BUILDING AND OPERATING
A CIDER VINEGAR PLANT

BY

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BUILDING AND OPERATING A CIDER VINEGAR PLANT

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Professor of Chemical Engineering

Dean of Engineering Studies

Dean of Cultural Studies

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In the spring of 1917 I was asked to design and equip a plant for the M. Steffen & Company, Chicago, Illinois, for the purpose of manufacturing cider vinegar. The plant had to be ready for manufacturing by autumn.

This resolved itself into the problem of securing the following:

Chicago site,
Site at the source of supply of apples,
Materials of construction,
Manufacturing equipment,
Labor.

The high cost of construction, the scarcity of labor, and the length of time required to build new buildings, disposed very quickly of my idea for a new plant.

The Chicago site had to be on a railroad line to facilitate cheap shipment of apples and cider stock from points outside of Chicago and, of course, finished goods from Chicago to other cities. It had also to be within easy hauling
distance of the "down town" wholesale grocery houses.

Good buildings on railroad tracks were at a high premium and anything suitable involved too great a sacrifice of capital. Buildings badly needing repair and on railroad tracks near the central portion of the city were diligently searched for. Finally a one and a half story building of seventeen thousand square feet on Kingsbury street located on the Saint Paul Railroad track was leased for a period of five years.

The building was in bad condition. The following was necessary in order to place the property in a manufacturing condition:

- New sky lights,
- Patching brick walls,
- Patching wood walls,
- Patching roof,
- Repairing shipping platforms outside of building,
Division of inside into office space, shipping space, manufacturing and storing parts, concrete piers for holding up large storage tanks, concrete floors, concrete washing tank ten by six by four feet deep.

And storage space for at least three cars of apples (one car of apples averages about 35,000 pounds).

Bids were asked for and the contract let for $13,500.

A steam boiler was purchased second hand from a dismantled building on Pine Grove Ave, its cost was $600.00. Its rated capacity was seventy pounds gauge. To install it and build a chimney cost $900.00 additional. The boiler furnishes sufficient steam to run pumps, heat the plant, office, and necessary water for cleaning barrels, bottles, and tanks.

The remodeled Chicago plant ready for
the installation of equipment cost **$15,000.00**.

The procuring of equipment for quick delivery from the dealers of vinegar equipment was impossible. Six months to a year was the usual stock phrase used in promising machinery, tanks, generators, etc. The impending prohibition enforcement suggested that much material might be purchased from breweries forced out of business. A number of breweries were visited by me and much was bought at prices ridiculously low.

The following was purchased and installed at about one-fourth of the original estimate for new materials and was in splendid condition:

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Each</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 - 25,000 gals. storage tanks</td>
<td>1</td>
<td>$460.00</td>
</tr>
<tr>
<td>installed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 - 15,000</td>
<td></td>
<td>$260.00</td>
</tr>
<tr>
<td>&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 - 7,000</td>
<td></td>
<td>$150.00</td>
</tr>
<tr>
<td>&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 - 3,000</td>
<td></td>
<td>$50.00</td>
</tr>
</tbody>
</table>
These tanks were of white wood, Washington fir, and cypress. The cypress is the best. The above was purchased from the Schoenhofen Brewing Company.

Three screw presses made by Boomer & Borchert Manufacturing Company were bought second hand for $400.00. These were purchased from hard cider plants going out of business in Illinois and Michigan.

Four pumps were bought from the Blackmer Pump Company, Chicago. These pumps are acetic acid proof and are bronze lined construction. They are portable affairs, motor driven, and are placed on trucks so they may be hauled to any part of the plant.

Several hundred feet of hose of about three inches diameter was purchased. This is used for portable piping. It is used to pump sweet juice and vinegar from fermentors to storage tanks and generator room. Wood logging is often used for this purpose but it
isn't as convenient as the portable hose. Vinegar pumped through iron pipes turns black due to the tannic acid in vinegars.

Thirty-one vinegar generators were built of white wood and Washington fir. Tanks from breweries were dismantled and the wood utilized for this purpose. The generators are four inches in diameter by nine feet high and two inches thick. They cost $43.00 each installed.

Five hundred feet of spruce logging four feet by four feet in ten foot lengths with one inch and one and one-half inch orifices were bought from R. W. Bartelmann of Chicago at twenty cents per running foot. This logging is installed permanently. Into it runs the vinegar and fermented juice from the supply tanks to feed the generators. Also the logging is used to conduct the finished vinegar from the generators to the finished product tank sunk into the ground below the generators. Couplings for the
logging were bought from the Bushnell Pump Company, Bushnell, Illinois at fifty cents each.

For each generator seventy bushels of beech wood shavings were purchased from the Redlich Manufacturing Company, Chicago, Illinois at forty-five cents per bushel. Corn cobs and rattan, when available, may also be used and are cheaper.

Three sets of knives for grinding the apples and run by motor were purchased from the Hydraulic Press Company, Mount Gilliad, Ohio at $18.00 per set. A grind stone for sharpening the knives was also purchased.

A small bottle filling machine, a bottle machine washer, a small air pump used for mixing the vinegar cut with water to reduce to proper strengths desired, barrel conveyor to convey barrels of vinegar up from filling room to shipping platform, some piping and some hose were bought from the
Fleischmann Yeast Company at a very low figure.

A small amount of laboratory equipment was installed for chemical tests on vinegars and sweet cider stock. The apparatus consists of a small still to estimate the alcohol in fermented apple juices, also "sugar stems", glassware, burettes, etc.

The entire equipment with labor necessary to build benches, ladders, platforms, and arrange little odds and ends about the plant cost $11,000.00. Thus the total cost of putting property on Kingsbury street in running order to manufacture one thousand gallons of cider vinegar per day cost $26,000.00.

While the Chicago factory was being remodeled and equipped, a diligent search was being made for sites in Michigan. Two sites were finally bought, one at Fennville and another at Coloma. Both of these towns are in the center of splendid apple growing communities and have records of never having had a total
failure of an apple crop.

Old buildings and ground were purchased. The locations are on the Perre Marquette Railroad. The repairing and equipping was done in a fashion similar to that in building the Chicago plant. Second hand tanks and machinery were bought and installed.

The Fennville plant located at Fennville, Michigan on the Perre Marquette Railroad was provided with four hydraulic presses, and a storage capacity of two hundred thousand gallons of juice. Pumps, boiler, pulleys, etc., were in the building. Eleven thousand dollars was necessary to purchase the factory, site and equipment and put this station in a position to manufacture. Only apple cider is made here and the juice shipped sweet to Chicago, or, is stored and sent as needed partially fermented, either to Coloma or Chicago to be made into vinegar.

The Coloma factory is located at Coloma.
Michigan, on the Pere Marquette Railroad line. The equipment was installed. This consisted of tanks with four hundred thousand gallons storage capacity, pumps, mixing tanks, fermentors, boiler, pulleys, platforms, fifty-one generators, cooperage shop, and two hydraulic presses. The total cost of equipment, ground and building was fourteen thousand dollars.

To operate the Chicago plant, the cost is as follows:

Vinegar maker ................... $40.00 per wk.
Vinegar maker, helper .......... 20.00 " "
One Cooper ....................... 30.00 " "
One Shipping Clerk ............. 40.00 " "
Two helpers, each $24.00 ..... 48.00 " "
One Office Manager .......... 50.00 " "
One Stenographer ............. 20.00 " "
One City Salesman .......... 50.00 " "

In busy seasons when large orders for bottling goods are to be filled additional labor is hired.
The duties of the vinegar maker is to keep the generators running, to make the various "cuts" from higher strength to lower strength; and to test the alcoholic liquor and the finished vinegar to see that full strength of vinegar obtainable is received from the alcoholic liquor.

The cooper’s duties consists in repairing second hand barrels. All vinegar is sold in used wine or whiskey barrels. These from time to time need new heads, staves, iron hoops or plugs to prevent leaking.

The shipping clerk handles the shop orders and fills, or superintends, the filling of barrels and bottles of the various strength vinegars which run from 40 grain strength to 55 grain. (10 grains is equivalent to 1% acetic acid strength.)

The helpers are used about the plant to aid where ever needed.

The office man keeps books and attends to out-of-city trade. He is aided by the stenographer.
The city salesman attends to the city contract work and also aids in the office work by following up orders and keeping the trade supplied on general conditions of the vinegar market.

The Fennville plant is managed by a superintendent the year round at thirty dollars per week. His real work lasts about four months of the year - in the autumn. The remainder of the time is spent in making repairs and preparing for the next season's run of apples. He has one assistant at twenty dollars per week. During the rush time in the autumn he will hire from five to ten men and boys at fifteen dollars to twenty dollars per week.

The Colome plant is managed by a superintendent at sixty dollars per week. He is a vinegar maker, attends to buying millions of pounds of apples and in fact is responsible for everything about the plant. He has two steady assistants the year round besides a
cooper and engineer. In the busy season he will hire ten to fifteen men, boys and women at ten dollars to twenty-five dollars per week. The pay of labor always depends, of course upon its scarcity and the kind of work to be done.

The progress of the apple through the Chicago plant to vineger is as follows:
The apples are shovelled from the railroad cars down into the storage bin. From here the fruit is shovelled into the concrete washing bin wherein the apples are washed with running water. Any metallic substances settle to the bottom and careful watch is kept to prevent anything hard from going up the incline into the slicing knives. From the washing bin, the apples go, via an incline belt composed of an iron chain and blocks of wood, to a set of motor driven knives. Here the apples are thinly rasped. The sliced apples fall into a hopper with a movable spout and are fed onto a press where a "cheese" is made up. When one press
is squeezing out the juice, another press is fed to make up another cheese.

The sweet cider juice is squeezed out into a small tank, sunk into the ground below the press. From this receiving tank the juice is pumped into storage tanks or into fermentors. If the juice is sold as sweet, one-tenth of one per cent of sodium benzoate is added and the juice barreled and sent out.

From the fermentors the alcoholic juice is pumped into storage tanks carefully painted on the outside with an asphalt paint and covered on the inside with paraffin to aid in preventing evaporation. The tanks are kept covered and in a cool place.

From the storage tanks the alcoholic juice is pumped into the receiving tank in the vinegar room. From here the generators are fed with the alcoholic liquor. From the generators the finished vinegar runs into a big tank sunk into the ground. From this
receiving tank the vinegar is pumped into the big storage tanks from where it is drawn for barrel or bottle shipment.

Once in a while vinegar is filtered to give it brilliancy. This stock is used for fancy bottled goods. The filtering was formerly done through bone black, but now it is done through paper pulp by pumping the vinegar up through the pulp as is done in breweries.

The cutting knives for rasping the apples are of steel and are sixteen inches long about one inch wide and three-sixteenths inch thick. They have teeth and look like a saw. Ten of these knives are set in slots in a drum. The teeth protrude above the periphery of the drum about one sixteenth inch. The drum is motor driven and in revolving crowds the apple between the knives and the side of the box in which the drum is set. The effect is a rasping one. These knives may be purchased from the Hydraulic Press Company, Mt. Gilliad,
Ohio.

The presses used for squeezing out the juice from apples are of two types, the screw type and the hydraulic. The former may be purchased from Boomer & Borchert, Syracuse, New York; the latter from the Hydraulic Press Company, Mount Gilead, Ohio. The screw types in the Chicago plant are motor driven. The hydraulic in Michigan are run by steam. They may also be run by motor. The screw type operates similar to the ordinary hand screw press. A platform operating on long screws is let down on a "cheese" which is made up on a small car run on tracks. The box of the car is fifty-four inches square and four inches high. When the "cheese" is made up on the car it is pushed underneath the press and the platform let down on the car. An indicator is so calibrated that when enough pressure has been applied, to procure all juice available, it swings down and registers this fact. This
operation takes, roughly, about one hour. With this type of press and a six hundred pound cheese about forty-two to fifty gallons of juice may be pressed per hour. In a ten hour day four hundred to five hundred gallons of juice per press may be squeezed out.

The hydraulic press operates with a piston-like motion. A broad base is pushed up. The "cheese" is lifted against the top and a pressure of four thousand pounds per square inch is applied. The hydraulic press will produce from fifteen hundred to two thousand gallons per ten hour day. It is easier to operate and takes up much less room. This type of press costs about twice as much as the screw type, but is far more economical to use. This type of press may be purchased from the Hydraulic Press Company, Mount Gilliad, Ohio.

The "cheese" is made up by leading the rasped apples from the hopper immediately under the knives by aid of a shute to the car. A
large sheet of canvass is laid over the box of the car. The rasped apples are let in and a layer of about four inches is made. Then the ends of the canvass are folded over the top of the rasped apples. On the top of the folded ends of canvass a thin lattice work of wood is laid. Then another large sheet of canvass is laid over the lattice work of wood. Another four inches of apples is run on and the canvass ends are folded over and another frame put on top. This "cheese" is then built up until it is about four feet high. Then the car is run under the press. While the press is operating on one "cheese" another "cheese" is built up.

The "first-pressings" is the name given to the cider juice expressed from the "cheese" after about an hour's pressure. This amounts to about seven gallons per one hundred pounds of apples. This juice is the richest in all the ingredients that make up sweet cider. The richness of the juice of course depends on many
things, i. e. the quality of the fruit from the standpoint of decay, ripeness, and variety.

The "second-pressings" is the name given the juice expressed from the pomace after the "first-pressing". The method of procedure producing the best results is to take the pomace after "first-pressings" and allow to partially ferment in warm water of about 85° F. for four or five days. But this is against the food regulations of most states. However, this is the procedure in Germany.

In Michigan the law states pomace for "second-pressing" must be repressed within twenty-one days; also water must not be added and the pomace must be kept under cover.

The pomace is built up in "cheeses" and squeezed in similar fashion as in the "first-pressings". From one to three gallons of juice per one hundred pounds of apples are received. The "second-pressings" of course is not as rich as the "first-pressings".
The pomace is the apple residue left after expressing "first or second pressings". When only "first-pressings" is expressed from the apples the pomace may be sold for jelly filler. When the "second pressings" is expressed from pomace, the dried pomace is used for fuel in the boiler.

Pomace should be repressed for "second-pressings" within four days after "first-pressing". Much depends on weather conditions. The colder the weather the longer the pomace may lay. If weather is warm the pomace will sour and prevent the subsequent juice from properly fermenting to alcoholic stock for vinegar.
## Analysis of "First Pressings"

<table>
<thead>
<tr>
<th>Variety</th>
<th>Season</th>
<th>Solids</th>
<th>Invert Sugar</th>
<th>Sucrose</th>
<th>Total Sugar</th>
<th>Ash</th>
<th>Rotation 400 mm. Ventske Degrees leit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ben Davis</td>
<td>Winter</td>
<td>12.96%</td>
<td>7.22%</td>
<td>4.01%</td>
<td>11.23%</td>
<td>0.29%</td>
<td>49.00</td>
</tr>
<tr>
<td>Baldwin</td>
<td>Winter</td>
<td>17.01%</td>
<td>8.16%</td>
<td>7.28%</td>
<td>15.44%</td>
<td>0.27%</td>
<td>39.00</td>
</tr>
<tr>
<td>Red Astrachan</td>
<td>Winter</td>
<td>12.94%</td>
<td>7.03%</td>
<td>3.72%</td>
<td>10.75%</td>
<td>0.39%</td>
<td>23.72</td>
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</tbody>
</table>

## Analysis of "First Pressings" of Mixed Apples and of the Pomace

<table>
<thead>
<tr>
<th></th>
<th>Water</th>
<th>Solids</th>
<th>Invert Sugar</th>
<th>Sucrose</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apples</td>
<td>79.15%</td>
<td>20.75%</td>
<td>10.56%</td>
<td>3.14%</td>
<td>0.33%</td>
</tr>
<tr>
<td>Pomace</td>
<td>68.27%</td>
<td>31.73%</td>
<td>3.52%</td>
<td>1.05%</td>
<td>0.52%</td>
</tr>
</tbody>
</table>
### Analysis of "First and Second Pressings" from Same Apples.

<table>
<thead>
<tr>
<th></th>
<th>Sp.G.</th>
<th>Solids</th>
<th>Invert Sugar</th>
<th>Sucrose</th>
<th>Total Sugar</th>
<th>Total Sugar after inversion</th>
<th>Ash</th>
<th>Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>&quot;First Pressings&quot;</strong></td>
<td>1.601</td>
<td>3.14</td>
<td>11.3</td>
<td>2.45</td>
<td>13.75</td>
<td>13.97</td>
<td>0.30</td>
<td>45.67</td>
</tr>
<tr>
<td><strong>&quot;Second Pressings&quot;</strong></td>
<td>1.062</td>
<td>2.61</td>
<td>7.24</td>
<td>1.38</td>
<td>8.62</td>
<td>8.76</td>
<td>0.39</td>
<td>30.14</td>
</tr>
</tbody>
</table>
Sweet juice is bought from the farmers, from apple canners (this stock usually made from skin and cores) and repress stock from sweet cider manufacturers. This outside juice should always be analyzed for the following: Acidity, alcohol, sugar, solids, soluble and insoluble $P_2O_5$, alkalinity of ash, optical rotation, sugar and non-sugar solids. A price is then offered. This kind of business usually does not pay unless the quantity amounts to a tank car or more. A tank car holds from seven thousand to ten thousand gallons of juice.

The juice is pumped into fermentors that hold from six thousand to ten thousand gallons. The yeasts always present on the juice are usually allowed to do the fermenting. Sometimes a brewery yeast bought from breweries or a selected pure culture yeast is added to the sweet stock. The sugars are then converted into alcohol and carbon dioxide according to the formula

$$C_6H_{12}O_6 + \text{yeast} \rightarrow 2C_2H_5OH + 2CO_2.$$
One hundred parts of sugar give 51.11 parts of alcohol and 48.89 parts of carbonic acid. This is the theoretical yield; but actually only about 92% of the theoretical yield of alcohol is obtained.

The sucrose present in the juice is not directly fermentable. By means of an enzyme that exists in some yeasts the sucrose is inverted to dextrose and levulose. These sugars are then converted into alcohol and carbon dioxide.

From time to time some of the juice is tested with a brix hydrometer to observe the process of fermentation. When the juice is fermented to 0 on the sugar-stem, all the sugars are fermented.

The fermented juice is a variable product. Depending on the temperature; the race of yeast predominating in the fermentation; the variety, soundness, and the ripeness of the apples used for sweet juice; varying amounts of the following
are obtained: Alcohol, glycerine, succinic acid, lactic acid and butric acid; also on the variety of apple, section of the country the apple is grown, and the degree of ripeness, varying amounts of soluble and insoluble $P_2O_5$, $K_2O$, $Na_2O$, and $CaO$ are obtained in the juice with varying amounts of sugar and non-sugar solids.

The temperature best for the fermentation varies with the race of yeast predominant in the fermentation. The products of fermentation vary with temperature and type of yeast predominant in the fermentation. In practice too little attention is paid to the fermentation because under the great stress of rush work with limited space to handle millions of pounds of apples the only thought is to finish the stock and send it moving to completion as rapidly as possible.

Temperature control and a pure yeast is the best way to handle the cider stock. With wild yeasts and moulds fermenting the sweet
stock, considerable sugars are destroyed with loss of alcoholic yield. Some moulds destroy as high as 12% of the sugar in fermenting.

The most suitable temperature for fermentation is 18 to 24°C (65 to 75°F).

To ferment to 0 the sugars in six thousand to ten thousand gallons of juice takes about a week's time.

Table Showing Difference Between Juices from Ripe and Green Apples.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Ripeness</th>
<th>Invert Sugar</th>
<th>Sucrose Sugar</th>
<th>Total Sugar</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ben Davis</td>
<td>Ripe</td>
<td>7.11%</td>
<td>4.15%</td>
<td>11.26%</td>
<td>0.28%</td>
</tr>
<tr>
<td>Ben Davis</td>
<td>Green</td>
<td>6.56%</td>
<td>0.68%</td>
<td>7.24%</td>
<td>0.32%</td>
</tr>
</tbody>
</table>
Analysis of Some Fermented Juices of Mixed Apples Just Before Generating to Vinegar.

<table>
<thead>
<tr>
<th>Solids</th>
<th>Acidity</th>
<th>Alcohol</th>
<th>Ash</th>
<th>Rotation 400 mm. tube Ventzke Scale Degrees Leit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.96%</td>
<td>0.46%</td>
<td>7.23%</td>
<td>0.22%</td>
<td>2.46</td>
</tr>
<tr>
<td>2.91%</td>
<td>0.62%</td>
<td>6.64%</td>
<td>0.28%</td>
<td>2.24</td>
</tr>
<tr>
<td>1.91%</td>
<td>0.58%</td>
<td>4.65%</td>
<td>0.24%</td>
<td>4.10</td>
</tr>
<tr>
<td>3.32%</td>
<td>1.20%</td>
<td>9.81%</td>
<td>0.34%</td>
<td>1.94</td>
</tr>
</tbody>
</table>

After fermentation the generator converts the alcoholic liquid into vinegar. It is an arrangement to allow air to pass up through material held in a container through which the alcoholic liquor passes down in fine drops.

The generator usually is nine feet high and four feet wide with staves about two and one-half inches thick. It is made of white wood or of oak. Six inches from the bottom and on the inside a perforated false bottom is placed. Inch holes are drilled through this and are about
three and one-half inches apart. Twelve inches above the false bottom of the generator, four holes are drilled in from the outside slanting down to the inside. These holes are about three-quarters of an inch in diameter. They are the vents which regulate the air supply going up the cask by aid of plugs. They are placed equally apart around the tank. The oxygen of the air oxidizes the alcohol of the juice to acetic acid.

About a foot down from the top of the cask is fitted what is called a "dumper". This dumping arrangement consists of a long axis with a scoop on each side. The alcoholic liquor coming through the vent in the top of the cask feeds into one of the scoops on one side of the axis. When heavy enough with liquid the scoop tips and pours out its contents over a perforated disk. The holes in this disk of wood are about one-eighth inch in diameter and placed about two to three inches apart. This disk is for the purpose of spreading the liquid. When one side of the axis
dumps its liquid, the axis rotates and brings into position the other scoop which is then filled and operates in a similar fashion as described.

Between the false bottom, and the perforated disk on top immediately under the dumper, are placed beech wood shavings, corn cobs or rattan. These give the surface to the liquid and spread it out into thin drops. The rattan is stamped down in the generator while the corn cobs and beech wood shavings are placed in loosely.

In cider vinegar making, the greatest care must be exercised in the management of the generators. Much money may be lost due to not receiving the full strength vinegar from the alcohol in the juice. Alcohol is lost in evaporation and destroyed by vinegar fungus. The generator should be carefully cleaned out about every three weeks and new filling put in. Every two or three days the top perforated disk should be
cleaned of "mother" (fungus growth) and if necessary the top layer of cobs or beech wood shavings removed when covered with "mother". The mother forms a thick film and air cannot pass through the generator.

The generators are placed in rows and sufficient space should be between each one to enable a person to walk around it. They are connected on top and bottom with wooden logging. The top logging runs over the entire row. Over each generator a faucet connected to the logging feeds the "dumper" through a small hole. If generators are incapacitated the faucets over them may be turned off without interfering with the others that are in good working order.

From the bottom of each generator a faucet leads to a pipe of wood or logging and this logging conveys the partially or finished product into a receiving tank sunk in the ground.

The generator room should have all the fresh air possible and no direct sunlight.
I will assume the most difficult case in the making of cider vinegar, i.e. starting with fresh generators, with fresh shavings or corn cobs. The filling in the generators is flooded with strong cider vinegar and soaked. From forty to sixty grain vinegar is used for this. The vinegar retains a great many vinegar bacteria and these lodge in the shavings or filling. These bacteria of a number of different species propagate and act, when the temperature is correct, as catalytic agents in the conversion of alcohol to acetic acid by oxidation with air.

After the soaking for several hours the vinegar is run out in a steady stream and as fast as it runs out it is fed in at the top from the filling tank. This is continued for about a week or until that time the generators become warm. The generators are now ready for alcoholic liquor. The strength of vinegar that may be made is restricted due to the effect of strong alcohol and strong vinegar on the bacteria. A
ten per cent alcoholic liquor will kill them. But even long before that strength their activity is checked.

If forty grain vinegar has been used to "heat up" the generators, then this vinegar is diluted in the "mixing tank" with the alcoholic liquor until the mixture shows about twenty-two grain strength of acetic acid. Then this mixture is fed by gravity to the generators in small steady streams through the faucets above each generator. The finished product from the bottom of each generator flows into the receiving tank. From here it is again pumped into a mixing tank and the mix diluted to twenty-two grain acetic strength with alcoholic liquor. This is continued until the generators are about 90 to 95°F. in temperature. They are then ready for their maximum production. Twenty-two grain vinegar with 2% alcoholic should now give on going through the generators once forty-two grains acetic strength of vinegar.
They are now ready to make any strength cider vinegar that may be made from the alcoholic cider stock.

If forty grain vinegar stock is to be made then the "mix" in the mixing tank is held at twenty-two grains. If fifty grain stock is to be made then the mix is held at thirty-two grains. This is done in this manner because the alcoholic liquor in its progress through a generator will increase in acidity, when conditions are proper, from fifteen to eighteen grains. This is a safe working condition. If more acidity is produced the generator is very likely to "go bad" and then the entire "filling" will have to be replenished.

When fermented cider stock tests fifteen proof alcohol, it should produce sixty grain vinegar. But evaporation, generator trouble (feeding generators too fast or too slow) and the almost unavoidable growth of mal-organism may cut this as low as thirty grain. Therefore,
it is necessary to have a skilled cider vinegar maker in constant attendance.

A temperature from 90 to 95°F. appears to be the most suitable for best working conditions. This may be observed either by inserting a thermometer in the generator or taking the temperature of the vinegar coming out. If temperature runs 15 to 20°F. over 95°F. the generator may "burn out" i.e. the bacteria destroyed. Then the generator must be refilled and gradually brought up to working conditions "heated up". The temperature is regulated by plugging the air vents or in feeding fast or slow the alcoholic liquid. The faster the "feed" the higher the temperature rises, and the more air required. The flow of the "feed" to each generator is controlled as follows: The "mix" is led from the mixing tank by wood logging running over all the generators. Over each generator a wood faucet fastened in the logging controls the flow. This flow is so regulated that each
generator produces about one and one-half gallons cider vinegar of forty-five grain strength per hour. The height of the vinegar in the receiving tank is measured from time to time with a yard stick. This gives the number of gallons in the tank. The increase may thus be noted from time to time. Knowing the number of working generators the control flow faucets over each generator are fixed to maintain the one and one-half gallons per generator per hour.

If the cider vinegar is to be stored a small amount of alcohol should be left in it. This appears to keep it. If it is all converted, mal-organisms and oxidation may decompose the acetic acid to carbon dioxide and water.
Some Analysis of Pure Cider Vinegar.

<table>
<thead>
<tr>
<th>Solids</th>
<th>Acetic acid</th>
<th>Alkalinity of ash</th>
<th>Soluble $P_2O_5$ per 100 cc</th>
<th>Insol. $P_2O_5$</th>
<th>Rotation 400 mm. tube Vantzke scale to left</th>
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<tbody>
<tr>
<td>1.98</td>
<td>4.56</td>
<td>29</td>
<td>11</td>
<td>6</td>
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<td>2.35</td>
<td>5.15</td>
<td>31</td>
<td>12</td>
<td>8</td>
<td>1.5</td>
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<td>3.10</td>
<td>6.10</td>
<td>33</td>
<td>16</td>
<td>15</td>
<td>2.9</td>
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</table>
The apples usually bought for cider purposes are the poor colored, the knarled, the specked, the undersized, the windfalls, and others unfit for table use and canneries. They are bought by the hundred pounds from the farmers. Sometimes the Chicago plant procures from south Water Street commission men, over-ripe apples or frost bitten ones.
<table>
<thead>
<tr>
<th>Variety</th>
<th>Season</th>
<th>Water</th>
<th>Solids</th>
<th>Invert Sugar</th>
<th>Sugar</th>
<th>Total Sugar</th>
<th>Total Sugar after inversion</th>
<th>Free Malic Acid</th>
<th>Ash</th>
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<td>Sweet Bough</td>
<td>Summer</td>
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<td>15.80</td>
<td>7.83</td>
<td>3.01</td>
<td>10.84</td>
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<td>Red Astrachan</td>
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<td>15.61</td>
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<td>Russet</td>
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Building & operating a cider vinegar plant