil is at once converted into gas and heat to the temperature of the heating chamber, which is always as great as the temperature of the material in the flask. The heated gas, of course, creates its own pressure in the heating chamber and is thus forced through the inlets 8 into the flask and into intimate contact with the material therein, such heated gas not chilling the material as it enters the flask. Indeed, at the beginning of the operation the temperature of the gas is greater than that of the material in the flask, so that at the outset the incoming gas not only does not chill the material but such gas assists in heating the same.

When it is desired to distribute the carbon throughout the body of the article as above described, the supply of oil from the inlet 12 is merely cut off, the flask being continued at carbonizing temperature until the desired distribution of carbon is effected.

975,106. Process of Extracting Copper from Ore. WILLIAM L. AUSTIN, of Riverside, Calif. Patented Nov. 8, 1910.

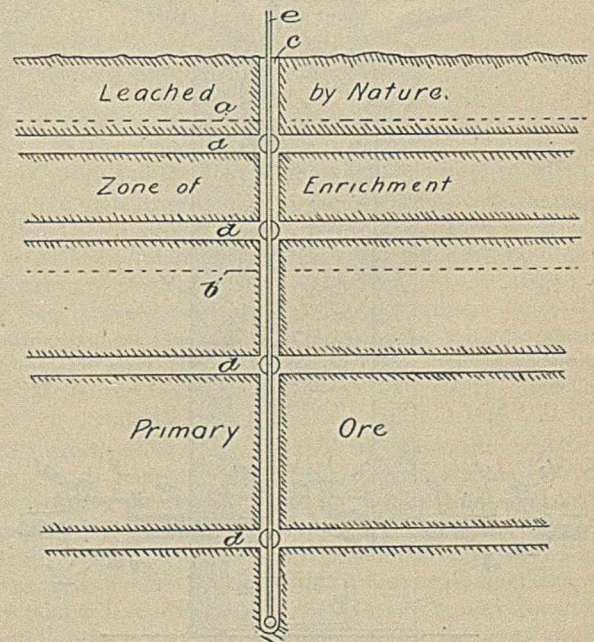
This invention relates to a process of extracting copper which is especially applicable in localities where there are minerals which can be rendered soluble, such, for example, as copper minerals, distributed through more or less porous rock. Such rock as porous porphyry (granite-porphry) for example, may contain, in the aggregate, a quantity of valuable mineral although too small a percentage to be worked profitably by ordinary mining operations. The mineral may, however, be profitably extracted by the process which I have discovered, which consists in applying a solvent so as to percolate through the mineral-bearing material without removing it by the usual mechanical mining operations from its original location, the percolating liquid extracting the mineral by leaching, and in providing for the collection and subsequent removal of the re-



carbon oil, into said heating chamber in small quantities, whereby said oil is converted into gas and heated, the heated gas then passing into said flask. The gas thus creates its own pressure in the heating chamber whereby said gas is forced into said flask and into intimate contact with the material therein.

Preferably the air is driven away from the material before the latter reaches the degree of heat which would produce oxidation, and air is kept away from said material until the carbonizing process is completed, thus avoiding oxidation and its attendant disadvantages. This expulsion of the air is accomplished by permitting a small amount of carbon-bearing gas to enter the flask containing the material before the latter has become sufficiently heated to oxidize, such supply of gas being sufficient to drive off the air, but insufficient, when initially supplied, to produce appreciable carbonization. After the air is thus driven off, the supply of gas is cut off and the gas in the flask lies dormant, thus excluding the air, until the material has been brought to the desired temperature for carbonization when the gas is admitted in carbonizing quantity and the process of carbonizing commences.

In practicing the process, the material is placed in the flask,



sulting solutions, from which the metals may then be separated in any suitable or usual manner.

In carrying out the process, an artificial drainage level is created at a point or points below the surface of the rock through

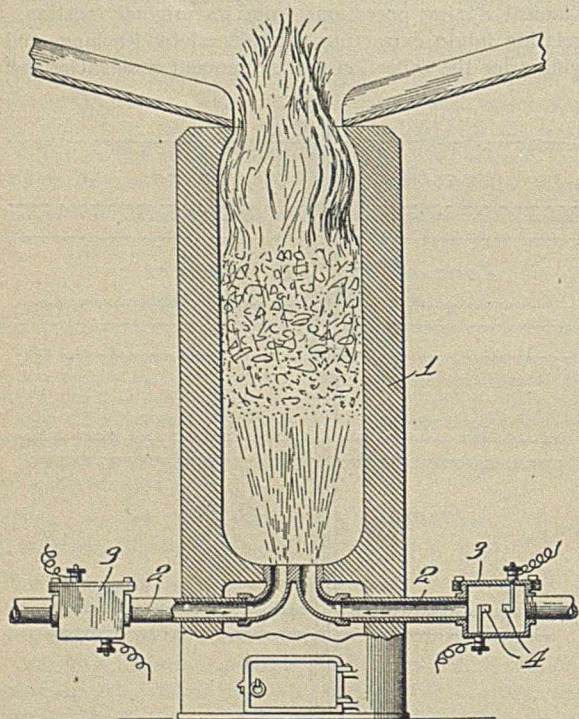
which the copper minerals are distributed. This may be accomplished by running levels and cross-cuts at different horizons, and by sinking shafts to a suitable depth, and in so locating these workings that water or any liquid permeating the rock will seek the lower levels and be collected therein. If, therefore, a quantity of water is distributed over the surface of the rock, or through any of the upper levels, it will percolate through the same leaching out the copper minerals and collecting in the lower workings. The resulting liquids are then removed, as by a pump, for further treatment to extract their metallic contents. It is desirable to carry out the process of extracting the metals from the solutions at or near the location of the ore-body so that the liquids from which the metals have been separated may, if desirable, be again allowed to pass through the rock. It is, however, immaterial, how the water is supplied, it being frequently practicable to divert the water from a running stream, or any reservoir, and to distribute it throughout the upper parts of the ore-body.

975,625. Process of Extracting Iron from its Ores. STEPHEN G. MARTIN, of Chicago, Illinois. Patented Nov. 15, 1910.

This invention relates to a process of extracting iron from its ores and its subsequent conversion into steel, and said process being applicable to the so-called non-Bessemer as well as to Bessemer ores, and by my improved process either one of said ores can be readily converted into iron of such quality as to be immediately available for the Bessemer blow.

The desirable qualities in iron applicable for the manufacture of steel are those of a metal free, or practically free, from sulfur, silicon, phosphorus and the like, and it is well known that such metalloids remain in undesirable quantities in iron produced by ordinary processes in blast furnaces.

The invention consists in dispensing with the use of atmospheric air in the blast furnace and substituting therefor modified or ionized air made by passing atmospheric air through the flame of an electric discharge, and this modified or ionized air passes



into the blast furnace in an absolutely dry state, and in such condition attacks the furnace charge with a high degree of chemical energy, which reduces the charge in much less time than is now required by methods in general use while the re-

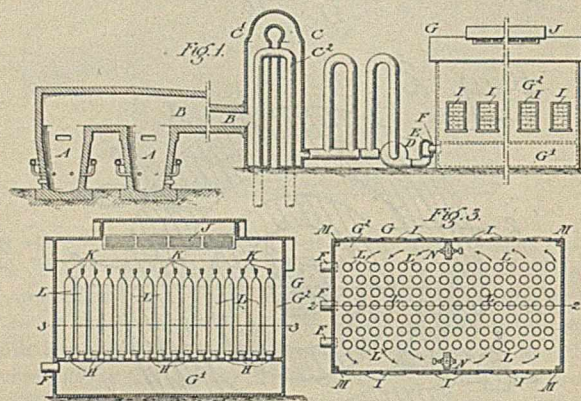
sultant metal is found to be homogeneous iron practically free from all metalloidal impurities and of the quality and conditions most desirable in iron which is to be converted into steel by the Bessemer process.

It has been demonstrated that when ordinary atmospheric air is passed through the flame of an electric discharge or through a flaming arc of electricity, a gaseous medium is produced consisting of pure air and gaseous peroxid of nitrogen, and this is the sense in which the applicant uses the expression "modified or ionized air," the gaseous peroxid of nitrogen being the active agent in the process. This gas is conducted into the furnace as rapidly as it is formed. Under these conditions dissociation of the gas (the temperature of the furnace being taken into consideration) does not take place during its passage from its source of supply to the furnace. It is, therefore, not necessary that means be provided to insure stability of the gas.

975,768. Apparatus for Manufacturing Sublimed White Lead. LOUIS S. HUGHES, of Joplin, Missouri. Patented Nov. 15, 1910.

This invention relates to apparatus for the manufacture of lead sulfate pigment and particularly to the construction of the screen or bag house used in separating the pigment from the gases from the furnaces wherein the sulfate is produced.

The lead sulfate pigment known in the market as "sublimed white lead" is made by treating lead-bearing material in oxidizing furnaces adapted to convert the lead in large part into a finely divided "fume" of lead sulfate, and the gases and fume



issuing from the furnace after being subject to various treatments to eliminate heavy and discoloring impurities are passed through cooling flues to reduce their temperature and then carried to the bag house where the pigment is separated from the gases.

The lead sulfate pigment as heretofore made has been found liable to harm when mixed with oil, and after many tests and experiments it has been ascertained that this tendency is due to the occlusion in the pigment of acid compounds of sulfur either  $\text{SO}_2$  or  $\text{H}_2\text{SO}_3$ .

The patentee claims to have discovered that the presence of the injurious acid in the pigment can be avoided by maintaining the gas and fume up to and during the screening operation at temperatures so high that the acid is maintained in dry vaporous form and thus prevented from becoming occluded in the pigment since it passes freely through the screen bags with the gases.

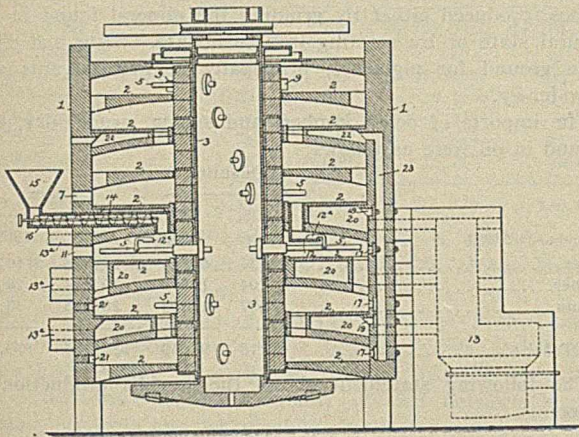
As heretofore constructed and used the screen chamber or bag house used in the separation of the furnace gases from the pigment has been quite freely ventilated, it being considered and used as, in effect, a part of the gas-cooling system, and free ventilation being also desired to get rid of poisonous gases in the bag house, and thus make it possible for attendants to enter it.

The invention consists in using in connection with the producing furnaces and cooling flues a bag house constructed with closed walls and opening only at its top so that the bag house will constitute in effect a part of the flue system of the furnace in which the fabric bags are already surrounded and submerged by an atmosphere of furnace gas maintained at a constant and, as compared with former practice, a high temperature. The temperature must not exceed 350° F. in view of the danger of burning or charring the bags, and it must not be less than 250° F. to secure the elimination of the acid compounds of sulfur.

976,525. Treating Sulfids or Sulfates. UTLEY WEDGE, of Ardmore, Penna. Patented Nov. 22, 1910.

The object of this invention is to facilitate the elimination of sulfur in roasting sulfids or sulfates, such as those of zinc or nickel.

In the roasting of sulfids or ores containing the same, the elimination of the sulfur remaining after the sulfid has passed through the preliminary stages of the roasting process requires the employment of an objectionably high temperature and even in such case the sulfur is not completely eliminated and objectionable amounts of sulfur are likely to be left in the



calcined or roasted material, owing to the formation of basic sulfates which are difficult to roast. In order to overcome this difficulty the patentee combines with the material, after it has passed through the first stages of its treatment, in the roasting furnaces, a reagent which will reduce the basic sulfates, the elimination of the remaining sulfur content down to the point desired being then readily effected without the employment of an objectionably high temperature during the latter part of the treatment.

The accompanying illustration shows the apparatus employed in the practice of patentee's process.

## INDUSTRIAL AND TRADE NOTES.

### GERMAN POTASH CONTRACTS.

Robert S. Bradley, of Boston, who is chairman of the board of directors of the American Agricultural Chemical Co., has issued the following statement in regard to the German potash situation, which recently assumed such an acute phase as to necessitate the sending of a special investigator over there.

"The potash business has been controlled by a German syndicate for more than 30 years. This control has been exercised not only over the production of the commodity, but its sale in all the markets of the world. It has been the custom to form such a syndicate for a period of five years, and the

last syndicate expired by limitation at midnight of June 30, 1909.

"For months before attempts had been made to form a new syndicate. I had been in Berlin for some time investigating and preparing to buy potash in case an opportunity was offered. By midnight of the day mentioned the delegates representing about 60 mines, who had been in session, had failed to come to an agreement. This caused an open market at the moment and I immediately made contracts running two years, together with option to run one year on a future contract period of five years. This covered the entire requirements of the American Agricultural Co. for seven years.

"At half past 1 o'clock that same morning, the president issued an edict calling a meeting of the delegates for 9 o'clock when a new syndicate was formed. This, of course, closed the opportunity to buy potash at less than syndicate prices.

"The contracts I had made were reported, of course, to the new syndicate and the news caused some consternation among the delegates because the prices were about 35 per cent. below the prices that had been ruling. For example, the syndicate price of muriate of potash landed in New York was \$33 a ton, while according to my contract it would be about \$20.

"In August they sent representatives over here to negotiate for a compromise of my contracts, but without result. The next month delegates representing about 60 American manufacturers went to Berlin and obtained a duplication of my contracts in consequence of their holding contracts made with one of the Schmittmann mines, whereby the latter guaranteed to these American manufacturers the same prices that my company might obtain. Schmittmann was therefore legally bound to give these manufacturers the same terms I had obtained, so that now instead of a matter of \$6,000,000 being involved there was \$25,000,000.

"Geheimrath Kempner and Herr Bielmann, another director of the potash syndicate, came over here the following December. We volunteered to meet them half way and divide the difference between the syndicate prices and the contract prices, because they presented a draft of an Imperial potash law which had been into the Bundesrath. This bill imposed an export duty on potash that would countervail the prices mentioned in our contracts.

"They accepted our offer on principle, but in figuring out the prices, they raised them sufficiently to countervail all the advantages left on a half-way compromise basis. We then broke off negotiations. Secretary Knox made a strong, emphatic protest to the Imperial German Government through Ambassador Hill, and the potash bill was subsequently withdrawn.

"Immediately thereafter, the United States and Germany completed a commercial treaty which gave Germany the benefit of the American minimum tariff. In May following, the Reichstag passed a potash law more drastic and more damaging in its effects on American contracts than the original Bundesrath bill which had been withdrawn at the protest of this government. But, at the same time, Ambassador Hill received assurance from the German foreign office that the law, as finally amended, would not invalidate, impair or affect the American contracts.

"Notwithstanding this assurance all shipments of potash, after the law went into effect, were taxed \$22 a ton over the contract price. This made the price of muriate of potash \$42 a ton, instead of \$20. The law imposes a duty in the form of a penalty tax for production over the allotted quota of a mine, and as the two mines which hold the American contracts are the only ones which overproduce, the tax affects only American contracts, and this is therefore absolutely discriminatory against American citizens.

"Negotiations were opened in Berlin. The American committee for the second time made a voluntary proposal to the Germans to divide the difference and meet them half way,

thus giving up over \$12,000,000. The Germans flatly refused to consider the proposal. Therefore the American committee left Berlin."

#### DISCOVERY OF "SHEELITE" IN NOVA SCOTIA.

(From Consul John E. Kehl, Sydney.)

An interesting event in the mineral development of the Province is the recent discovery of "sheelite" in Halifax County, Nova Scotia.

Sheelite is one of the minerals containing tungsten. It is of no known use in itself, excepting as an ore from which tungsten may be extracted. The mineral is chemically a tungstate of calcium. As an ingredient in the chemical side of steel-making it is quite important. At present the world's annual output, coming mostly from Sweden, is placed at 4,000 tons. If present indications are correct, the recent discovery in Nova Scotia will not only yield sufficient for the steel plants in the Province, but will have an effect on the markets of the world. The ore is reported to yield 60 per cent. of tungsten acid to the ton of sheelite. At present 25 men are at work on the preliminary experiments. It is believed that Mr. Hiram Donkin, deputy commissioner of mines, Halifax, Nova Scotia, will give interested parties all reasonable information.

#### IRON AND STEEL BY ELECTRIC PROCESS.

(From Consul-General Henry Bordewich, Christiania, Norway.)

Experiments to produce iron and steel from Norwegian ores by the electric process have been made during the last three or four years, partly by aid from the Government, in response to a petition sent to the Department of Commerce and Industries by the Christiania Polytechnical Society. Private interest has in this manner been awakened, and the industry now promises to become one of considerable importance. The Norwegian iron ore is often so poor that smelting by the old process was found profitless.

The owners of a paper mill at Tinfos, in Notodden, Telemarken, Norway, have for some time been making experiments for the purpose of producing iron by melting iron ore by the use of electricity as the source of heat. The works were completed in February last, and there has already been an output of 250 tons of iron. The ore used has been mined partly at Lango, near Kragerø, and partly at Klodeberg, near Arendal. The melting was accomplished by the use of an electric furnace of about 500 horse-power. This is the first iron produced by the new process, and in commemoration of the event there has been cast and sent to the Christiania University an ingot of the metal weighing 60 kilos and provided with an appropriate inscription.

A stock company, styled the Hardanger Electric Iron and Steel Works, is at present being organized. The capital stock is to be \$294,800, of which there has already been sold \$160,800. There are 4,400 shares of \$67 each. The works are to be located at Ullensvang, in Hardanger, on the west coast, and the object is to produce iron and steel from Norwegian ores by a patented electric process of Swedish origin. The company has secured electric energy from the adjoining water power at Tysse, for a period of thirty years, at a cost of \$8.04 per horse-power; 4,200 horse-power will be required. The ore to be used is to be bought from mines in other districts on the best obtainable terms. The transportation of the ore will be found expensive, but it is believed that this drawback will be offset by the cheap power and excellent harbor facilities at the place.

Among the principal promoters of the undertaking is the stock company styled Det Norske Aktieselskab for Elektrokemisk Industri. The director of this company is interested in the Tysse water powers, which are to furnish energy for the smelting works. Among the promoters are many influential and responsible men, and it is believed that the required capital will be raised without difficulty.

#### MINERAL PAINT PRODUCTION.

(From advance chapter on Mineral Resources by the U. S. Geological Survey.)

The annual consumption of paints and varnishes in the United States exceeds in value \$200,000,000; the railways alone will distribute among the paint and varnish manufacturers in 1910 between \$20,000,000 and \$30,000,000. It is, therefore, a matter of great interest to comprehend the various products which help to make up this vast trade.

The production of the natural mineral pigments and metallic paints and mortar colors in the United States in 1908 and 1909, together with the imports of similar products during the same years, all quantities being given in short tons, was as follows:

Description.	Quantity.		Value.	
	1908.	1909.	1908.]	1909.
	Tons.	Tons.		
Ocher.....	17,019	14,310	\$156,360	\$137,880
Umber and sienna.....	2,756	1,546	70,996	43,872
Metallic paint.....	16,224	25,414	182,007	256,373
Mortar colors.....	9,026	11,620	86,961	116,126
Slate and shale ground.....	4,828	8,247	40,220	58,882
Total.....	49,853	61,137	536,544	613,133

Metallic paint and mortar colors are red and brown iron oxides, produced either by grinding the mineral found in the natural state or by roasting iron carbonate. Slate and shale were ground for pigments, principally in Pennsylvania and New Jersey.

The imports of ocher, umber, and sienna, crude, dry, and ground in oil were as follows:

Item.	Quantity.		Value.	
	1908.	1909.	1908.	1909.
	Tons.	Tons.		
Ocher.....	4,127	6,848	\$ 75,076	\$110,664
Umber.....	1,204	1,596	20,264	26,381
Sienna.....	887	1,205	28,865	33,334
Total.....	6,218	9,649	124,205	170,379

The following statement shows the world's production of ocher:

Country.	Quantity.		Value.	
	1907.	1908.	1907.	1908.
	Tons.	Tons.		
United States.....	16,971	17,019	\$164,742	\$156,360
United Kingdom.....	16,455	....	70,117	....
France.....	36,217	36,442	423,830	457,072
Germany.....	1,679	....	5,290	....
Canada.....	5,828	4,746	35,569	30,440
Belgium.....	220	....	876	....
Japan.....	331	....	2,531	....
Cyprus (4 ports).....	7,301	....	20,279	....
Total.....	85,002	....	723,234	....

*Pigments Made Directly from Ores.*—The important pigments made directly from ores of valuable metals are zinc oxide, lead zinc oxide, zinc lead, sublimed white lead, and sublimed blue lead. The quantities and value produced in the United States were as follows:

Description.	Quantity.		Value.	
	1908.	1909.	1908.	1909.
	Tons.	Tons.		
Production:				
Zinc oxide.....	56,292	68,974	\$5,072,460	\$6,156,755
Zinc lead.....	8,430	7,655	778,200	634,714
Sublimed white lead.....	9,100	9,915	973,700	1,070,820
Sublimed blue lead.....	1,311	981	121,923	101,043
Total.....	75,133	87,525	6,946,283	7,963,332
Imports of zinc oxide:				
Dry.....	2,318	3,059	262,876	342,999
In oil.....	105	268	16,798	54,085
Total.....	2,423	3,327	279,084	397,084



*Chemically Manufactured Pigments.*—Under this heading are grouped the important lead pigments made from pig lead and lead compounds, and such minor pigments as lithopone and Venetian red, both of which are chemically precipitated from mineral salts. Much of the material now sold as Venetian red, however, instead of being precipitated from ferrous sulphate and calcium hydroxide, is made in several ways, such as by calcinating both pyrites and a mixture of ferrous sulphate and terra alba, and also by grinding natural red iron oxide with a white base, such as ground oyster shells.

The following statement shows the amounts and value of the chemically manufactured pigments produced in the United States in 1908 and 1909, together with the quantities and value of similar pigments imported during the same years:

Description. Production.	Quantity.		Value.	
	1908. Tons.	1909. Tons.	1908.	1909.
Basic carbonate white lead:				
In oil.....	101,109	115,259	\$12,552,771	\$14,736,360
Dry.....	31,479	32,840	3,338,830	3,468,722
Red lead.....	16,720	19,103	2,065,202	2,335,799
Litharge.....	15,542	20,690	1,887,506	2,363,002
Orange mineral....	397	590	65,498	98,723
Lithopone.....	8,292	14,847	639,483	1,105,281
Venetian red.....	8,825	8,358	159,650	145,733
Total.....	182,364	211,687	20,708,940	24,253,620
Imports.				
Corroded white lead.	270	347	30,452	39,963
Red lead.....	323	380	28,155	30,428
Litharge.....	48	45	3,327	3,740
Orange mineral....	243	248	26,645	27,562
Venetian red.....	1,557	2,000	25,745	28,864
Total.....	2,441	3,020	114,324	130,557

*Consumption of Paints and Varnishes.*—G. B. Heckel, secretary of the Paint Manufacturers' Association of the United States, is quoted as follows:

The annual consumption of paints and varnishes in the United States exceeds \$200,000,000, white lead, zinc oxide, and linseed oil alone amounting to nearly \$40,000,000. Roughly speaking, this consumption is about equally divided between house-painting products and technical products (railway and bridge paints, wagon and implement paints, etc.). During the two years of depression paint consumption in the first classification was reduced by about one-half, this reduction being about balanced by the remaining demand in the second classification.

The consumption of paint by the railways of the country has been conservatively estimated at from \$12,000,000–15,000,000. But it must be remembered that, during the past two years, this consumption has been limited on the basis of "rigid economy" and that now not only must the railways add their normal annual equipment, but they must also add the new equipment deferred for two years, besides providing for the repairs and renewals deferred during the same period; we shall, therefore, be conservative in estimating that the railways during the coming year will be forced to distribute between \$20,000,000 and \$30,000,000 among paint and varnish manufacturers.

#### EXPORT PRICES OF GERMAN POTASH.

(From Consul-General Robert P. Skinner, Hamburg.)

The manufacturers of nitrate of potash in Germany have formed a trust agreement under which identical prices are demanded at the several factories. It is only possible at times for individual dealers to propose better terms than can be obtained direct, because such dealers make contracts for 50 or 100 tons at a time, and are thereby enabled to break large lots into small ones, and sell the smaller quantities below the trust quotations.

The best prices within my possession on powdered and granulated nitrate of potash for export to Africa, Asia, North America,

Australia, Spain, Portugal, and Greece follow: In quantities less than 5,000 kilos (5 metric tons), 42 marks (\$9.996) per 100 kilos (220 pounds); at least 5,000 kilos, 41 marks (\$9.758) per 100 kilos; at least 50,000 kilos (50 tons), 40 marks (\$9.52) per 100 kilos. Small, medium, and large crystals cost 1 mark (\$0.238) per 100 kilos more. Long crystals (strahlen) cost 2 marks (\$0.476) per 100 kilos more.

These prices are f. o. b., packed in barrels of 400 to 500 kilos (880 to 1,100 pounds). For smaller barrels an extra charge will be made as follows: Barrels of 550 to 660 pounds, 9.52 cents; 440 pounds, 14.28 cents; 330 pounds, 19.04 cents; 220 pounds, 23.8 cents; 110 pounds, 47.6 cents; double bags of 220 pounds, 2.38 cents; 110 pounds, 1.19 cents.

The prices quoted are f. o. b. Hamburg. Freight from Hamburg to New York is quoted at the rate of 15s. per ton of 1,000 kilos (\$3.65 per 2,204 pounds), or 13s. 6d. (\$3.28) on annual contracts.

#### OUTLOOK OF CHILEAN NITRATE BUSINESS.

(From Consul Alfred A. Winslow, Valparaiso.)

The nitrate industry of Chile has made good progress during the past year, notwithstanding the low prices prevailing for nitrate in the markets of the world.

A number of new nitrate works have been opened, and most of the well-equipped plants have been running at full capacity, and seemingly at a good profit. During the first nine months of 1910 there were 3,942,648 tons of nitrate produced in Chile, against 3,200,039 tons for a like period in 1909, and 3,092,506 tons exported against 2,847,564 tons for the same time in 1909. The world consumption was 4,399,698 tons for the first nine months of 1910, against 3,612,020 tons during a like period in 1909.

In this increase United States interests have taken an active part all along the line. American interests have taken over several nitrate works within the past year, and are negotiating for several more. The use of nitrate has increased very rapidly in the United States during the past few years, the exports thereto having been 120,618 tons for 1907, against 335,722 tons for 1908 and 458,081 tons for 1909.

The outlook seems good for this industry, even at the present low prices of nitrate. The nitrate works that are provided with improved machinery and are run according to modern ideas seem to be prospering, while antiquated methods fail. There would seem to be still good openings for more American capital in this industry in Chile.

The agricultural interests of Chile are using much more nitrate from year to year, with excellent results. The Chilean Government gives special rates on the railways for nitrate as an inducement to the farmers.

#### WOOD DISTILLATION.

(Preliminary comparative report for 1909 issued by the Census Bureau.)

There was consumed in the United States during the calendar year 1909 in the industry of wood distillation, 1,265,000 cords of wood, as against 978,000 cords in 1908 and 1,282,000 cords in 1907. The average cost per cord reported for the 1909 consumption was \$3.21, which was an increase of 23 cents, or 8 per cent. over that reported for 1908, and of 6 cents or 2 per cent. over that for 1907. While a substantial increase is noted in that branch of the industry using yellow pine, fir, and other soft woods as material, the revival of activity was more marked in hard-wood distillation, due undoubtedly to the material advance in the average value per gallon of wood alcohol over the two preceding years.

While the average value per unit has varied little for most of the products of hard-wood distillation during the past three or four years, for alcohol it has fluctuated over a wide range,

following the passage of the so-called denatured alcohol law, which became effective January 1, 1907. The average value per gallon reported for crude alcohol manufactured during the calendar year 1906 was 34 cents. In 1907 it dropped to an average of 15 cents, increased to 17 cents during 1908, and reached an average of 24 cents in 1909.

The use of sawdust and other mill waste as material in 1909 was substantially greater than in any preceding year, and the indications are that the industry will develop largely in future in the direction of utilizing this class of material.

A comparative summary of the operations in 1909 of the 116 hard-wood distillation plants using 1,150,000 cords beech, birch, maple, etc., and the 31 soft-wood distillation plants using 116,000 cords longleaf pine, etc., follows:

Product.	Hard wood.		Soft wood.	
	Amount.	Value.	Amount.	Value.
Charcoal, bushels.....	53,075,000	\$3,299,000	2,403,000	\$210,000
Crude alcohol, gallons	8,468,000	2,082,000	.....	.....
Gray acetate, pounds..	148,769,000	2,203,000	.....	.....
Brown acetate, pounds	2,157,000	22,000	.....	.....
Iron acetate, gallons..	303,000	28,000	.....	.....
Oil, gallons.....	38,000	3,000	323,000	770,000
Tar, gallons.....	.....	.....	1,365,000	105,000
Turpentine, gallons ..	.....	.....	683,000	243,000
All other.....	.....	5,000	.....	59,000
Total value.....	.....	7,642,000	.....	687,000

#### NEW BRITISH ALUMINUM ALLOY.

(From Consul Albert Halstead, Birmingham.)

A Birmingham firm has discovered and patented a new alloy of aluminum, which is called *clarus*, and for which many claims are made.

It is claimed that this alloy is at least 60 per cent. stronger than ordinary aluminum and that its weight is one-third that of brass of an equivalent volume; that it will take a very high polish, equal to that which can be obtained with silver; that atmospheric surroundings do not cause it to tarnish; that castings are not brittle, but can be bent cold; that it is suitable for castings of any size, and that in all circumstances such castings have been found to be sound and free from blowholes and other defects.

It is claimed that the new alloy is excellently suited for automobiles and for electric-railroad, railroad-car, and aeroplane fittings. The manufacturers state that it has been made into sheets, drawn into wire, and into tubes and rods; that they have spun it and stamped it, and that they have made hand-pole brackets for the underground electric railways of London, for railway-carriage fittings, for carriage furnishings, street-car fittings, and automobile and motor-bus fittings.

*Cost of Production—Patent Rights.*—They assert that it is very little more costly than pure aluminum. Inasmuch as in aluminum alloys much spelter has been used to reduce the cost, the cost of production of this alloy would be greater probably than that of alloys with heavy percentages of spelter, etc. The alloy *clarus* is made from aluminum of 98–99 per cent. purity.

The owners of the patent are prepared to sell the exclusive rights in the United States in preference to permitting its manufacture in the United States under license or exporting the finished product, and are ready to demonstrate its usefulness. (The name of the owners of the patent can be obtained upon application to the Bureau of Manufactures.)

#### FLAX AND LINSEED OIL.

ENGLAND.

(From Deputy Consul-General Carl R. Loop, London.)

The price of linseed oil in the English market, according to a prominent dealer, changes almost hourly. At the time of

writing (October 25th) the United States is probably buying crude untanked oil from this market or from Germany at about \$11.20 per 112 pounds, in barrels f. o. b. London, less 2½ per cent. for prompt cash.

American linseed oil does not at present participate to any extent in the English market. One dealer advises that it could not have been bought here for some months past, save at a price (c. i. f., London) far in excess of that of English or Continental oil, and adds that it would be almost impossible to make a price here for oil for shipment from the United States.

Crude linseed oil, as supplied from the crushers here, is put up in barrels of about 50 American gallons, in pipes varying from 125–175 American gallons, and also in returnable steel drums of 150–200 American gallons. Linseed oil coming into this country from the Continent is almost invariably sent in barrels, but a part of it is imported in steel drums. Assuming 7½ pounds to be the equivalent of an American gallon, 1 hundred weight (112 pounds) is the equivalent of 15 gallons, and a ton of 2,240 pounds is equivalent to 298 gallons.

The present supply of linseed oil is by no means normal, and has not been during the whole year, the demand far exceeding the supply, and it is said that this situation applies not only to the United Kingdom, but to all parts of the world.

The linseed crop in the United States is just now becoming available for oil; the new crop from Argentina will not be available in the United Kingdom or in the United States until early in the year 1911, while the next Indian crop will not be available for oil until April or May, 1911.

The bulk of the linseed imported into Europe is produced in Argentina and India; small shipments are occasionally made from Russia, and also from the United States, but shipments from the latter have gradually decreased in volume.

The shortage of linseed, both in the United States and Argentina, became apparent at the beginning of the current year, and prices began advancing accordingly, both for the seed and for the oil, until in April a rise in oil of some \$49 per ton (2,240 pounds) had been registered. Owing to various causes, over-speculation included, prices then receded very considerably, but recovered again in August and are now higher than ever, with a difference of no less than 20 (\$97.33) per ton of oil over the prices ruling a year ago. These continued high prices are due to the very unsatisfactory reports regarding the new crops in the United States and Argentina, and if these reports prove true prices will certainly go still higher, and in such case linseed oil in England and elsewhere is not likely to rule below \$195 per ton during next year.

Turning to reliable newspaper statistics for October, 1910, it appears that the ruling price for linseed in London ranges from £45 5s. to £45 15s. (\$220.21–222.64) per ton, while in the corresponding week of 1909 the price varied from £30 to £30 5s. (\$146–147.21) per ton. The importations into the city of London during the week ended October 20, 1910, amounted to 11 barrels from Belgium.

#### RUSSIA.

(From Consul-General John H. Snodgrass, Moscow.)

The Russian flax crop of 1910 is medium in quantity, but of good quality. The buying price at present (November 1st) is 20 per cent. higher than in 1909, occasioned principally by the larger export demand and the limited stock of the European mills.

During August and September there were few clearances of stocks on account of exporters having succeeded in getting holders to give way in price, but in many places the full asking price was paid. As a rule, dealers have been and are now holding firmly to the little flax they have to sell. A prominent commission house reports as follows:

We are not yet in a position to form a definite opinion as to the

yield compared with last year, taking Russia as a whole, but we are inclined to the belief that the 1910 crop will show a moderate excess. There has been an increase in the total of business carried through in the consuming countries, brought about not by any general buying but by some largish clearances of stocks of certain descriptions, chiefly water-retted; prices have fluctuated to a slight extent, but the last sales reached the highest figures paid. There has been a fair number of transactions in tows; a good deal more would have been done if there had been a greater choice of quality, or if sellers had been more amenable as regards price. A few sales of new crop Slanetz flax have been made at prices which are decidedly under the ideas of the majority of shippers. We have not yet been able to trace any sales of this year's water-retted flax.

The latest official returns show the yield of flax in the several provinces of Russia in the year 1907 was as follows, in tons: Pskov, 32,951; Tver, 64,877; Smolensk, 89,797; Viatka, 47,118; Livonia, 49,568; Vitebsk, 24,989; Perm, 23,931; Kovno, 19,966; Vladimir, 14,485; Kostroma, 16,515; Yaroslav, 16,182; Mohilev, 16,627; total, 417,006 tons.

### CHINESE LACQUER WARE.

(From Vice-Consul Henry Oscar Nightingale, Foochow.)

The manufacture of the lacquer ware known to the Chinese as the "No. 1 Foochow lacquer" can hardly be called an art; it is rather a craft, the result of infinite labor and patience, since the laying on of the coat or color requires no more skill than the simplest form of painting.

This lacquer, although very popular and greatly sought by the Chinese, is little known in America, doubtless owing to a lack of appreciation or the cost, since the market is flooded with a cheap form of lacquer that seems to answer all requirements. The superiority of the No. 1 Foochow lacquer over all other forms is due to its durability and beauty; it takes more time to prepare (in some cases several years) and possesses a finish and depth of color unlike any other products of the same nature. The extreme care taken to refine the pure lacquer, the number of coats given, and the great quantity of gold and silver leaf usually used in the last coat are the cause of this.

Concerning the gold and silver leaf used, one imparts to the lacquer a dull gold color, in whose depth a fine gold powder may be discerned, and the other gives a silver-green effect. Sometimes a little coloring matter is added, but the result is supposed to be better without it. The quantity of gold mixed with the lac is about one-third the selling price for these articles, which usually ranges from \$2-3000.

The earliest record of lacquer is from the Sung dynasty, although it probably existed long before that date but in a more crude form. It was introduced into Japan in the third century from Korea, at the time of the conquest of that country by the Empress Jingo. The seventeenth century marked great progress in the industry in Japan, and the gold lacquer became very popular, but from that time its popularity decreased and the demand did not revive until the last few years. Last year the export from Japan was 219,525 yen. The export of No. 1 Foochow lacquer, though a far superior article, is so small as to be classified in the customs returns under the head of furniture.

The lac, as is well-known, is not a manufactured product, but the sap of the *Rhus vernicifera*, or *Ch'i shu* of the Chinese. The tree is tapped at night during the summer season and the lac sold to the consumer as a dried cake or in a semifluid state. It is first placed in a rectangular pan, where it is continually stirred with a spatula for about two days, then pressed by twisting the lac through a sack made of fine grass cloth and lined with a thick layer of cotton. The refined lac is put into the pan again for a day and the same process is repeated. So prepared, the lac will answer for the first coats given the articles,

but for the final or color coat the lac used undergoes this process four times.

The invention of the No. 1 lacquer is said to belong to the Shen Shao An family, in whose hands the manufacture still is. To this same family is also accredited the invention of silk lacquer.

The term lacquer ware applies only to the thing which has undergone certain preparations before receiving several coats of lac. Ordinary woodwork covered with Ningpo varnish, or even with lac, is not included. The proper lacquer ware may be chiefly divided into two kinds, the ordinary and the silk.

The ordinary lacquer is applicable to almost every kind of furniture and to ornamental articles for the houses, but is commonly applied to woodwork. Only very old wood, usually cedar which will neither warp nor crack, is used for this purpose. Articles and ornaments of the most delicate carving are treated in this fashion. To prepare the woodwork, such as furniture, for lacquer, a lacquerer scrapes the wood 1 or 2 inches wide along any crack or joint or opening that may exist; it is then filled up with lac and two or three coats of linen cloth, which will not only cover the depth but also serve to keep the parts together. After a fortnight or longer, when the lac on the linen is perfectly dry, the woodwork is covered with a thin coat of black lac mixed with a little ching-chu, a kind of clay, the preparation of which will later be described.

Ten days later, a process of general polishing is applied to the article with fine pumice stone of various shapes and sizes. About every ten days a new thin coat of the lac mixture is put on. The article is always polished before receiving a new coat. After the ninth or tenth coat of this black lac mixture, the article is thoroughly polished so as to receive the color coat.

For the preparation of the final coat, a small portion of lacquer that has undergone the refining process four times is mixed by a pallet knife on a stone surface with the gold or gold and silver leaf. When thoroughly mixed, it is placed in the center of a thin sheet of cotton paper. The paper is then rolled together with the lacquer inside, the ends being twisted in opposite directions, until the lac oozes through. This is repeated three times. There is great waste by this process which may also account for the price charged for some of these articles.

There is but one coating made of this lacquer. Sometimes a flat surface is decorated by adding flowers or birds with ordinary paint, but this is not very popular, since the color and quality of the lacquer itself are deemed sufficient decoration.

The silk lacquer is generally applied to small articles either for practical use or for ornamental purposes, such as vases, card cases, and images.

The art is so far advanced that images of almost every description can be made under this system, with accuracy and clearness. The process commences by pasting a coat of native printing paper with rice glue mixed with ching-chu powder on a well-modeled clay image, care being taken to cut the paper into proper sizes to suit the different parts where it is pasted, and to paste it so neatly that every wrinkle of the face or fold of the material, should there be any, will remain clear cut. After the pasting, the figure is thoroughly washed with this thin mixture and left to dry for two or three days.

On top of the paper is then pasted the silk with a plaster of black lac and pulverized ching-chu, with still greater care as to the overlaps and folds than is required in the paper coating. Ten days later another coating of silk is added after the necessary polishing has been applied.

For small articles only two coats of silk are sufficient, but in the case of larger ones one or two more coats may be added. When the silk molding is dry and carefully finished subsequent coatings of black lac mixture are applied thereto at an interval of about every ten days in the same manner as to the wood, only greater care is exercised and longer time spent in the

polishing. Before receiving the color coat the image is immersed in water for such a length of time that the clay inside will dissolve and can be taken out through a hole left at the bottom of the figure for that purpose. After the removal of the clay the opening is sealed and a fortnight later the hollow and exceedingly light article is ready to receive its decoration.

On silk as well as woodwork the color coat is applied but once. The lac, though black itself, can be made almost into every color existing, and of various shades, by mixing it with other ingredients. The most costly colors are those which contain the greatest quantity of gold dust, and the colors in most common use are bronze or other green of various shades, and liver-purple or dark maroon-gold.

The term gold lacquer is easily misinterpreted to mean lacquer ware sprinkled with gold dust or fragments of gold foil or inlaid with gold thread, etc. In gold lacquer the gold or silver has been pulverized so fine that it appears no more as sprinkled dust, but its richness is blended with the other coloring matter and the refined lac giving a lustrous and lovely tint of a uniform shade.

The lac in the ching-chu mixture used for the primary coating has passed the refining process only twice instead of four times, as is described in the foregoing for that of the last coat. A little water is added to the lac when it is being mixed with the pulverized ching-chu. Ching-chu is a refined red clay. It is dissolved in water, and after the impurities, such as sand, have been removed, the muddy water is filtered through certain layers of paper and porous tiles. The fine clay found on the top of the paper is dried into tablets or bricks, in which form it is sold at the market. This pulverized clay mixed with the lac will form a crisp coating on the woodwork or harden the silk in the silk lacquer.

A genuine No. 1 Foochow lacquer will stand any climate and any amount of washing, even with boiling water. In the common form of lacquer unrefined lac is used for the primary coating, and that for the color coat has not been refined more than twice. Instead of ching-chu, which is comparatively expensive, the powder of broken bricks and tiles is freely used. The color lac is very seldom or never enriched with pulverized gold and silver. Linen is substituted for silk. Very little or no polishing is done in each and every interval between the coatings, until before the last coat.

Owing to cheapness, there is much greater demand for the imitations than the genuine. Ordinary lacquer ware will receive on an average but five coats, whereas No. 1 never less than nine and sometimes as many as twenty. (Seven photographs accompanied the foregoing report and will be loaned to interested firms on application to the Bureau of Manufactures.)

## OFFICIAL REGULATIONS AND RULINGS.

Only a few of the more important rulings are reported here. For others the reader is referred to the publications of the Board of Food and Drug Inspection and to Treasury Decisions.

### FOOD INSPECTION DECISION NO. 129.

*The Certification of Straight Dyes and Mixtures under Secondary Certificates. (Amendment to F. I. D. 77.)*

In Food Inspection Decision 77 provision is made for the recertification of straight dyes (*i. e.*, the seven accepted dyes of F. I. D. 76) and mixtures thereof, with or without other harmless ingredients.

Doubt has been expressed as to whether the requirements of F. I. D. 77, with respect to certification, are the same for those who are not manufacturers as they are for manufacturers. This amendment is issued relative to recertification in order to remove uncertainty and to indicate the scope of F. I. D. 77.

All persons, manufacturers or others, requesting certification of mixtures or recertification of straight dyes, or of mixtures

or combinations thereof, shall submit the following form of secondary certificate to the Secretary of Agriculture:

### SECONDARY CERTIFICATE.

I, . . . . ., residing at . . . . ., do hereby depose and state  
(Full address.)

that I have repacked . . . lbs. of certified lot (or lots) . . . . .  
purchased from . . . . ., of . . . . .

This repacking has been accomplished in the following fashion:

. . . . .  
(Full description of what has been done with the lot or lots.)

Certified mixture No. J. D. & Co. . . . ., or certified straight  
dye No. J. D. & Co. . . . .

(Name.)

Trade name . . . . .

Subscribed and sworn to before me, . . . . ., in and for the . . . . .  
of . . . . . at . . . . ., this . . . . . day of . . . . .

. . . . .  
(Name of officer authorized to administer oaths.)

When the secondary certificate refers to mixtures, the term "mixture" means:

not only such mixtures as consist wholly of certified coal-tar dyes but also those which contain one or more certified coal-tar dyes (and no other coal-tar dye or dyes) in combination with other components, constituents or ingredients not coal-tar dyes, which other components, constituents, or ingredients are in, and of, themselves or in the combination used harmless and not detrimental to health or are not prohibited for use in food products; the exact formula of such mixtures, including all of the components, constituents, or ingredients, or other parts of the mixture, together with a statement of the total weight of mixtures so made, must be deposited with the Secretary of Agriculture. (F. I. D. 106.)

The term "straight dye," as used herein, refers to the seven dyes specified in F. I. D. 76.

In the case of mixtures one (1) pound samples, and in the case of straight dyes one-half ( $\frac{1}{2}$ ) pound samples must be submitted with the secondary certificate. If larger samples are needed in individual cases the Department will ask for them.

Only those mixtures will be certified which contain no other dyes than coal-tar dyes previously certified. Mixtures containing animal or vegetable dyes are not subject to certification.

The above form for secondary certificates varies but slightly from that given in Food Inspection Decision No. 77. It contains the addition "Certified mixture No. J. D. & Co. . . . ." and "Certified straight dye No. J. D. & Co. . . . ." When the manufacturer or other person submits a secondary certificate, whichever legend is appropriate to the certificate is to be used. The initials are to be those of the person or firm filing the certificate; the blank space is to be filled with the number of the secondary certificate filed by that particular person or firm. For example, the firm of J. D. & Co. has already filed fourteen secondary certificates, the new one to be filed under the form given above will then be labeled "Certified mixture No. J. D. & Co. 15," or "Certified straight dye No. J. D. & Co. 15," as the case may be; that is, the recertified straight dyes or certified mixtures are to be given a number in regular order, according to the number of such secondary certificates filed by any person or firm. The completed legend is the one to be used in marketing the products thus submitted under the secondary certificate. Notification will be given of the acceptance or rejection of the certificate when investigation of the product has been completed.

Makers of secondary certificates must submit the trade name of mixtures produced, and no such trade name or keyed modification thereof should be used on any other mixture prepared by the same person or company.

Secondary certificates are to be sent in duplicate to the Department of Agriculture; the duplicate need not, however, be signed or sworn to. The samples should be submitted with the secondary certificates.