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TECHNICAL PUBLICATION No. 5

OF

THE NEW YORK STATE COLLEGE OF FORESTRY

AT

SYRACUSE UNIVERSITY

HUGH P. BAKER, Dean

The Hardwood Distillation Industry in New York

BY

NELSON C. BROWN

Wood Utilization Series No. 1

Published Quarterly by the University

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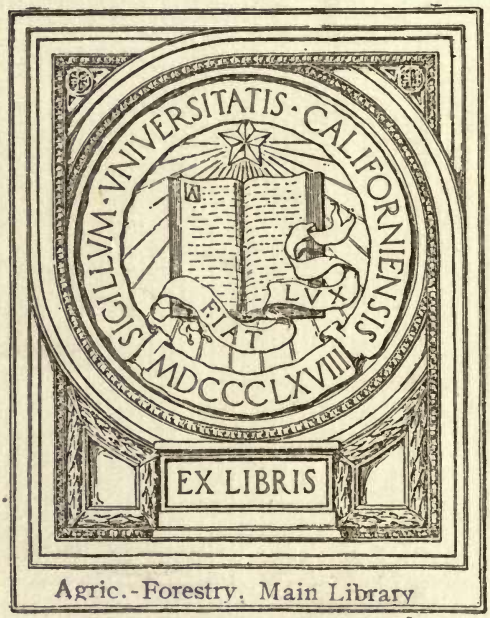

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Photograph by Nelson C. Brown.

This shows the character of cordwood in 50-inch lengths used in the wood distillation industry. Practically all of this wood is made up of mixed beech, birch and maple. It must be seasoned at least one year before being used in the distillation process. In some of the wood yards of these plants several thousand cords are seasoning. The wood is used with the bark on, and everything down to one inch diameter is frequently taken.

Over 192,000 cords of hardwood are annually consumed in this industry in New York State.

Photograph taken at the plant of the Maryland Wood Products Co., Maryland, Otsego County, N. Y.

PREFACE

In order to meet intelligently the demand for information about the distillation of hardwoods in New York State, the New York State College of Forestry decided to carry on as one phase of its research work, an investigation of the commercial methods used in the distillation of hardwoods in the State. This industry was started and largely developed within the State. New York is still one of the leading states engaged in the distillation of hardwoods.

In writing the report, the purpose throughout has been to make the explanations as simple and clear as possible, using as few technical and involved terms as are consistent and in many instances engaging in reiteration that may at times seem unnecessary. The industry is closely identified with certain aspects of chemistry, but the author has purposely avoided a discussion of chemical changes that take place in the distillation of wood since the intent has been to make the report valuable to the wood producer and user in New York State rather than to those engaged directly in the work of wood distillation.

In the conduct of the investigation form letters were sent to every wood distillation plant in the State to obtain information upon woods used, equipment, methods and costs, daily and annual capacities and yields in charcoal, wood alcohol and acetate of lime. Personal visits have also been made to most of the twenty-five plants in New York State as well as several in other states and information has been checked up by a number of those prominent in the industry.

The author wishes to express cordial appreciation of the kindly interest shown him by those engaged in the industry. He wishes especially to express his sincere gratitude to the following men who have shown interest in the work and have

helped in making necessary corrections and changes: Mr. F. A. Mason of W. A. Case & Sons, Buffalo, N. Y.; Mr. George L. Mackay, Warren, Pa., Mr. John Troy of Olean, N. Y.; Mr. E. B. Stevens of Buffalo, N. Y.; Messrs. W. S. Gray & Son of New York City; Mr. S. J. McConnell of Hancock, N. Y. and Mr. J. L. Stuart of Binghamton, N. Y.

NELSON C. BROWN.

SYRACUSE, N. Y., *November 1, 1916.*

CONTENTS.

History

Introduction.

The heating or carbonizing of wood for the purpose of manufacturing charcoal has been in practice as long as history is recorded. It is believed that it is as old as civilization itself. In the manufacture of charcoal by the old process, the wood is heated to such temperatures that it becomes carbonized while the gases that pass off in the form of dense, heavy, black smoke have given rise to the modern processes of distilling wood.

Altogether two distinct branches of the industry have been developed in this country. The most important branch is devoted to the utilization of the denser and heavier hardwoods and seeks the recovery of the following commercial products: wood alcohol, acetate of lime, and charcoal. In addition, the minor products are wood tar and wood gas, both of which are at the present time usually utilized as fuel in the heating process. Only those hardwoods that are comparatively free from an excessive content of gums, tannins, resins, etc., are desirable. The so-called northern hardwoods, such as maple, birch and beech, are considered the most suitable. Hickory and oak are also considered of almost equal value.

The other branch of the wood distillation industry requires resinous woods and the objective products are, on the other hand, turpentine, tar, wood oils, and charcoal. The southern longleaf pine is the best wood for this kind of distillation and up to the present time has been practically the only one used for this purpose. This bulletin deals only with the distillation of hardwoods in New York State.

Early Practices.

The first record of the distillation of wood on a commercial scale in this country is in 1830 when James Ward began the manufacture of pyroligneous acid at North Adams, Mass. This is the raw liquor distilled from the condensed vapors that pass off in heating the wood. So far as can be learned from records, it was not until 1850 that the distillation of wood for the production of volatile products and semi-refined products was begun. According to the most authentic records the first successful wood distillation plant in this country was established in New York State in 1850, when John H. Turnbull, of Turnbull & Co., Scotland, who had for some time been connected with the industry, came to this country and erected at Millburn, Broome Co., New York (now Conklin on the Delaware, Lackawanna and Western Railroad) a small chemical plant. The copper and steel castings were brought from Scotland. There were eight cast iron retorts, 42 inches in diameter and about 8 feet long, and the necessary copper stills, copper log condensers, etc. A number of men, experienced in the industry were brought over by Turnbull from Scotland and many of these men and their sons became managers of plants which soon after sprang up in southern and southeastern New York.

The retorts were charged each twelve hours with wood cut in eight foot lengths. The vapor was condensed in a copper log condenser and the liquid recovered was pumped into settling tanks, from which it was drawn to the copper stills for distillation. The settled tar was drawn off from these settling tanks each day, and spread with a ladle over the charcoal, which was burned under the retorts, the copper and lime stills, and the pans — all distillation being accomplished by this direct method. Little or no effort was made to save the wood spirit, the main object being to produce acetate of

lime, for which a high price was obtained both in the home and Scotland markets.

The methods followed in operating the plant demanded a large amount of hand labor, and sturdy men of experience were needed to carry the work forward. These men with their families, came from time to time from Scotland. In a short time Millburn became known as the Scotch Settlement and it was famous for the number of trained men who, after getting their experience here were called upon to take charge of distillation plants not only in New York but in Pennsylvania, Michigan, Canada and other centers as well.

About 1865 (or soon after) a Mr. Pollock, a chemist, of Morrisania, New York, began refining wood spirit in a small way. The market developed rapidly. Shortly the Burcey Column was introduced to the crude plants, thereby adding to the power of the stills to recover wood spirit of 82 per cent. test. The production of wood spirit being greatly increased, it became desirable to install a central refining station, and the Burcey Chemical Co., with a refinery at Binghamton, New York, resulted. A refinery was also started in Brockton, Mass. in 1877.

For a long time the sale of charcoal was limited, the greater part being consumed as fuel in the plants. Slowly the market developed, until to-day practically the entire output is shipped, hard and soft coal taking its place under the boilers and retorts, and live steam being used in the stills (now fitted with coils), and in the pans, which have steam jackets at the bottom.

At the present time, plant operation is along efficient lines. Old time methods have been discontinued, and the manual labor is now greatly reduced. In the woods there is also a noticeable improvement. Cord wood is now to some extent cut from the limbs and refuse tree trunks, after the lumberman has taken out all the best timber in the shape of logs.

Thus the danger of fire is reduced and the ground, which otherwise would be covered with scattered brush, is free for new seedlings to take root without delay, or the stumps left to sprout up with a new wood crop.

Utilization of Wood in the Industry

Favorable Conditions in New York.

New York State forests are very fortunately located for the carrying on of the wood distillation industry. It has three very necessary conditions for successful operation, namely: (1) a plentiful and therefore a relatively cheap wood supply; (2) comparatively near a good fuel supply, such as natural gas and coal; (3) reasonably accessible to a market for the products of the industry. The only desirable condition that is not present is that of large iron furnaces where the charcoal can be utilized to the best advantage.

New York State contains an unusually good supply of native woods for use in the wood distillation industry. The highlands of the southeastern part of the State, the Alleghany plateau of the southern part of the State and the lower elevations of the Adirondacks, embracing a considerable portion of northeastern New York, contain splendid stands of beech, birch and maple and in the former two regions these and other species sprout to excellent advantage. In fact, many areas have been cut over at rotations of twenty years where the cut showed an annual growth of one cord per acre per annum. This rate of growth is as good as can be expected under the best forest management.

Desirable Species.

Woods that are hard and heavy are the most suitable for the wood distillation industry, especially those that are, in addition to the above qualifications, free from tarry and resinous products. As a rule, heartwood is considered much

more desirable than sapwood and there is an almost uniform opinion among manufacturers to the effect that hard maple is considered best and that beech and birch follow in order. Chestnut contains too much tannin for successful production of distillates. Ash, oak and hickory are considered almost as good as the so-called northern hardwoods, namely, beech, birch and maple. Cherry and elm contain too much tarry material and consequently the distillate results in an excessive amount of wood tar which has very little commercial value and in addition there is an insufficient yield of alcohol and acetate of lime. Basswood, popple, cottonwood and the soft woods or conifers are entirely too soft and light. The conifers such as spruce, white pine, balsam, fir, hemlock, etc., are undesirable on account of the resinous nature of their wood and their light weight. Other native species found in New York do not grow in sufficient quantities to make them of any importance for use in the industry.

Stumpage Values

The value of the timber on the stump varies considerably. On large logging operations where the tops, limbs, defective trees and brashy material are utilized, practically no stumpage value is used, because the utilization of this material is considered as salvage. On most of the New York operations steep, rocky hillsides, covered by the desirable hardwoods are anywhere from one-half mile to several miles from the plant or shipping point. Stumpage on these operations, particularly in Delaware county, which is the center of the industry in New York State, runs about 75 cents per cord. Altogether it varies between 25 cents to $1 per cord. There is a general tendency for stumpage values to rise. This has been especially true during the past decade. Since the European War broke out, the stumpage values have been inflated to a considerable extent.

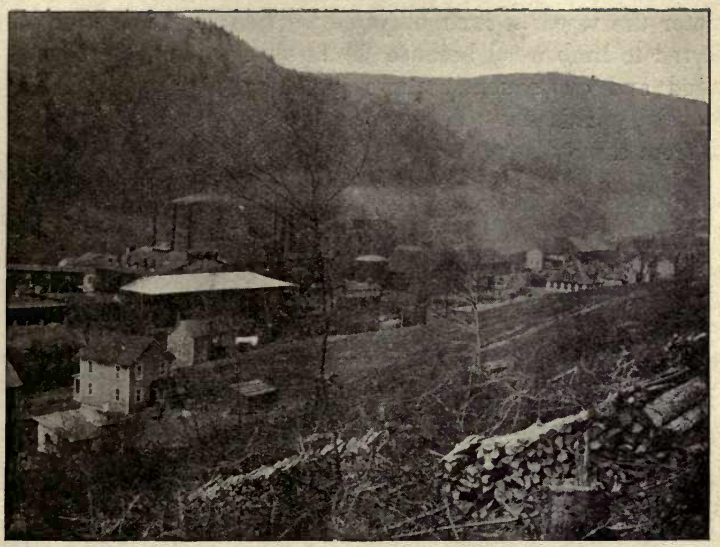
Cutting and delivering to the factory.

Cutting is done by choppers who in many sections, particularly in Delaware county, look upon getting out the annual cord wood supply in the winter as a lucrative means of winter employment. The trees are cut up in fifty inch lengths and hauled on sleds when snow is on the ground or on wagons directly to the acid plant. Hauls up to eight to ten miles are fairly frequent.

For cutting and stacking, the usual figure is about $1.25 to $1.40 per cord. Cutting is usually done by contract, and where the wood is favorably sized and located for chopping and the ground fairly level, cutting and stacking can be done as low as $1 to $1.10 per cord by experienced choppers. The maximum figure is about $1.50 per cord. The cost of hauling varies with the distance and the character of the ground and the road over which the load is hauled. One and one-half to two cords are usually considered the maximum load under the most favorable conditions. The total cost of wood delivered at the commercial plants is about $4 per cord. Estimates obtained from all the New York plants show that the average value of cordwood delivered at the plants is $4.06 per cord. The maximum cost was estimated to be $5 per cord at one plant. At another plant, the cost was estimated to be $3.25 per cord, which was the minimum estimated cost in the State.

Seasoning.

In all cases the wood must be seasoned for at least one year before being used in the ovens or retorts. If used green, the high moisture content is excessive and too much heat is required to derive the product. At many of the plants it is estimated that before seasoning, the average cord of mixed beech, birch and maple weighs in the neighborhood of 6,200 pounds. After seasoning the average cord weighs about 3,800 pounds. The wood is used in the process with the



Photograph by Nelson C. Brown.

General view of the Keery Chemical Co. plant near Cadosia, Delaware County, N. Y. This view was taken from a sprout stand of timber cut over for "acid wood." This stand has been cut over on three different rotations. A growth equivalent to approximately one cord per acre per annum was determined to be the average yield. The timber was made up almost entirely of hard maple, beech, and birch. This is a six oven plant having a daily capacity of 60 cords. It is one of the few plants in the State which has a refinery to turn out 95 to 98 per cent wood alcohol. The wood yard is shown on the extreme right. The cooling ovens are shown on the extreme left. The refinery is the tall building in the center of the picture.

The wood in the foreground is left to season for at least one year before being used in the distillation process.

bark on. All forms of limb and body wood down to two inches in diameter are utilized. When over eight inches in diameter the wood is commonly split. Body wood is much preferred to limb wood because the latter contains too much sapwood and consequently more moisture. As mentioned previously, yields from heartwood are much greater than those from sapwood.

Opportunities for utilization of sawmill and woods waste.

Some of the most successful plants in this country are operated where woods waste consisting of tops, limbs, crooked trees, defective logs and broken material in the woods can be profitably utilized. Haul roads, skidways and railroads maintained and operated for the purpose of getting out logs can be utilized to excellent advantage in getting out the other material for distillation purposes, and under these conditions the wood can be delivered at the factory at a very low comparative cost. This is the method usually followed in connection with the large distillation plants in Michigan and Wisconsin and is also followed to some extent in the Adirondacks and other parts of the State. Where the larger logs are utilized for lumber, the material that would otherwise be wasted, is used for wood distillation purposes. This feature constitutes an important contribution to the cause of forest conservation because one of our greatest problems of forestry in this country is the utilization of our enormous waste. At present we waste as much as we utilize, and any form of forest utilization which contributes to closer utilization may be highly commended. The removal of all of this material from the forest also means that the fire danger is greatly lessened.

The larger refuse from the manufacture of lumber in sawmills is used to advantage in the largest plants in this country in Michigan. It is believed that this form of utilization of sawmill waste will come into greater prominence in

New York State. Only the larger forms of sawmill waste, such as slabs, edgings, trimmings, and similar material can be utilized to commercial advantage. The sawdust, shavings and similar material usually cut up by the slasher cannot be utilized profitably except as fuel, but experiments are now being undertaken which may permit of the utilization of sawdust and shavings for distillation within a short time or as soon as some promising experiments can be perfected on a commercial basis.

Management of timber lands.

Several of the wood distillation companies in New York own tracts as large as 50,000 acres each or lease tracts nearly as large. These are managed on a permanent basis and carefully protected from the annual ravages of fire during the dangerous dry seasons. These companies are practicing one of the best forms of forestry because they utilize the products of the forest most completely, the maximum growth of the forest is stimulated, and forest fires, the greatest enemy of the forest, in so far as practicable, are eliminated. The rougher and more mountainous portions of Delaware county are admirably suited to forest culture on account of the steep, rocky hillsides which contain many springs and seepage flows, thus permitting the most rapid growth of timber and stimulating the sprouting capacity in all of the larger trees. The cutting is usually done in the winter time. The following spring the stumps sprout up thriftily and vigorously to a height of from five to ten feet the first year. After a period of from twenty to thirty years the stand is cut over and the same process is repeated. In one section four different age classes of timber were noted where average yields of one cord per acre per year had been obtained after the original forests were cut over. These tracts are in much better condition than they would be under ordinary conditions of lumbering because the forest is renewed both from sprout

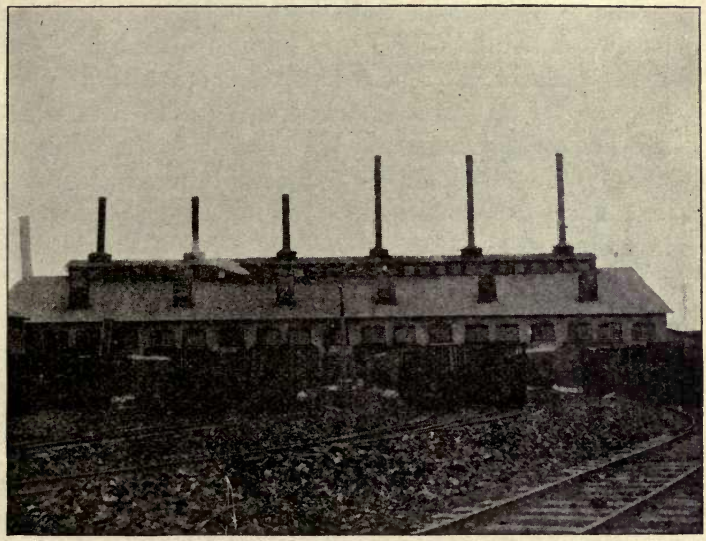
and from seed. The vigor of the forest is therefore maintained, forest fires are kept out and all of the available wood product is utilized. It would be a highly desirable situation if all forest industries could be run on the same basis.

Statistics of wood consumption in New York.

For a long time New York was the leader in the consumption of wood in the hardwood distillation industry. In the early nineties, however, the industry spread into Pennsylvania, and the greatest consumption at present is found in Michigan where, although there are comparatively few plants, the total consumption of wood exceeds that of any other State. From an investigation carried on in the spring of 1916, the State College of Forestry has determined that the annual consumption of hardwood for the industry in New York at that time was 192,330 cords. The daily capacity as reported by these plants was 643½ cords. These figures have been compiled as a result of both the daily and annual capacities of the twenty-five plants in the State, as estimated by the plants themselves. The latest available statistics as compiled by the Bureau of Census at Washington, D. C., for the consumption of hardwoods in New York State in this industry was for 1911, for which year it was announced that 132,400 cords were consumed.

The largest plant in the State in the spring of 1916 consumed 80 cords per day. This was an 8-oven plant located in Delaware county. The smallest plant in the State was one consuming only 12 cords per day in Sullivan county. This was an old cylinder retort plant containing 8 pairs of retorts. The average daily capacity of the individual New York plant is 25.74 cords and the average annual capacity is 7,691 cords.

As a rule the oven retort plants are much larger in daily capacity than the round retort plants. The smallest oven retort plant is a 2-oven affair consuming 16 cords per day with an 80 cord plant per day the largest. The smallest



Photograph by Nelson C. Brown.

One of the largest wood distillation plants in the country located at Cadillac, Mich. In the background are shown the oven houses with a smoke stack for each of the six 52 foot ovens. In front are shown the first set of cooling ovens, then the second set of cooling ovens, and finally the trucks containing charcoal cooling in the open in the foreground. This plant has a daily capacity of 96 cords, and uses chiefly mill waste from one of the large saw mills at Cadillac.

Photograph taken at the plant of the Cadillac Chemical Co.

round retort plant also consumes 12 cords per day with the largest one consuming 30 cords per day.

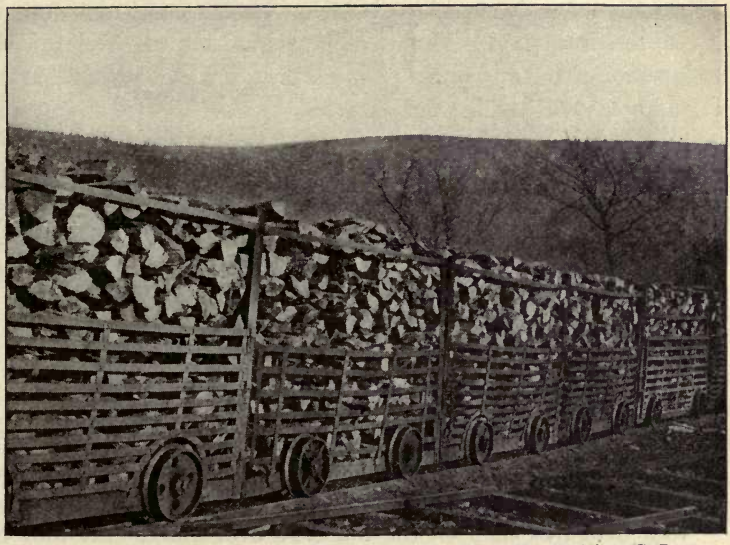
Statistics of wood consumption in the United States.

The latest available statistics of wood consumption in the hardwood distillation industry in the United States were for 1911, when it was reported that 1,058,955 cords were consumed. Of this amount Michigan with 13 plants led with 396,916 cords; Pennsylvania was second with 50 plants consuming 364,539 cords, and New York third with 25 plants consuming 132,400 cords. Seventeen other plants scattered in 11 different states, chiefly in the east, reported a consumption of 165,100 cords.

It is very likely that with the stimulation of high prices for products of the wood distillation industry, due to the great European War, the total consumption in the whole country in hardwood distillation amounts to about 1½ million cords, although this is a very rough estimate. The following table shows the statistics of wood consumption for the United States as compiled by the United States Bureau of Census from the years 1907 to 1911, inclusive:

Year	Number of Establishments	Number of cords of hardwood consumed
1907	100	1,219,771
1908	101	878,632
1909	116	1,149,847
1910	117	1,257,917
1911	105	1,058,955

This table shows how the consumption of the wood in the industry dropped off after the enactment of the Federal law in 1907 which resulted in the serious drop of prices obtained for the crude wood alcohol.



Photograph by Nelson C. Brown.

Wood cars loaded and ready to be sent into the ovens. Each 52 foot oven contains four of these trucks. Each truck contains between 2 and $2\frac{1}{2}$ cords of 50 inch wood. In the process of distillation this wood is reduced about one-half in quantity to its final form as charcoal.

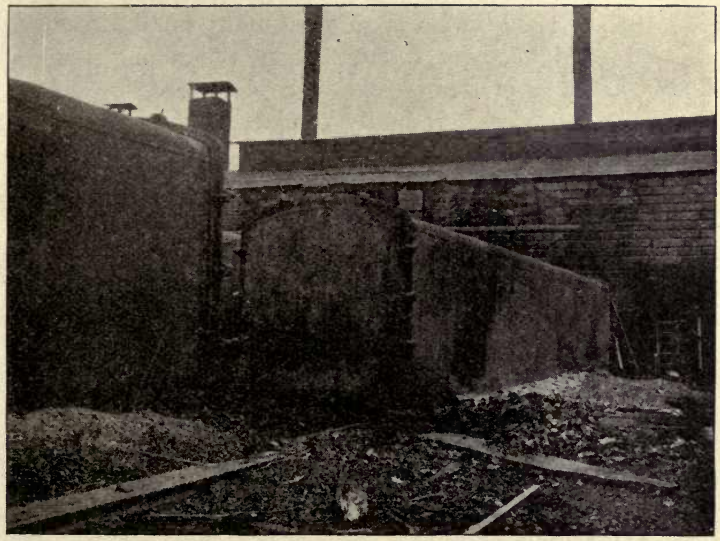
Photograph taken at the Maryland Wood Products Co. plant at Maryland. Otsego county, N. Y.

Developments in the Industry.

Up to nearly 1860 practically all of the acetate of lime used in the dye business in this country had been imported from Europe. Acetate of lime was the principal product sought after in wood distillation in the early developments of the industry. The distillate was not utilized for wood alcohol or for any other purpose than for lime acetate, and the charcoal was used, when convenient, for fuel for manufacturing pig iron and for other purposes. Acetate of lime was commonly used even in the wet condition before it had been thoroughly dried out. In the early days of the industry it brought as high as 18 cents a pound even in the wet condition. At the present time (October, 1916), dry gray acetate of lime is bringing 3½ cents a pound, whereas in the fall of 1914 it was only bringing 1½ cents a pound. In the spring of 1916 it brought 7 cents per pound.

Mr. Patterson was one of the first men to establish a plant in New York, located at Kirkwood, near Binghamton. Mr. Thomas Keery entered the business with him at Keeryville, between Cadosia and Apex, in Delaware county, and this firm has been in the business ever since. At that time the brown acetate of lime was full of tar and not nearly equal to the present refined product. The charcoal and alcohol were usually allowed to go practically to waste. Enormous prices were obtained for acetate of lime so that interest was greatly stimulated in the industry.

About 1885 the raw form of wood alcohol was developed and an attempt was made to sell it at the hat manufacturing industries at Danbury, Conn. This was one of the very first large fields for the use of wood alcohol, and it brought high prices. Formerly grain alcohol had been used to stiffen hats and the use of wood alcohol rapidly came into common practice. At first as high as 70 cents a gallon was paid for this wood alcohol.



Photograph by Nelson C. Brown.

Oven house in the background, the first cooling oven in the center, and portion of the second cooling oven on the left. After being heated to a high temperature for 24 hours, the cars of hot charcoal are moved from the oven house to the first cooling oven. After remaining in this cooling oven for 24 hours, they are moved into the second cooling oven where they remain for another day.

Photograph taken at the Beerston Acetate Co. plant, Beerston, N. Y.

Charcoal developed as the price of acetate went down. Acetate of lime was used to fix the color in dyes, particularly in Fall River, Mass. Gradually a big influx of wood distillation plants came in and the prices gradually dropped. Around 1885 to 1900 there were a great many small capacity plants and most of them followed very rough and crude methods. All of them used the cylinder retort process. These plants, however, were gradually replaced by the larger modern plants using the long oven instead of the old retort. There is now a much smaller number of plants than formerly, but, on the other hand, there is a much greater annual consumption of wood in the industry, due to the economy in plant operation with the advent of the oven in the early nineties.

Up to 1900 the industry was almost wholly centralized in the State of New York. At that time a few plants were started in Pennsylvania just over the border from the southern tier of counties in New York. About 1902 to 1906 the industry was further developed in Michigan, where the largest wood distillation plants, some of them utilizing as much as 110 to 200 cords of wood per day, are now located. Ideal conditions are present for the successful manufacture of wood distillation products in Michigan because of the availability of the raw material in connection with hardwood, saw and planing mills, together with the fact that iron furnaces are maintained in connection with them where the charcoal can be used to the best economical advantage. In addition the raw material is secured from the waste of sawmills and logging operations and one of the principal products can be utilized on the ground without excessive shipping rates.

Before 1907, wood alcohol had been bringing from 38 to 40 cents per gallon wholesale for the crude product, that is. the 82 per cent crude alcohol. When the Federal Internal

Revenue Department removed the tariff on grain alcohol, which took effect September 1, 1907, the price of crude wood alcohol dropped to about 16 cents per gallon, and gradually came back to 26 cents. The approximate present price is 45 cents per gallon, a price stimulated largely by the European War conditions. Before the war the price was about 28 cents per gallon of crude 82 per cent alcohol.

Processes of Manufacture.

Within the past fifty years the developments in the processes of manufacture followed in hardwood distillation have been remarkable. The history of the industry represents an evolution from the old wasteful charcoal pits. To recover the condensible gases lost in making charcoal by the old pit process, brick kilns were used. This was a very crude process, but represented a great step in advance. Next came the round iron retorts placed in "batteries" of two each in long bricked-up rows, and within comparatively recent years the steel oven, which is a great labor and time saving device. The following are brief descriptions of these three processes which followed each other in rapid chronological order.

Brick Kilns.

The brick kilns supplanted the old charcoal pit as a means of manufacturing charcoal when the iron industry in this country assumed large proportions. Brick was substituted for the open air sod or clay covered pit because manufacture was simplified, the loss of carbonization was minimized, and burning, therefore, could be carried on with greater safety. However, a good portion of the vapors are lost with the brick kilns as they are with the old open air pit since the yield is only about 40 per cent to 50 per cent of the yield from the oven process. These brick kilns are made with a circular base, with holes in the base for drafts of air regulated by

special doors and the vapors are drawn off by exhausters through wooden ducts. This practice was followed especially in Pennsylvania and in Wisconsin, where an abundant supply of the desirable hardwoods was found in a location near blast furnaces where pig iron was produced. Pig iron, manufactured by the use of charcoal is considered far superior to that made by coke. The pig iron made with charcoal commonly bring about $5 a ton more than that manufactured with coke. The brick kilns were usually built to hold 50 to 90 cords each and were charged and discharged by hand. The complete manufacture of charcoal by the brick kilns including charging and discharging required from 15 to 25 days. The heating necessary to distill the wood is supplied by the combustion of part of the charge within the apparatus, in the same way that charcoal is made in the open air pit. The yield of charcoal by this method is somewhat below that manufactured in the retorts or ovens and is generally considered inferior in grade. The brick kiln is only desirable when the chief product is charcoal and transportation facilities are not available or the market is too distant for the other products of wood distillation, such as wood alcohol and acetate of lime. Where other forms of fuel, such as natural gas and coal are out of the question and the manufacture of charcoal is desired, it is also commonly used.

Most of the brick kilns in operation are in Michigan and Wisconsin, where charcoal is in great demand in connection with iron furnaces. There are no brick kilns operating in New York at the present time for the manufacture of charcoal.

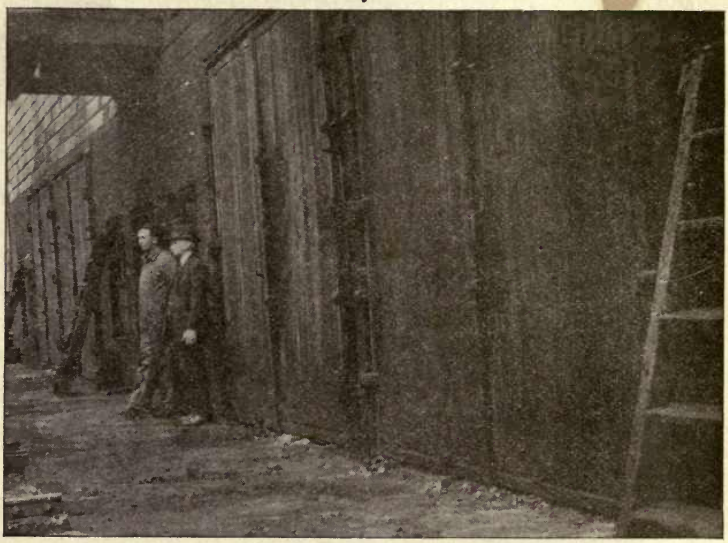
Iron Retorts.

The iron retort followed the brick kiln and was the first device invented whereby the vapors from the carbonization of wood are collected on an efficient basis and distilled in the form of pyroligenous acid and later refined into wood alcohol,

acetate of lime, etc. The yields, however, are much lower on account of slow firing. These retorts were small cylindrical vessels originally of cast iron and later steel cylinders 50 inches in diameter by 9 feet in length. They were placed horizontally in pairs and batteries of 10 to 15 pairs were common in long brick rows in the earlier plants. Each retort was sufficiently large to hold about five-eighths of a cord of wood. Heating was provided externally by a fire box located underneath the retort. For fuel, coal, charcoal, wood gas, wood oil, wood tar, and wood itself, have been used. The retorts are built and discharged from the single door in front which can be fastened tightly and sealed with clay to prevent the entrance of oxygen after the heating process is started. Along the top of these rows of retorts the surface is bricked over and serves as a drying floor for the acetate of lime. A run, that is the period from the first charging of the retort to the removal of the charcoal after the process, usually requires from 22 to 24 hours.

Oven Retorts.

The small round retort is now being rapidly replaced in the larger and more progressive plants by the large rectangular retort or oven retort. This is also known as an oven. Up to about 1900 a large number of these round retort plants were in operation, but about 1895 the oven retort came in which provides for loading and unloading the retort by the use of cars which are run directly into the chamber. This resulted in a considerable saving of labor charges so that all of the new plants now being constructed are introducing the ovens. In several of the states, there are not as many plants active now as there were twenty years ago, but there is a vastly larger amount of wood being consumed per plant, due to the fact that the oven retorts can consume as high as 10 to 12 cords in a single oven, whereas the old round retort held only about five-eighths to 1 cord of wood.



Photograph by Nelson C. Brown.

Twin doors in front of ovens. When these are opened after the distillation process is completed, the trucks of charcoal are pulled by cable into the first cooling ovens which are to the immediate left of the picture. In the background on the left are shown the doors of the second battery of ovens. This is a four oven plant.

Photograph taken at the Beerston Acetate Co. plant, Beerston, N. Y.

The modern hardwood distillation plant, therefore, is usually the oven retort plant. This was a decided advance in the manufacture of wood distillation products. As noted above, it is largely a labor saving device, and although the initial cost is considerably greater the operating charge per cord is so much smaller than with the round retort that it is being universally introduced. The ovens are rectangular in cross section and may be anywhere from 25 to 56 feet in length. The common form is an oven 52 feet in length, 8 feet 4 inches in height and 6 feet 3 inches in width. These ovens are usually arranged in pairs similar to the process followed with the round retort. The cars, each loaded with about two cords of wood, are run in on standard or narrow gauge tracks directly into the ovens. They are heated in a manner similar to the round retorts, that is, by means of a fire box underneath, although there may be fire boxes at one or both ends, and the fuel in the Pennsylvania and southern New York regions is usually either coal or natural gas. In the Delaware county section the fuel consists of coal from the Scranton region. The vapors pass out from one or two large openings at the side or at the end and are condensed through a large copper condenser. The process of distillation requires from 22 to 24 hours with the oven retorts, and when the doors are unsealed and opened, a cable is attached to the first car and they are drawn from the ovens directly into the first cooling oven which is of the same type of construction and shape as the heating oven. The capacities of the oven plants vary with the number and size of the ovens. In the Lake States there are some oven plants that now consume as high as 200 cords a day. The largest plant in New York State has 8 ovens which consumes 80 cords of wood per day and has an annual capacity of 24,000 cords.

Whereas the charcoal is emptied from the round retorts into round containers, sealed tightly to cause the slow cooling

of the charcoal without admission of oxygen, the charcoal after the heating process is completed in the oven retorts is left in the cars and drawn into the first cooling oven and left for 24 hours. This is of the same type and construction as the charring oven. The cars containing charcoal are then drawn into second coolers where they remain for 24 hours; then left in the open air 48 hours, so that there is a period of 96 hours which lapses between the time of the completion of the heating process and the time when the charcoal is loaded on the cars. It must remain on the freight cars at least 12 hours before shipment so that 108 hours lapse to the time of final shipment. This precaution is taken to prevent fire, which frequently causes the loss of charcoal and cars in transit.

Distillation.

Although many changes have been introduced in the manner in which the wood is heated for distillation purposes, very few changes have been made within the last twenty years in the refining of the crude distillate.

In the modern oven retort operation the process requires from 23 to 26 hours for completion. When the wood is rolled in trucks into the ovens, the doors are hermetically sealed and the fires are started underneath. In from one to two hours the wood is sufficiently heated up so that water distillation takes place. This distillate contains about 2 per cent acid. Then the "green gas" comes free for about five to six hours.

It is considered desirable to heat up the wood gradually and also to let it cool off gradually at the end of the process. The exothermic process, that is, that part of the process in which the wood fibers break down under the intense heat, does not take place until the temperature is run up to about 300 degrees Fahrenheit. In about six hours after closing the

Photograph by Nelson C. Brown.

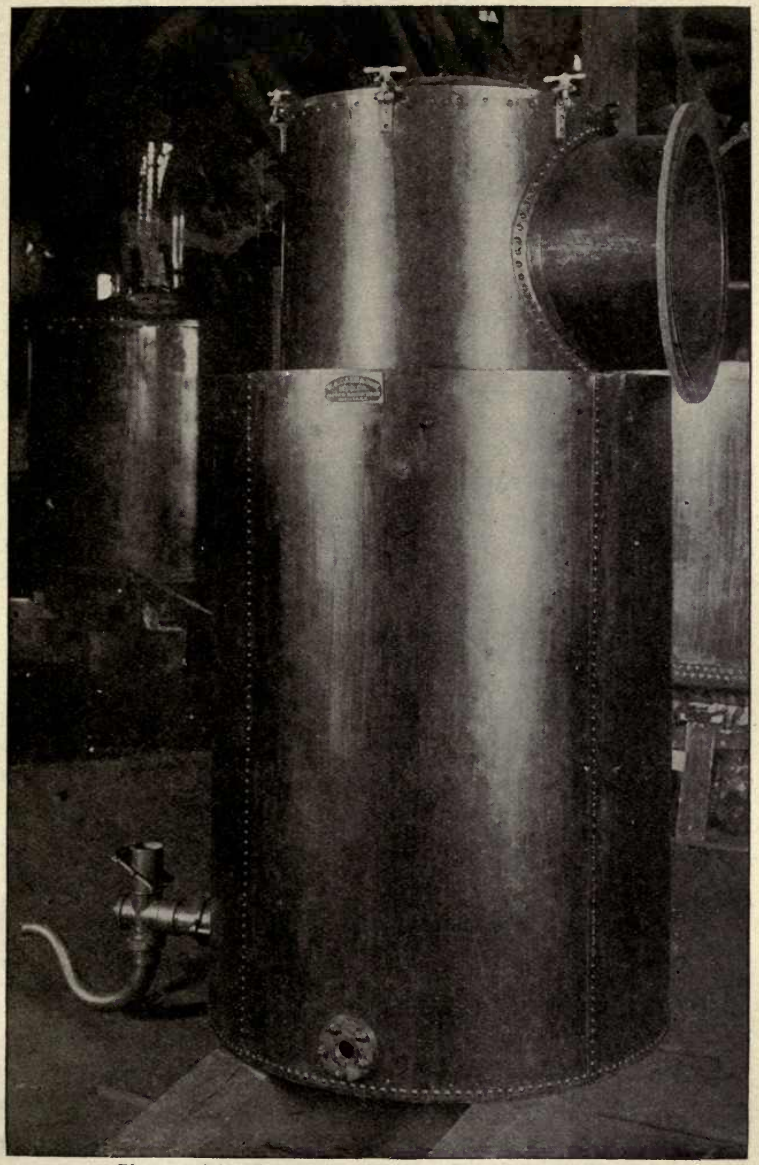
Looking down the alley between the first and second sets of cooling ovens on the shore of Lake Cadillac, Cadillac, Mich. After cooling for 24 hours in the ovens to the right, the trucks of charcoal are pulled by means of a cable into the cooling ovens on the left. Each cooling oven is 52 feet in length and holds four trucks at one charge. Note the standard gauge tracks between the cooling ovens and the manner in which the dirt is piled around the base of the cooling ovens to keep them air tight.

Photograph taken at the plant of the Cadillac Chemical Co., Cadillac, Mich.

doors the temperature attains an average of about 450 degrees Fahrenheit. It is then maintained between 450 and 600 degrees Fahrenheit. Temperatures of over 600 degrees Fahrenheit are considered undesirable. After about six hours of heating the pyroligneous acid begins to flow, and the best average is maintained up to about the eighteenth hour. An operator can determine from the color of the pyroligneous acid whether there is too much heat maintained, and if the wood fibers have broken down sufficiently. At the end of the heating process, the distillate forms tar to a large extent. After about the eighteenth hour the latent heat in the oven settings is sufficient to complete the process to the end, but the heat is gradually decreased until the charcoal is withdrawn.

As the gases and vapors pass out through the nozzle of the oven, they are condensed into a yellowish green, ill-smelling liquor called pyroligneous acid. A copper run takes this condensate to the raw liquor "sump," a tank in the ground, and so placed that the liquor will run into it by gravity. Meanwhile, the "fixed" or noncondensible gas is trapped and taken off at the outlet of the condenser and used for fuel underneath the boilers or ovens or perhaps both. A simple goose neck is used to trap off the gas.

The pyroligneous acid is next pumped from the "sump" in the ground to a series of wooden settling tubs of which there should be at least five in number. These tubs are usually from five to eight feet in diameter and six to eight feet in height. The purpose of these tubs is to settle the tar and heavy oils. The heavy tar is taken to a wooden tar still equipped with a copper condenser. This tar still is of wooden construction because the tar would eat up the copper in about a year. The residue remaining in the tar still is utilized together with residue from primary stills as boiler fuel.



Photograph by The Matthews Northrup Works, Buffalo, N. Y.

The Modern Oven Condenser.

This is placed at the rear or side of the oven and the gases are condensed through this into the raw liquor called pyroligneous acid and wood tar.

The pyroligneous acid is then run by gravity to the primary steam-heated copper stills equipped with automatic feed in order to supply the still continuously. The residue or boiled tar which gradually fills up in the still from the bottom is distilled by itself and run off at intervals of a few days or whenever the deposit reduces the flow of distillate from the still. During this process, which is known as "tarring down," the distillate is run into a separate tank and the light oils which rise to the top are drawn off. The acid liquor is then piped to storage tanks or tubs with the regular run from this still. These copper stills are made in any size which will give them the most flexible operation, that is, the size is determined by the question of economy in operation in labor cost. This in turn depends upon the capacity of the plant in cords of wood. The vapors from the copper still are conveyed through a large copper neck to an all copper tubular condenser encased in a steel water jacket. The flow of distillate from these condensers is piped to storage tubs.

From the storage tubs the acid liquor goes to the liming or neutralizing tubs. These are wooden tubs 12 feet to 14 feet in diameter, about 4 feet high, and provided with an agitator operated by a shaft and bevel gear from the top. The liquor is neutralized by adding slacked lime, a small quantity at a time. The proper quantity of lime is commonly determined by the color of the liquor, which changes at the neutral point between an acid and alkaline substance to a wine color, followed by a straw color and the appearance of beads on the surface.

From the neutralizing tubs the liquor is pumped or forced by means of a steam ejector to the "lime lee" stills. These stills are constructed of steel plate, the heat being applied by copper steam coils. The alcohol vapors pass off through an iron or copper neck, and are condensed in a copper condenser, and piped to storage tanks.

When the alcohol has been distilled off in the lime lee stills, the residue or acetate solution is forced by steam or air pressure to a settling pan located over the carbonizing ovens. After the impurities settle and are drawn off the acetate liquor is run into a large shallow steam jacketed steel pan, and boiled down to the consistency of mortar; it is then shoveled out and spread on brick, steel or concrete kiln floors over the ovens and thoroughly turned and dried; it is then shoveled into sacks for shipment as acetate of lime.

The alcohol liquor from the lime lee still is drawn from the storage tanks previously mentioned into a steel alcohol still provided with copper steam coils, and distilled off through a copper fractionating column consisting of a series of baffle plates having a tubular water cooled separator at the top. By this process the lower proof products are thrown back for further distillation, while the more volatile vapors pass over through a condenser, the distillate being sold to the refineries as finished crude alcohol of 82 per cent proof.

Plant Equipment.

The equipment of a modern hardwood distillation plant demands a comparatively large initial investment. They are usually located with reference to a large available supply of hardwoods which can be brought to the factory at a comparatively low cost per cord. From 10 to 40 acres are usually required for the plant and its adjoining storage yards and trackage facilities. The modern plant has from 2 to 8 oven retorts which are usually 52 feet long and housed in a retort house; open space for two sets of cooling ovens; a shed for the cooling and shipment of charcoal and the still house and power plant which are usually separate from the retort house. Most of our modern wood distillation plants in New York cost from $50,000 to $500,000 for the initial investment.

Before the European War it was usually estimated that a complete plant, aside from timber lands and the woodyard, would cost $2,000 per cord of daily capacity. Since the war this average has risen to $2,500 per cord. However, this may vary about $2,000 and $3,000 per cord, depending upon the degree of completeness, cost of transportation, labor costs, character of the machinery and materials installed, etc. This means that an 8-oven plant with approximately an 80 cord daily capacity will cost in the neighborhood of $200,000. Using these same figures, the smallest modern oven plant with only two ovens and with a daily capacity of 20 cords, will cost in the neighborhood of $50,000.

A plant with seven 25-foot ovens built about fourteen years ago cost in the neighborhood of $125,000 fully equipped.

The following is a brief description of the principal features of equipment that are usually found in the hardwood distillation plants of New York State:

Storage Yards.

The storage yards should be in the close vicinity of the retort house and connected with it by standard gauge tracks running through the stacks of piled cordwood. The storage yards should consist of between 5 and 20 acres, depending upon the capacity of the plant and should be slightly raised in elevation above the retort house so that the loaded cars can be rolled easily into the ovens as needed.

Inasmuch as the wood must be seasoned for between 1 and 2 years, it is necessary to have a large, convenient and well-located wood yard so that there should be at least 6 month's seasoned supply on hand all the time.

At a 35-cord capacity plant it is planned to have 10,000 cords of wood as an advance supply continually on hand.

The wood is usually cut in 50-inch lengths and stacked in long piles up to 12 feet in height on either side of the standard gauge tracks from which the unseasoned wood is

unloaded from freight cars. In other cases parallel roadways are left open for the wagons to unload directly from the woods. Parallel tracks between these roadways are then provided to load the wood cars for the ovens after seasoning. In cylindrical retort plants the wood is commonly rolled in on wheelbarrows or open trucks and loaded by hand.

Retort House.

The retort house is the largest building in the plant. It houses the cylindrical retorts or oven retorts and in some cases the stills and appliances for treating the pyroligneous acid as well. However, in the most modern plants, the still house is a separate building.

The principal requisite of a retort house is that it should be of fire-proof construction on account of the very inflammable nature of charcoal and wood alcohol. One retort house at a plant having a daily capacity of 38 cords, is 60 feet in width by 240 feet long, 20 feet high to the eaves and 40 feet to the peak of the roof. Steel beams and supports are used throughout with sheet iron roof and siding. Other retort houses are either built of stone or brick in order to reduce the fire hazard and therefore obtain low insurance rates. Most of the New York plants are poorly arranged because of their enlargements from rather modest beginnings and no definite plan seems to have been followed in the arrangement of the plant.

Trackage and Cars.

The tracks are usually standard gauge with the rails from 40 to 75 pounds in weight and are so arranged as to bring the wood from the storage yards to the retort house and then to conduct the cars loaded with charcoal through the two sets of cooling ovens and out to the charcoal shed where the charcoal is loaded on freight cars. The most modern plants have the progressive arrangement, that is, the loaded cars come from the storage yards directly to the retort house; follow

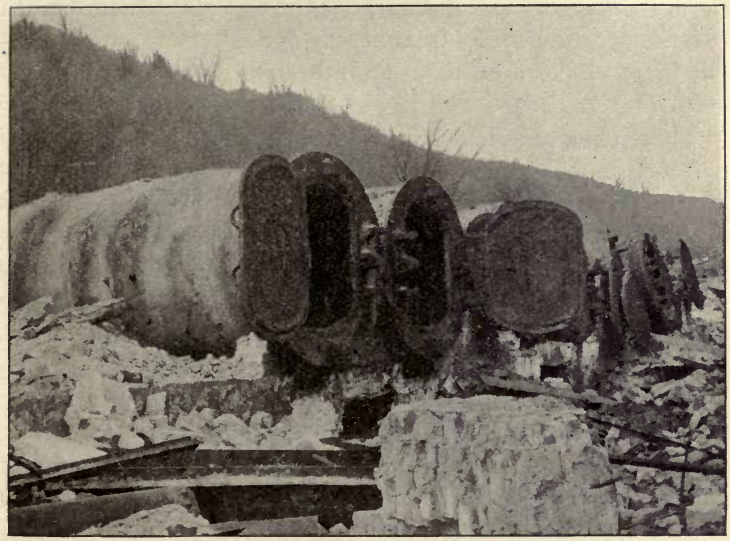
through in one continuous direction to the first cooling oven and then to the second and on out to the charcoal sheds where the charcoal is shipped. The return tracks take the empty cars back to the storage yards where they are reloaded and the same process followed out.

The cars are all of steel construction and hold from 2 to 2½ cords of 50-inch wood. A 50 to 54-foot oven will hold 4 of these cars in one charge. A 25-foot oven will hold 2 of them. They are built in different sizes but the usual style of car is 52 inches wide, 6 feet 6 inches high and 12 feet 6 inches long with 4 small wheels. They first came into use in the middle nineties and have proven to be a great success.

The cars cost from $80 to $140 apiece, f. o. b. at Warren, Pa. They last indefinitely according to most of the operators, so that there is very little depreciation charge on them. Both sides of the car are detachable to facilitate the loading and emptying of the cars.

Retorts.

The old iron retort was a cylindrical vessel holding about five-eighths of a cord. The standard size was 50 inches in diameter by 9 feet in length. Cordwood 48 inches in length was used instead of the 50-inch length commonly used in the oven retorts. The retorts are set in brick work in pairs, each pair forming a battery and heated directly from beneath. They are charged and discharged from a single door in front which can be hermetically sealed. Considerable labor is involved in the charging and discharging of these retorts and the ovens with the cars running directly into them on tracks are a great improvement. With the invention of the ovens in the early nineties very few of the old round retorts were installed. In fact, all of the new plants being developed in New York State have the long oven retorts. At the present time there are 352 retorts distributed over 15 plants in different parts of the State.



Photograph by Nelson C. Brown.

Cylindrical retorts of an old-fashioned retort plant, now burned down and dismantled. These retorts are arranged in batteries of two and are heated by direct heat underneath. Each retort contains about $\frac{5}{8}$ of a cord and must be loaded and unloaded by hand. The modern oven is a vast improvement over this old-fashioned method.

This photograph was taken at the Keery Chemical Co., Cadosia, N. Y.

Ovens.

The oven or oven retort is a vast improvement over the round retort, the chief advantages being that a large amount of wood can be distilled at one time and considerable labor is saved in charging and discharging the ovens, the loaded wood cars being run directly in from one end on tracks and hauled out by means of a cable on the other end to the first cooling oven.

These ovens in cross section are 6 feet 3 inches wide and 8 feet 4 inches high. In length they vary from 25 feet to 50 feet, although the usual length used at the present time is a 52-foot oven which holds 4 cars. These ovens are usually installed in batteries, that is, 2 ovens being placed close together and called a battery. In Michigan there are as many as 7 to 10 batteries in a single plant. The largest New York plant contains 8 ovens and is located at Corbett in Delaware county. Altogether in New York State there are 46 ovens distributed over 10 plants.

These ovens have air-tight doors on one or both ends, depending upon whether the charcoal is to be taken out in the same direction as it entered or sent out through the progressive form of trackage arrangement. The ovens are of steel, usually three-eighths of an inch in thickness, while the bottoms and backs are of one-half inch material. The oven is sustained by means of angle irons riveted perpendicularly on the sides and on one side near the top are riveted cast iron nozzles, usually two in number, which are attached to the condensers. In the heating process it is said that the 52-foot oven will expand 4 inches in length due to the tremendous heat applied during distillation. These ovens only last from 3 to 12 years, so that the depreciation charge is very high.

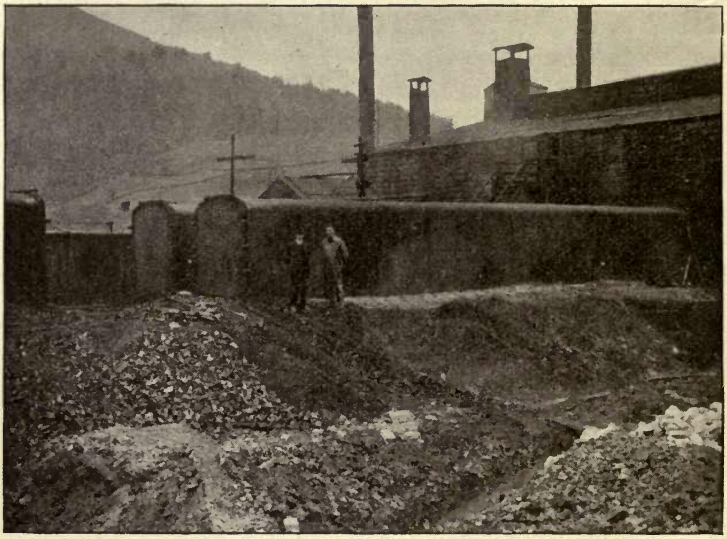
The 52-foot oven costs about $1,800 and approximately an equal amount is required to install and set it up ready for operation.

Cooling Ovens.

In every oven retort plant the charcoal is gradually cooled by being run into cooling ovens located immediately in front of the retort house in the open air. The first cooling oven is about 8 to 10 feet from the charring oven and the second cooling oven about an equal distance beyond the first cooling oven. The accompanying photographs show the arrangement of the cooling ovens in relation to the retort house. The cooling ovens appear to be the same in size, shape and construction as are the ovens themselves. However, the sides are only of three-sixteenths inch steel and usually there are doors at both ends. There are no bottoms to these cooling ovens as they rest directly on the ground. Dirt is piled around the base to prevent the admission of air.

The cars with the heated charcoal, after the distilling process, are rolled directly into the first cooling oven. As soon as the air is admitted on the opening of the doors, the charcoal bursts in flame and as soon as possible after the cars are rolled into the cooling oven the doors are hermetically sealed, so that the charcoal will cool slowly. The charcoal is left for 24 hours in the first cooling oven, 24 hours in the second cooling oven, then is left at least 48 hours in an open shed or in the open air and after being loaded on the freight cars it is left standing for at least 12 hours before shipping. This means a total of 108 hours from the time of heating to the time of leaving the yard. A government regulation prescribes this procedure because " punky " knots hold fire for a long time in the charcoal and it is necessary that these extreme precautions be taken to prevent burning of the cars.

In some of the plants, an outlet pipe is used near the top of the cooling oven to permit the escape of the acid fumes. It is claimed by some that this saves the eating of the iron by these fumes.



Photograph by Nelson C. Brown.

General view of the plant of the Beerston Acetate Co., Beerston, Delaware county, N. Y. On the right is shown the oven house containing four 52-foot ovens. In the center is shown a battery of cooling ovens into which heated charcoal is drawn in trucks and left standing for 24 hours. The end of the second cooling oven is shown on the extreme left.

Still House.

The provision for redistilling the pyroligneous liquor is usually housed in the old plants along with the cylindrical retorts but in the more modern oven plants the apparatus is placed in a separate fire-proof building usually in close proximity to the power house or in connection with it.

The equipment of the still house consists principally of the settling tubs, neutralizing tubs, storage tubs, steam pans, copper and iron stills, condensers, fractionating column, etc., required for the three principal distillations previously described. Although the equipment in some small details may vary in each plant, the general process of separating the acetate of lime and the wood alcohol as well as the wood tar, is the same as was in common practice about 20 years ago.

For each separate plant, however, individual plans are drawn up to meet the requirements of local conditions. Altogether it is estimated that the equipment of the still house costs between $430 and $500 per cord of daily capacity. In the description of processes of manufacture, the function of the various equipment in the still house is described.

The following is the usual equipment used or recommended for a hardwood distillation plant consuming 30 cords of wood per day:

Retort condensers including tubs and outlet connections, number and size depending upon style of retort or oven installed.

Copper liquor run for conducting raw liquor from condenser outlets to storage tub.

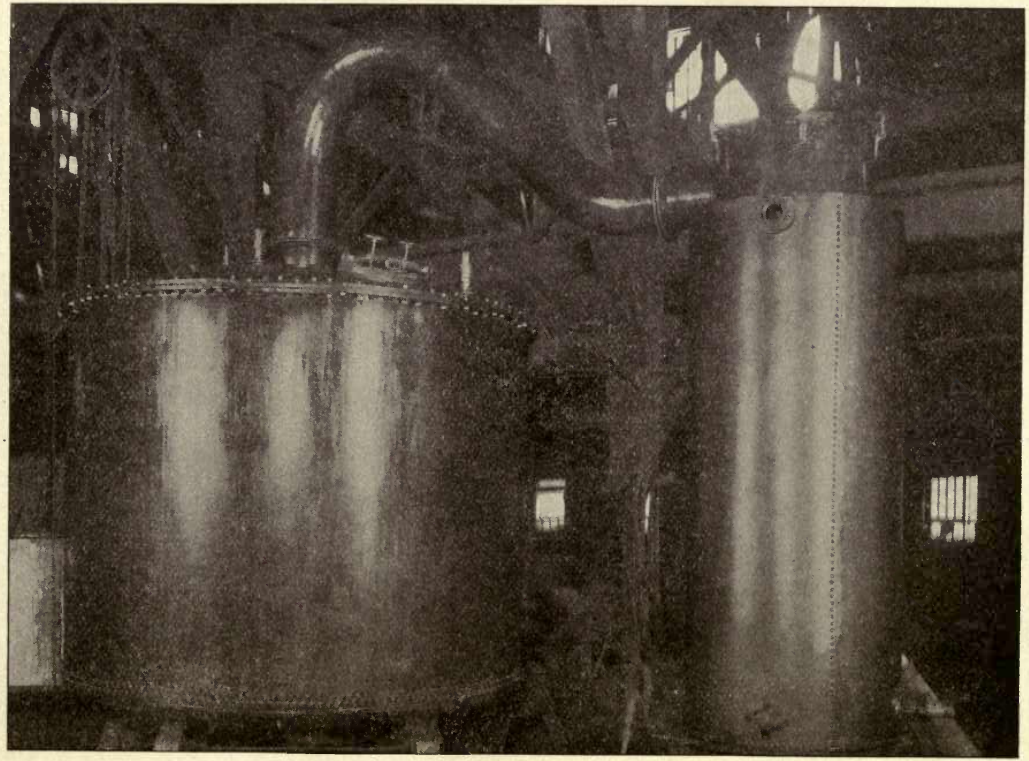
Copper gas main and connection for conducting wood gas from condenser outlets to boiler for fuel.

5 wooden setting tubs for raw liquor from storage tank above mentioned.

1 copper still complete with copper steam coils, neck and condenser for first distillation of raw liquor. Wooden storage tubs for liquor from copper still.

Wooden liming tub with power agitator for neutralizing liquor from storage tubs above mentioned.

1 iron lime lee still fitted with copper steam coils and condenser (an iron neck may be used on this still).



Photograph by The Matthews Northrup Works, Buffalo, N. Y.

The primary or raw liquor still with condenser and neck. This is one of the most modern and approved forms of stills and condensers.

1 or 2 steel storage ranks for lime lee liquor.

1 steel alcohol still with copper steam coils, column, separator and condenser for producing 82% crude alcohol from lime lee liquor above mentioned.

Steel storage tank and one large steel shipping tank for raw liquor. The residue from lime lee stills (acetate of lime) would be piped to the open steel settling tank and then to steam pan. The acetate of lime would then be shoveled from steam pan to drying floor on top of ovens if possible in order to utilize waste heat from ovens.

The use of a small wooden tar still with copper neck and condenser for distilling raw tar from settlers which contain a considerable quantity of alcohol is also recommended.

For refining the crude alcohol further one would require one steel still with copper steam coils, refining column, separator and condenser for first distillation; one steel still with copper steam coils, column of different type than used in first distillation including separator and cooler for second distillation. The alcohol in first and second distillation is treated with caustic soda. A steel tank graduated in inches or gallons should be provided for caustic soda storage and charging stills.

2 steel storage tanks would be required for each still, each tank having the capacity equal to still.

An all copper still with copper steam coils, refining column of special type including separator, cooler, hydrometer jar, necks, etc., complete would be required for third distillation. The alcohol would be treated with sulphuric acid in this distillation. Suitable storage and shipping tanks which may be of steel to be provided for finished goods.

This latter outfit would produce commercial refined alcohol of 95% to 97% purity.

Drying Floor.

The drying floor is a flat, level space surfaced with cement or concrete usually placed over the ovens. The heat of the ovens furnishes the necessary temperature to dry out the acetate of lime. After being dried it is bagged up and shipped directly in freight cars.

Charcoal House.

The charcoal house is usually an open-constructed affair slightly elevated above the level of the oven house so that the cars containing charcoal can be unloaded directly into box cars or into charcoal bins. The trucks containing charcoal must be left either in the open air or standing in the charcoal

house at least 48 hours before the charcoal can be dumped into the box cars. Most of the charcoal is shipped in the loose state. Sometimes it is separated into as many as five grades, the finer product being bagged and shipped in sacks containing 25 or 50 pounds each. In all cases the charcoal house is well removed from the oven house to decrease the danger from fire. It is also well protected by means of hose, water pails, fire extinguishers, etc., to minimize the fire hazard.

Cost of Plant and Equipment.

As outlined before, the initial cost of a modern complete wood distillation plant is very large. It is estimated that under present market conditions an investment of $2,500 should be provided for each cord of capacity. That is, if a plant is so designed to be of 50 cords capacity, the initial investment required would probably be about $125,000.

Before the great European war, it was generally estimated that a complete plant would cost about $2,000 per cord of capacity. The difference in the above estimates is due to the fact that the cost of iron, steel, copper and other materials used in the manufacture of wood distillates, have risen tremendously as a result of the competition to better conditions in this country, together with a demand for supplies from European countries.

The old fashioned cylindrical retort plant is much less expensive for the initial expense but the heavy charges due to labor result in excessive operating charges. A 24-round retort plant, that is, one containing a battery of 12 pairs with each pair of retorts holding about 1¼ cords, costs $75,000 for the entire plant.

When it is figured that the modern plant costs $2,500 per cord of capacity, it is estimated that one-third of this charge is for buildings, while the apparatus costs about two-thirds.

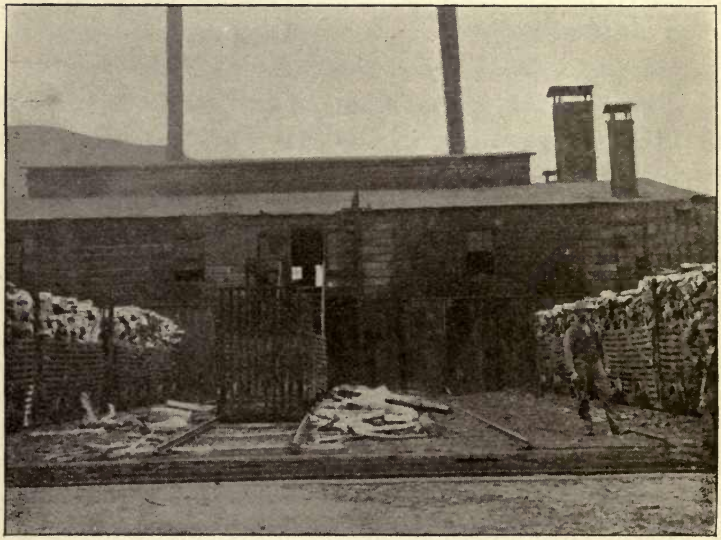
Plant Operation.

The following are the principal features of plant operation. Each is briefly described, giving the principal commercial features involved, such as costs, per cord charges, and other commercial features involved in the operation of a wood distillation plant.

Fuel.

Altogether there are six forms of fuel commonly used in the hardwood distillation industry. They are as follows: Coal, natural gas, charcoal, wood, wood tar and wood gas. Altogether coal is most commonly used. In the district centering around Olean many of the plants use natural gas. Most of the plants in the Olean district, however, are just over the New York line in Pennsylvania. The plant at Vandalia is the only one in the district in New York State. Both hard and soft coal are commonly used for the purposes of direct heating and the production of steam. Most of the Delaware county plants use coal. Practically all of the plants in the State use the wood tar and wood gas, which are products of the distillation process, directly under the ovens or retorts or under the boilers.

The estimates regarding the cost of fuel vary considerably. Altogether estimates were received from $1.15 to $2 per cord. The cost will naturally vary with the kind of fuel used, the distance from source of supply, efficiency of boilers and steam pipes and other correlated factors. In one of the larger plants of the State which has seven 25-foot ovens, it was estimated that 300 bushels of charcoal, 300 gallons of wood tar and all of the available wood gas were used for each charge of seven ovens. At a prominent plant in Delaware county it was estimated that 300 pounds of soft bituminous coal were used for the distillation of one cord of wood. In an oven containing ten cords, therefore, this would require 3,000 pounds of soft coal for one charge. It is estimated that



Photograph by Nelson C. Brown.

Cars loaded with seasoned wood ready to be pulled into the ovens, the doors of which are shown at the oven house. The ovens are charged every 24 hours. This illustrates the progressive arrangement, the cars after the distillation process being pulled out the farther side into the cooling ovens.

Photograph taken at the Beerston Acetate Co., Beerston, Delaware county, N. Y.

the fuel value of wood tar is at least twice as much as that of coal for a given weight.

Labor.

Labor is a very important item in the cost of production. Altogether the labor is unskilled at all of the plants with the exception of the plant superintendent or manager, and in the case of the largest plants there is a chemist or expert engineer employed who receives more than the ordinary day wages. There is a distinct tendency to raise wages at the various plants. At the present time these vary between $1.50 per day to $1.60 at one plant up to $2 per day at others. All plants, of course, run night and day but there is a very small force engaged in the work during the night time. At most of the plants there is a given piece of work to be done each day, and when this is completed the men are free for the rest of the time. For instance, in the wood yard, the day's work may consist of loading so many cars of wood. When this particular work is completed, the men are through for the day.

Altogether the larger the plant the greater is the economy in labor. The greatest saving in labor in the development of the industry, has been the change from the old round retort plant to the modern oven plant. Owing to the fact that the trucks are pulled in and out of the oven by means of a power cable, there is a great saving in labor over the old round retort plants where the retorts had to be loaded and discharged by hand.

At a 4-oven plant having a capacity of 40 cords per day, there were the following employees:

2 firemen at the boilers.
2 men in the still house.
2 firemen for the ovens.
4 men in the dry-kiln.
4 men to charge and draw extra trucks or cars.

1 extra man about the piping.
2 men in the wood yard, handling wood.
1 foreman.

This makes a total of 18 men on the 24-hour shift, that is, there are 13 men on during the day and 5 during the night. This list does not include the teamsters used in drawing the wood from the chopping area to the storage yards.

At a 2-oven plant there were 12 men employed beside the superintendent. All of these men were common labor paid at the rate of $1.50 per day. The firemen were on 8-hour shifts and all others were on 10-hour shifts. The following shows the number of men required on this particular operation:

2 still house men, one on the night, and the other on the day shift.
2 kiln men, one on the night and one on the day shift.
3 firemen in 8-hour shifts each.
3 oven men to load wood on cars or coal screener.
3 extra handy men.

The labor cost per cord varies very much. In two plants the costs were $1.15 and $1.18 per cord respectively. At other plants the labor cost is sometimes as high as $1.50 to $1.70 per cord. The labor charge is considerably higher, of course, in the cylindrical retort plants than in the oven plants due to the reasons given above.

Depreciation Charges.

Owing to the intense heat required to distill the wood, and the acid nature of the products, depreciation charges on the ovens, retorts, cars and distilling apparatus are very heavy. Ovens usually last only from 3 to 12 years. The coolers last much longer as a rule and the wood cars last from 12 to 20 years. Altogether a depreciation charge of from 50 cents to

Photograph by Nelson C. Brown.

Charcoal cooler used in the old cylindrical retort plants. The charcoal was shovelled from the retorts directly into this container and kept in an air-tight condition to prevent combustion. In the modern plant the charcoal is now cooled in the same truck in which it is heated, the trucks being run into cooling ovens on standard gauge tracks.

Photograph taken at the dismantled retort plant of the Keery Chemical Co., Cadosia, N. Y.

$1 per cord is customary at most of the plants. However, the usual charge is likely to be nearer $1 than the lower figure.

The life of the copper apparatus is about 10 to 12 years and there is considerable salvage on old copper.

Cost of Operation.

The cost of operation depends on a large number of factors, the chief of which are the charges for wood, fuel and labor. Transportation charges for material such as fuel, supplies, etc., are also an important consideration.

It is very difficult to say what the average costs of operation should be. They are usually figured or based on the charges per cord. At the various plants, the method of cost computation varies considerably so that it is very difficult to compare one with another. The degree of efficiency also varies considerably as it is very difficult in this respect to compare them. At an oven retort that has been run for some time in Delaware county, the costs per cord were figured as follows:

Wood	$4.00
Labor	1.50
Fuel	1.77
Lime	.19
Supplies, oils, etc	.32
General expenses	.51
Depreciation	.58
Insurance	.08
Taxes	.22
Total	$9.17

The above computation was based on a month's run and a very careful record was kept of all costs. There were 16 men employed at this factory, not including the men engaged

in cutting and hauling the wood, nor the office force. The standard wage scale was $1.60 per day and the factory was located in the region in which a plentiful supply of wood could be obtained.

At another oven plant the following costs were observed. These are also given per cord of wood.

Wood	$4.00
Fuel	1.50
Labor	2.00
Depreciation, etc	1.00
Marketing	1.47
Total	$9.97

Yields.

The yield of products at hardwood distillation plants varies considerably. The yield at any particular plant depends upon the following factors:

1. Temperature, that is, the maximum and minimum temperatures used during the exothermic process.

2. The rapidity of heating. Too rapid heating will cause a much smaller and lower grade of product. Usually about 10 hours is the time required to get wood up to the highest temperatures. If heating is done too rapidly the color of the pyroligneous acid is much darker and the yields are consequently much lower.

3. The species of wood. There is a general consensus of opinion among the New York plants, that maple is the best wood with beech next and birch third. Oak and hickory are also desirable species but if there is too much soft maple, basswood, poplar, gray birch or other inferior species, the yields will be lowered.

4. The character of the wood. It is generally assumed that the dryer and more thoroughly the wood is seasoned, the

better will be the product. It is also true that heart wood yields much larger and better products than sapwood, and body wood is much more desirable than limb wood.

5. Efficiency of the plant. This is determined by the character of the machinery and equipment, arrangement of the apparatus and many other factors connected with the efficiency of an operation.

The products of hardwood distillation in New York State are as follows: wood alcohol, acetate of lime, charcoal, wood tar and wood gas. The latter two are practically always used as fuel under the boilers or retorts.

From an investigation of the 25 plants in New York State it was determined that an average yield of 42.7 bushels of charcoal are obtained per cord of wood from all of the plants. There was a maximum yield of 50 bushels of charcoal per cord and a minimum yield of 38 bushels.

The average estimated yield of acetate of lime was 199.47 pounds per cord of wood. The minimum was 171 pounds and the maximum 220 pounds.

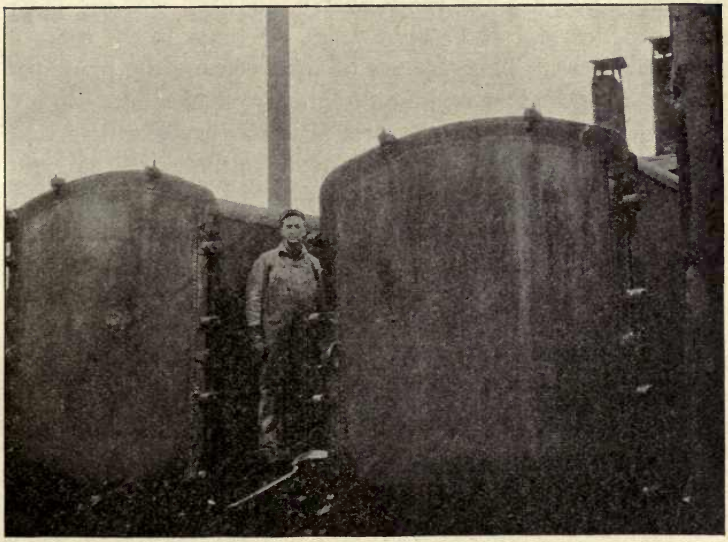
In wood alcohol the average yield was 9.9 gallons of 82% wood alcohol per cord of wood. The minimum was 8 gallons and the maximum 11 gallons per cord.

It is estimated that between 23 and 28 gallons of wood tar are secured per cord with an average of about 25 gallons. It is estimated that about 11,500 cubic feet of gas are secured per cord of wood.

These figures are based upon the individual estimates of the various wood distillation plants of the State. Altogether much better yields are secured from the oven plants than from the cylindrical retort plants.

Value of Products.

One of the greatest drawbacks to engaging in the wood distillation business has been the great fluctuation in the price



Photograph by Nelson C. Brown.

End view of a pair of cooling ovens showing the character of the door, lugs and method of heaping dirt around the base to prevent the entrance of air. The trucks loaded with the heated charcoal are drawn directly from the oven-house into the first cooling oven and left there for 24 hours. They are then drawn into the second cooling oven for another 24 hours. After that, the charcoal stands in the trucks in the open air for 48 hours, after which it is loaded on the freight cars where it remains 12 hours before it is sent off to its destination.

These cooling ovens are kept air tight to prevent combustion of the heated charcoal.

Beerston Acetate Co., Beerston, Delaware county, N. Y.

levels for all of the principal products, namely, acetate of lime, wood alcohol and charcoal.

In the early days of the industry, charcoal was the principal product and it brought from 10 cents to 20 cents a bushel or more. Then acetate of lime became the principal product sought after and finally the wood alcohol. Before the Federal legislation, the profits were very excellent and attractive but since 1907 and up to the outbreak of the great European war on August 1, 1914, price levels were very uncertain and several of the concerns were driven out of business.

Up to the time of this war, the prices obtained for acetate of lime varied between $1.25 to $2 per hundred pounds. Since August 1, 1914, the following price levels have been obtained:

August to October	1914	$1.50 per 100 lbs.
November	1914	1.75 per 100 lbs.
December	1914	2.00 per 100 lbs.
January	1915	2.00 per 100 lbs.
February to May	1915	2.50 per 100 lbs.
June to August	1915	3.50 per 100 lbs.
September to October	1915	4.00 per 100 lbs.
November to December	1915	5.00 per 100 lbs.
January	1916	6.00 per 100 lbs.
February to August	1916	7.00 per 100 lbs.
September	1916	5.00 per 100 lbs.
October	1916	3.50 per 100 lbs.

In regard to wood alcohol, the prices have also fluctuated considerably. Quotations varied between 30 cents and 45 cents per gallon for the crude 82% alcohol. Since the outbreak of the war, however, the use of both wood alcohol and acetate of lime have been greatly stimulated for their use in the manufacture of certain war munitions and the prices have steadily advanced.

During the year 1914 the market price of 82% crude wood alcohol was 25 cents per gallon delivered to the refineries in tank cars and the price of 95% refined delivered to buyers in free wooden barrels to points east of the Mississippi river 45 cents per gallon in 1 to 10 bbl. lots and a small discount in carloads. Prices held at these figures until October, 1915, when the price of 95% refined wood alcohol began to advance first to 50 cents, later to 55 cents, then on February of 1916 to 65 cents, and on October 1, 1916, to 70 cents, the price of crude steadily advancing to the present figure of 45 cents per gallon. These advances were made possible by the rapid increase in the price of denatured alcohol, this material now being 60 cents per gallon. There is every indication that the price of both alcohols has gone sufficiently high for some time to come. In the spring of 1916, 97% refined alcohol brought 70 cents per gallon. Methyl acetone was worth 90 cents to 95 cents per gallon and pure methyl or columbian methanol was worth $1 a gallon.

With the increased use of both acetate of lime and wood alcohol, the demand for charcoal has not kept pace with these other two products, and consequently prices have suffered very materially. At the present time, charcoal is only bringing around 5 cents to 6 cents per bushel. In 1914 it was bringing 7 cents a bushel wholesale at the acid factory. The estimated production of charcoal in this country before the war broke out, was about five million bushels a month and the iron furnaces took by far the greatest proportion of this.

Practically all of the products of the wood distillation industry are sold wholesale in carload lots at the factory. The wood alcohol is shipped in tank cars or in tight barrels. Charcoal is shipped in sacks and the acetate of lime is also shipped in sacks or bags. Up to the present time, no regular market has been developed either for the wood gas or wood tar. Both of these are usually now consumed as fuel under-

neath the retorts. It is very likely that some time in the future a definite market will be developed for the utilization of wood oils and wood tar. It can be made into creosote but the process is so expensive that this form cannot compete successfully with coal tar creosotes.

The following table shows a comparison of values of products per cord under conditions prevailing in 1914, and those occurring in 1916. This table is based upon the average of yields of acetate of lime, wood alcohol and charcoal per cord. The values are those described before. The following table shows that the operators were receiving more than twice as much for their products under market conditions in the Spring of 1916 than they did under those prevailing before the war.

	Yield per cord	Value per unit 1916	Value per cord 1916	Value per unit 1914	Value per cord 1914
		Cents		*Cents*	
Acetate of lime....	199.47 lbs.	7	$13 97	1.7	$3 39
Wood alcohol.....	9.90 gals.	37	3 66	25.	2 48
Charcoal.....	47.7 bu.	6	2 86	7.	3 34
			$20 49		$9 21

Utilization of Products.

The utilization of the products of the hardwood distillation industry has been a great problem, especially since the Federal law of 1907 went into effect. The greatest money return is received from disposal of the acetate of lime and the prices received for this product have undergone great fluctuation.

Altogether there are three primary products derived from the process, namely, the raw pyroligneous acid, the wood gas

and the charcoal which remains as a residue from the distillation of the wood. The secondary products as a result of the separation of the tar from the pyroligneous acid and the further distillation of the pyroligneous acid, are first, wood tar, second, acetate of lime and third, wood alcohol.

The utilization of the five derived products of this industry, therefore, are described in the following order: acetate of lime, wood alcohol, charcoal, wood tar and wood gas.

Acetate of Lime.

During the year 1916, it is estimated that in New York State there will be produced 38,396,835 pounds of acetate of lime. This is based upon the annual consumption in New York State of 192,330 cords with an average yield of 199.47 pounds of acetate of lime per cord. At a valuation of seven cents per pound this material is worth $2,685,788.

It is estimated that approximately 100,000 long tons of acetate of lime are produced every year in this country. Under normal conditions, that is, before August, 1914, only about 75,000 long tons were produced.

Under normal conditions the export and domestic consumption of acetate of lime about equalled each other. Now this product is chiefly consumed in this country.

Probably 75 per cent of the acetate of lime produced in this country is used as the raw material for the acetic acid industry. More recently there has been a tremendous demand for the use of acetate of lime as a source of acetone. About 100 pounds of 80 per cent acetate of lime are equivalent to 50 to 60 pounds of refined acetic acid or 20 pounds of acetone. Acetic acid is used chiefly for the manufacture of white lead, acetone in the textile and leather industries and in a great variety of other commercial manufactures. One of the most important present uses is in the manufacture of cordite and lyddite, two high explosives. Acetone is also

used largely as a solvent for the cutting of gun cotton and in the manufacture of smokeless powder.

In many of the European countries acetic acid or wood vinegar is a common product on the market. However, the manufacture of wood vinegar from acetic acid is prohibited in this country.

Wood Alcohol.

During 1916 it is estimated that there will be produced 1,904,067 gallons of 82 per cent wood alcohol in New York State. At the current value of 45 cents per gallon, this should be worth $856,830.15. This is based upon the total consumption of 192,330 cords per year in the industry and the average yield of 9.9 gallons of 82 per cent wood alcohol per cord.

It is further estimated that between 10 and 11 million gallons of wood alcohol are produced every year in this country. Its greatest single use is as a solvent. Probably 90 per cent of all the wood alcohol used is for this purpose in one way or another. Its greatest consumption is probably in the paint and varnish industry in which about 35 to 50 per cent is utilized.

Practically no wood alcohol is used in the raw 82 per cent state. It is all refined to a higher state of purity before being utilized. One concern refines a good share of the total product of the country.

Wood alcohol is used very largely in aniline dye factories to make colors, especially greens, purples and light blues. It is also used in the manufacture of formaldehyde, photographic films and in stiffening hats.

Refined wood alcohol of high purity or methyl alcohol, that is, of 99 to 100 per cent purity, is sold under a great variety of trade names, such as Columbian methanol, colonial methyl, diamond methyl, etc. As an extraction agent wood alcohol is used in the manufacture of smokeless powder, nitro

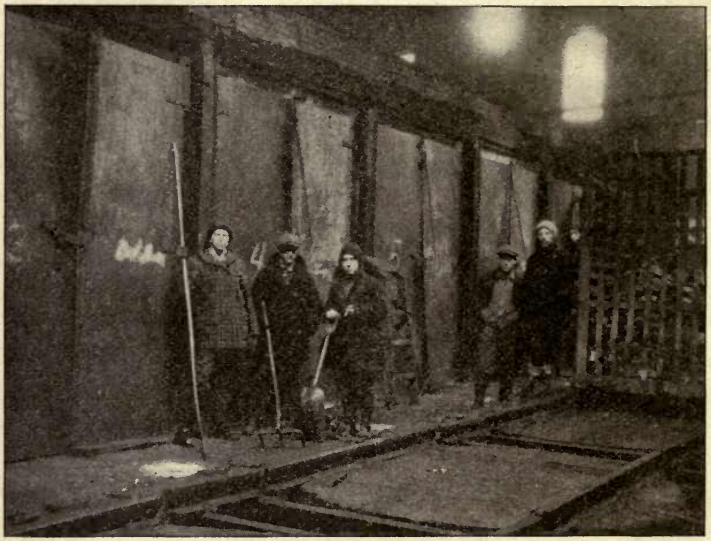
cellulose and other explosives. Gun cotton for example is freed from cellulose nitrates by extraction with wood alcohol.

Other common uses are as follows: As fuel, as an illuminant, as a denaturant and in various chemical and medicinal preparations.

Charcoal.

The annual production of charcoal for 1916 in New York State is estimated to be 8,198,491 bushels. At a valuation of six cents per bushel this should be worth $491,991.46. This is estimated on the basis of the average production of 42.7 bushels of charcoal per cord from 192,330 cords of wood annually consumed in the industry in New York.

Up to about 1905 the great market for charcoal was in the reduction of iron ores. Important methods of steel production within recent years, however, have gradually eliminated the strong demand for charcoal for this particular purpose. Charcoal iron, or Swedish iron as it is often called in the trade, is still in demand for certain specialized uses, especially for high grade steel used for tools, instruments, car wheels, etc. Pig iron reduced with charcoal commonly brings $5 a ton more than coke iron. A single blast furnace uses between 10 and 12 thousand bushels of charcoal a day. Where there are from 5 to 10 blasting furnaces at a single ore reduction plant, it is easily seen that the consumption of charcoal may be very large. A great many of the hardwood distillation plants in Michigan and Wisconsin have ore reducing plants in connection with them. These are the conditions under which the greatest economy in charcoal utilization is practiced. Much of the charcoal for these plants, however, is made by the open pit or bee-hive kiln as well as by the oven plants. An investigation carried on by the United States Forest Service showed the consumption of charcoal in this country to be as follows: seventy-six per



Photograph by Nelson C. Brown.

Interior of the oven house of the Tupper Lake Chemical Co., Tupper Lake, N. Y., showing the outside doors of the ovens. In the immediate foreground is a turn-table from which the loaded wood cars are sent into the oven for distillation. The residual charcoal is withdrawn from the same door and sent into the first cooling ovens, which are on the right of the picture. The white spot in the left foreground indicates the opening through which the charcoal is fed into the furnaces beneath. For fuel, charcoal, wood gas and tar are used. On the right is a wood car containing charcoal which is shovelled directly into the furnaces. Twenty-five foot ovens which contain two cars at a charge, are used in this plant. There are seven ovens arranged in a row.

cent went to blast furnaces; 19.5 per cent was utilized in domestic uses; 1.9 per cent was used for chemical purposes; 1.03 per cent was used for power mills and the remainder went to smelters, railroads, etc. However, replies from only 60 per cent of the plants were received, so that it is not likely that a large number of plants throughout New York and Pennsylvania are properly represented by this estimate.

Charcoal is probably used in a greater variety of ways from the New York plants than from those in other states. There is no question but what the greatest majority of charcoal produced in this country is still used in blast furnaces and for the manufacture of gun powder.

One New York plant screens it and ships it in five different grades. When the charcoal is shipped it is screened to remove the finer pieces. This is ground up in some cases and pressed into briquettes and used for fuel. Other common uses for charcoal are for medicinal purposes, for poultry and cattle food, in chemical manufacture and for fuel in a great variety of ways.

Wood Tar.

Based upon the annual consumption of wood in this industry there are 4,808,250 gallons of wood tar produced in New York State every year. This figure is based upon the average production of 25 gallons of wood tar per cord. At the present time practically all of the wood tar is used for fuel under the ovens or boilers. Throughout the country it is estimated that between 30 and 40 million gallons of wood tar are used in this way. In some cases prices of between 4 and 8½ cents have been received per gallon for the use of this material in chemical manufactures, but its use is very limited. It is estimated that some time in the future a method will be found for using this wood tar as a basis of

creosote on a commercial scale. A good share of our creosote at the present time is made from coal tar and a large part of it is imported. There is no question that some time in the future this material will be used for the preservation of wooden material, such as ties, poles, mine timber, etc.

Wood Gas.

It is estimated that about 11,500 cubic feet of gas are derived per cord of wood. On this basis there are produced annually in New York State 2,211,795,000 cubic feet of wood gas every year, from 192,330 cords.

This gas is used entirely as a fuel underneath the ovens at the present time. In some localities in Germany and Austria wood gas has been used for illuminating purposes, and it is very possible that at some time in the future this may be used for a much more economical purpose than as a fuel underneath the ovens. This, however, is looking a long way in advance and it is probable that for some time at least it will continue to serve the purpose of fuel along with the wood tar and coal or other fuel brought in to supply the necessary amount of heat.