DISTILLATION OF ALCOHOL.

B. Chimney.
C. Apparatus for boiling the sorghum cane or other substance.
D. Stopcock for drawing off the juice.
E. Furnace.

The furnace is so constructed that the smoke on leaving the boiling apparatus traverses the tubular pan A, and returning by the two sides finds its way to the chimney. It is easy to understand the economy of this arrangement in utilizing the waste heat.

The manner of extracting syrups by this method is as follows: The stalks of sorghum stripped of leaves are cut up by means of a stalk-cutter, and as cut, are placed in the boiling apparatus, care being taken to place a wicker-work hurdle on each layer of 15 or 20 centimeters. When the apparatus is filled with cut sorghum, it is filled with water enough to cover the cane, then for each 100 litres of water in the apparatus are added 200 grammes of sulphuric acid. It is then boiled for twenty minutes; the syrup is now drawn off by the cock, the bagasse being at the same time pressed by the screw fixed above the boiler. The juice is then poured into the tubular pan to be evaporated to the proper degree of concentration (20° or 25° is generally enough).

The boiler is then emptied of bagasse by the assistance of a fork, and a second operation begins.

Syrups prepared in this way are only fit for distillation, and may be bought by the distiller at the same price as molasses from the beet.

The following is the method adopted by M. Vide for ascertaining the true value of such syrups and thereby fixing the price.

We know, says he, that molasses is sold at 40°, and by the 100 kilogrammes. Let us suppose a cask of sorghum syrup contains 160 kilogrammes at 25°; this is the product of 1000 kilogrammes of cane; we will multiply 160 by 25, which will give 4000; divide 4000 by 40, and we find the true quantity of merchantable molasses 100 kilogrammes; this is sold according to the price of alcohol. July 30, 1857, trois six was worth 118, and beet molasses 26 francs per 100 kilogrammes. Then we find the value 26 francs per 1000 kilogrammes of cane with 200 kilogrammes of forage over. The hectare yielding upwards of 50,000 kilogrammes of cane will produce 1500 francs to the farmer. The cost of extracting the syrup from the sorghum may be estimated at a maximum of 6 francs for 1000 kilogrammes of stalks, which will cause a deduction of 250 francs to the hectare; there will remain then 1250 francs, which is a heavy yield as compared with other crops, while over and above the syrup, each hectare produces 30,000 kilogrammes of forage.

If it is desired to fit these syrups for table use, it is necessary to saturate them with Spanish whiting and clarify them with animal charcoal.

The syrup of beets is extracted as follows:—

The beets cut in thin slices by means of a root-cutter are cast, as they are cut, into a copper containing 200 litres of water and one kilogramme of common salt. When these slices have been macerated for about ten minutes, they are withdrawn from the copper and dripped, and are then thrown into the boiler c in layers of about 25 centimeters, being careful to lay a wicker hurdle on each layer. When the apparatus is full, the block which serves as a part of the press is put in place and the whole carefully covered with a moistened cloth; the fire is then kindled under the boiler, into which have previously been poured 40 litres of water; this is quite sufficient water to furnish by ebullition, enough steam to cook the slices of best. When these are cooked the discharge cock is opened, and the press applied; the juice drawn off ought to weigh four or five degrees by the areometer of Baume according to the richness of the beets. This juice is then turned at once into the tubular pan A to be concentrated to a syrup, marking 22 or 25 degrees of the areometer of Baume. In this form it may be put in hogsheads and preserved during the winter.
The succeeding operations are conducted in the same way, with this difference, that by refilling the boiler with water there are left forty litres of juice, marking four or five degrees.

The salt water in the copper used for macerating the fresh slices of beets may answer for four or five macerations, and need only be renewed when it marks 4 or 5 degrees; when it may be used in the boiler in place of the 40 litres of water. At the end of the day's work, this, as well as all the juice marking 4 or 5 degrees, should be concentrated to a syrup with the exception of forty litres of water, which may be left in the boiler to recommence the operation next morning.

By this process, according to M. Viale, 1000 kilogrammes of wine yield 130 or 140 litres of syrup at 25 degrees, according to the nature of the beets, and 600 kilogrammes of pulp.

This process of Viale renders it possible for small farmers to make the pulp themselves according to their necessities, and enables them to forward the juice with facility to the distiller in a proper state of concentration. They avoid, too, the transportation of the beets to the distillery, and the return of the pulp to the farm, at a season of the year when such transportation is always difficult.

The Jerusalem artichoke is treated in the same manner as the beet.

The apparatus of M. Viale is readily set up on a farm, occupies but little space, and may be operated by any farm hand. It is so simple as to require few repairs, and is of quite a moderate cost.

Alcohol from the Asphodel.

The asphodel, commonly called in France the king's rod, is a beautiful plant growing in the South of Europe, the tuberous roots of which are reproduced abundantly, according to climate, every two or three years. Its stalk, which rises to the height of about one meter, is covered in the month of April with a beautiful white or yellow flower. Its leaves, which are very like some varieties of flag, dry up towards the end of summer, to be renewed at the beginning of autumn, and remain green all winter, except when the cold is very severe.

There are many varieties of the asphodel, but the principal are, the branching asphodel (Asphodelus ramosus), which appears to be the original type of the plant, and is found growing wild, and the yellow asphodel which is cultivated in gardens. The wild asphodel, which is the variety used for purposes of distillation, is never cultivated, but grows in great abundance on the plains of Algeria, in Corsica, Sardinia, Tuscany, Sicily, Spain, in the South of France, and in fact all along the coasts of the Mediterranean.

The root of the asphodel forms a cluster of fusiform tubercles, brown on the outside, white within, as large as the thumb, and eight or ten centimeters long; stands by analogy between the root of the turnip and the dahlia.

No attempts have been made to cultivate the asphodel, because it requires two or three years for its vegetation, and manufacturers content themselves as if working a sort of mine without troubling themselves about its reproduction. An analysis of the root shows that it contains the following:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>68.84</td>
</tr>
<tr>
<td>Ash</td>
<td>0.75</td>
</tr>
<tr>
<td>Fatty substances, soluble in ether</td>
<td>2.20</td>
</tr>
<tr>
<td>Substances transformable into grape sugar, by the action of ferment, or acid</td>
<td>15.25</td>
</tr>
<tr>
<td>Pectine</td>
<td>2.30</td>
</tr>
<tr>
<td>Albumen coagulable by heat</td>
<td>0.42</td>
</tr>
<tr>
<td>Cellulose</td>
<td>7.00</td>
</tr>
<tr>
<td>Loss</td>
<td>0.34</td>
</tr>
</tbody>
</table>

100.00

The large proportion of principles susceptible of being transformed into alcohol (27.55 parts in 100), found by
M. Marcé in this analysis, excites the suspicion that he operated on selected tubers collected under favorable circumstances, because, as we shall see hereafter, we do not in practice obtain such favorable results.

It should be remarked that the roots of the asphodel do not furnish alcohol in abundance, except during the season of flowering, which is in April, May, and June. Before and after this period the quantity of alcohol diminishes, and finally is reduced to nothing.

The distillation of the asphodel, originating at a time when wines and spirits were very dear, appears to have no future. Although it produces alcohol at a very moderate price, since the roots are collected on uncultivated land, where their spontaneous growth enables them to be sold for the cost of collecting (15 to 15 francs for 100 kilogrammes), it is evident that it cannot contend in an abundant season with the mines of the south. The disagreeable odor of asphodel spirit, which it is difficult to remove, even partially, will always interfere with its sale, except when the price of other spirits is very high.

We shall nevertheless examine the different processes used for the extraction of alcohol from the roots of the asphodel.

In the first process, the roots are washed to remove the earth adhering to them, then crushed in an oil-mill, or by some special machine, so as to reduce them to the condition of pulp. After this operation, the pulp is thrown into common vats, where it is covered with water and stirred, then set to ferment by adding 200 grammes of dry yeast to 100 kilogrammes of roots. After the fermentation, the clear liquor is drawn off and distilled in any kind of apparatus. The amount of alcohol obtained by this method is usually from 3 to 4 litres at 96° to 100 kilogrammes of the root; but it would be much greater if the material itself were distilled in the vat in which it was fermented, by means of a special arrangement adapted to the use of a jet of steam.

In Algeria there are some distillers who allow the materials to ferment without the addition of any leaven; this method is objectionable, because the fermentation is developed too slowly, and as a consequence, notwithstanding what certain persons may say, the result is by no means profitable.

By the second process, the roots are also washed before being subjected to the action of a rasp similar to that which is employed for reducing beets to a pulp. When this pulp has been submitted to the action of a press (hydraulic or other), the juice, after being heated to 20° or 24°, is poured into a fermenting vat, then 250 grammes of dry yeast for each hectolitre of liquid are added, and the fermentation is very well established. When this is completed, the liquor is distilled, and yields an average of 4½ or 5 litres of alcohol at 96° to 100 kilogrammes of roots.

By the third process, the roots, after being washed and reduced to a pulp, as above, are placed in a saccharifying vat with two or three per cent. of sulphuric, or five or six per cent. of hydrochloric (muriatic) acid, and fifty or sixty per cent. of water. In this state a jet of steam is turned into the vat so as to produce ebullition, which is maintained for seven or eight hours. When the saccharification is completed, the juice is saturated with carbonate of lime, and, after a sufficient rest, the clear liquor is drawn off to be fermented, by the addition of enough water to reduce the temperature to 20° or 24°.

By this process 150 or 200 grammes of dry yeast are sufficient to obtain a very good fermentation, and the result leaves nothing to be desired, since it yields from six to seven litres of pure alcohol to 100 kilogrammes of the root, the taste of which, although sufficiently marked, is far superior to that obtained by the preceding methods.

Finally, as the result of practical observation, it is found that all the processes applied to the distillation of the beet are adapted to the distillation of the roots of the asphodel, particularly that of the hot maceration with the use of sulphuric or some other acid.
Alcohol from Figs.

Generally this spirit is obtained from common dried figs. The fruit is reduced to a pulp by crushing or grinding, and covered with water, and left to ferment. When this is completed the liquid is drawn off, and the marc subjected to the action of a press; the resulting juice is then added to the fermented liquor and the whole distilled.

The operation may be conducted as was done by the author in Algiers. The fruit was covered with water without being crushed, and, after a proper fermentation, which is started spontaneously, was distilled, both the liquid and fruit, by means of a steam jet. By this process the yield is ordinarily from 48 to 52 litres of brandy at 50°, having quite an agreeable odor and taste.

Alcohol from Various Substances (Vegetable and Others).

We have already examined among vegetables, those most usually employed for the production of alcohol or spirits, whether on account of their richness in sugar, the facility of extracting it, or on account of the low price of its production; but it still remains for us to speak of a number of vegetable and other substances which may, under certain circumstances, present some advantages to the manufacturer.

All vegetable substances are susceptible of producing alcohol, because most of them contain sugar, starch, gum, pectine, inuline, and cellulose, and these elements may be easily transformed, by the aid of an acid or some other saccharifying agent, into uncrystallizable sugar, either solid or liquid.

Alcoholizable substances are divided into two classes: the first comprises those which contain sugar or glucose, already formed by nature; the second comprises those which must be subjected to some artificial operation for developing and obtaining the saccharine principle.

Carrots, turnips, parsnips, artichokes, pumpkins, the whole family of squashes and melons, cornstalks. Among fruits: apricots, cherries, peaches, gooseberries, white currants, raspberries, strawberries, mulberries, elderberries, dates, &c., may all produce alcohol by some one of the processes already described. It is only necessary to adopt that which has been recommended for analogous substances in the course of this work. Seeds and nuts of many plants, as well as roots, and even some leaves, as well as milk of cows and other animals, and honey, have been used to produce alcohol in some of its forms.

Alcoholizable Substances of the Second Class.

Peas, beans, lentils, and various farinaceous seeds, chestnuts, horsechestnuts (buckeye), acorns, &c., are saccharified like grain or starch, either by the assistance of malt or sulphuric acid, and in the same manner as we have described under the proper head.

The root of the Chinese yam (Dioscorea batatas) will yield seven per cent. of pure alcohol if distilled by the process recommended for the common potato.

Lichens, dahlias, and madder are also capable of yielding a notable quantity of alcohol. The manufacture of alcohol from the last is, in the garance factories, made a source of considerable profit by utilizing much material that has hitherto been suffered to go to waste, on account of the manufacturers being ignorant of the great source of profit they were daily and hourly throwing away.

Cellulose.—This name is applied to the cellular portion of the wood of vegetables. The parts of plants in which cellulose is found most nearly approaching purity, are, besides those of very young growth, the pith, the down, the succulent mass or flesh of fruits and roots, that are rapidly developed, and very light woody tissues. It is almost pure in old linen, cotton, the pith of the elder, and in white paper.
DISTILLATION OF ALCOHOL.

Cellulose plays an important part in the growth of all vegetables, because it constitutes the foundation of all the organs. It is no less useful in the economic arts and manufactures, since it constitutes the useful substance of wood and vegetable fibre, as cotton, hemp, &c., and other filamentous substances, which are converted by man into thread, cloth, &c.

In 1819, M. Braconnet discovered the means of converting cellulose into grape sugar or glucose, by the action of sulphuric acid. In less than a quarter of an hour he converted ligneous matter into dextrine; then this was very soon transformed into sugar, under the influence of the same acid, diluted with water, and brought to a state of ebullition.

The following is the process as described by him, viz:

- He takes six parts of hemp or linen cloth well washed and cut into small pieces, on which are poured eight parts of concentrated sulphuric acid, a small quantity at a time. The mass is constantly stirred in order that the cloth may imbibe the acid equally, and at the same time escape as much as possible the risk of heating. The ligneous matter assumes a brown color, and becomes at first a very hard and compact mass; but in less than twenty minutes it is converted into a brown paste, pitch-like and viscous, which is completely soluble in cold water. Enough water to effect its complete solution is then poured on this paste; after which, the acid liquor is saturated with chalk. It is filtered to separate the sulphate of lime; evaporated by a gentle heat, and to separate any traces of lime still remaining in the solution a small quantity of oxalic acid is added. It is filtered again, and the gummy substance is precipitated by the addition of rectified alcohol. The precipitated gum is re-dissolved in water; on evaporating the solution to dryness, a pale yellow translucent substance is obtained, which has a brilliant conchoidal fracture; this is dextrine.

- If it is desired to transform the ligneous matter into sugar, instead of saturating the gummy paste with lime as above, it should be boiled for ten hours, care being taken to replenish the water as it evaporates. The dextrine then changes completely into sugar, which may be obtained perfectly pure and white.

- From one hundred parts of dry rags, according to M. Braconnet, we can obtain 115 parts of white sugar. This conversion of lignin into gum and sugar is not difficult of explanation, since we know that cellulose is isomeric with dextrine and starch. It is none the less truly marvellous when we thus see that a simple derangement in the elementary principles of a substance is sufficient to effect an entire change in its properties. All ligneous substances, as different kinds of wood, bark, straw, &c., like rags, are capable of producing sugar. It was not altogether a witticism when a learned professor exclaimed, that in the present state of the science, a block of wood becomes a loaf of sugar in the hands of the chemist.

Alcohol from wood was the subject of a communication to the Academy of Sciences at its session October 29, 1854. M. Pelouze presented a small sample on the part of one of his pupils, M. Arnould. He describes the process used by him as follows, viz:—

"Under existing circumstances, when the manufacture of alcohol has been so largely developed that it has turned many primary substances, particularly the cereals, from their legitimate and most useful application, I have thought it a matter of some interest to present to the Academy some researches into a new method of producing alcohol, although these researches are not yet complete.

Encouraged by the experiments of M. Braconnet, published thirty-five years ago, and by the more recent publications of M. Payen, I have undertaken to produce substances analogous to starch, sugar, and alcohol, from vegetable fibre, and especially from wood.

My first efforts have completely answered my expectations. I have succeeded with certain fibres in rendering soluble 97 per cent. of the substance used, and for..."
certain varieties of woods I have succeeded in rendering soluble from 75 to 80 per cent. of the wood employed, and have then converted the sugar into alcohol.

The following is a brief summary of the process of preparing alcohol from white wood:

The wood, in the form of coarse sawdust, is dried at 100° so as to drive off the water it contains, which is often more than half its weight. When cold and in a suitable vessel, concentrated sulphuric acid is poured on it with great care, and in small quantities at a time; the acid is poured on very slowly to prevent the matter from being heated. The acid is mixed with the wood as it is poured in, then the mixture is allowed to rest for twelve hours; after which it is stirred carefully until the mass, which is at first almost dry, becomes fluid enough to pour. The liquid, diluted with water, is then heated to ebullition; the acid is neutralized by chalk, and the liquor, after filtration, is subjected to fermentation, and then the alcohol is distilled off by the ordinary processes.

In this experiment the quantity of sulphuric acid employed might have been equal to, while it might not have been less than 110 per cent. of the weight of the dry wood used.

From researches in progress, I am led to believe that the quantity of acid may be considerably reduced; but even now with the proportions indicated above, alcohol may be economically manufactured from materials as cheap as wood, sulphuric acid, and chalk.

I hope that the Academy will excuse my having presented a work not yet completed, on account of its importance as a matter of public utility. In fact, the nation has at its disposal a new and almost inexhaustible source of food, since from wood, dextrine, sugar, and alcohol can be produced so economically. Governments will see that famines, so painful to all, become more and more rare, if not impossible, since wood will contribute doubly to the general supply of food at first directly, and then by yielding products which have been drawn mainly from the cereals, which constitute the principal article of food to all peoples. This new application of wood will restore to a product so abundant, and the preservation of which, in so many respects, is so important, a part of its value, at a time when it is almost driven from use by the applications of iron and coal."

Doubtless all these speculations of M. Arnould are very beautiful, but are they not illusions so common with inventors! It is not everything to produce alcohol, it must be produced at such a price as to yield a profit from which the distiller should be remunerated for his labor; and although fully recognizing the merit of those men of science who consecrate their lives to opening up new processes, we practical distillers hold ourselves in reserve. Let us leave to philosophers the care of making scientific discoveries; let us apply ourselves to introducing them into practice only when we are fully satisfied of their practicability, or where experience has assured us of success.

Madder. - We copy from the interesting work of M. Paul d'Aspremont the following details, which include some notice of the factory of Messrs. Julian fils et cie, at Sorgues (Vaucluse).

This factory turns out every day 1200 kilogrammes of flowers of madder, and 2500 kilogrammes of garancine. M. Julian, the father, discovered the flowers of madder in 1852, and he was one of the first, in 1847, to distil the washings of madder for the purpose of obtaining alcohol. At present, when this factory is in full operation, it produces as much as 800 litres of spirit at 87° in one day, which indicates a consumption of 8000 or 9000 kilogrammes of the powdered root. The wash (or waste waters) do not yield more than two per cent. 1000 kilogrammes of powdered madder yield 70 or 75 litres of alcohol at 55°.

The preparation of the roots to render them fit for the use of the dyer is not very complicated. As the farmers or their brokers bring in their products, they are spread out in extensive sheds. As all purchases are for cash, it
follows that the factories should be possessed of a large capital. It is not possible for me to ascertain the exact figures; but I infer from the amount of the entire product, which is not far from thirty-five or forty millions of kilogrammes for Vaucluse and the neighborhood, that during the course of the season, the manufacturers disburse twelve or thirteen millions of francs. I do not speak of the large quantities which come from Naples and the Levant, and which are imported into Vaucluse to be manufactured. Without exaggeration, we may well estimate the floating capital necessary to carry on the madder factories of this department at fifteen or sixteen millions.

The first operation to which the root is subjected is that of drying. It is placed in a drying-room heated to about 50°, where it remains 48 hours. M. Julian uses, every day, 130 bales of 85 kilogrammes each. The second operation comprises scraping, winnowing, and grinding. The roots are first freed from the earth which adheres to them; they are then passed through the winnowing machine, and are thrown under vertical grinding stones, which reduce the roots to powder. This product bears the name of powder of madder or ground madder. It is used to dye red on cottons, and other common materials. The powder contains all the mucilaginous substances and saccharine elements of the root, which tends to enfeeble its tinctorial power. It, therefore, yields much less coloring matter than the flowers of madder, which is much more concentrated. The powder sells for 80 francs for the common and 92 francs for the palus per 100 kilogrammes.

The flowers of madder was discovered in 1852, by M. Julian (the father). The product is used to dye in light tints. The following method is used for preparing it: The ground madder is placed in a box, and six times its volume of water is poured on it. It is then filtered through a woollen cloth, pressed, dried, ground to powder, and the flower packed in barrels. In this state it is put on the market. The price is from 160 to 200 francs for 100 kilogrammes.

The flowers of madder is debarrassed by the washing and pressure of all the mucilaginous substances which the roots contain; the proportion varies according to the nature of the soil on which it has grown. Calcareous soils produce purer madders of more lively color. These are better adapted for making the flower.

The waters which have been used for washing the powder, as well as that from the press, are collected together in vats, where they are fermented by the ordinary processes. The first runnings which were obtained by this method, in 1847, sold for eighteen francs per hectolitre, at 80°. This alcohol had a horrible empyreumatic taste; but since that time a Pole, M. Pongoski, has discovered a means of rectifying madder spirit so that it sells at the same price as beet spirit, and is used for the same purposes.

Garancine is the third product obtained from madder root. First, the powder is washed and pressed, as if intended to produce the flower. The washings are used for making alcohol. After this operation the powder is placed in vats and covered with water, acidulated with from 25 to 40 per cent. of sulphuric or muriatic acid. It is boiled for an hour and a half. The liquor drawn off, is not distilled, unless alcohol is at a very high price. The powder is placed in other vats, where it is washed with cold water. The acid which still remains is neutralized by soda; the second washing lasts twenty-four hours. It is then left to drain, and when dried and ground, the garancine is packed in casks. This preparation is used in printing calicoes.

The discovery made, in 1857, by M. Pongoski has given a great value to madder spirit. M. Santel, of Sorgues, tested the process, which is as simple as it is ingenious. The process consists in passing a jet of
alcoholic vapor into a distilling column charged with charcoal in coarse powder. This charcoal absorbs the empyreumatic oils contained in the spirit, and alcohol is thus obtained of good flavor, or rather without any sort of flavor.

The coal used by M. Sautel is prepared from willow, poplar, or birch. The wood is inclosed in retorts and distilled. It requires 600 or 700 kilogrammes of green wood to make 100 kilogrammes of charcoal. The cost of production is 20 francs. With 100 kilogrammes 5 hectolitres of alcohol are rectified. The coal loses 10 per cent. of its value every time it is used. It may be revived by reheating it in the retort. The cost is almost nothing.

It is obvious from these figures that the process of Pongoski is but little dearer than the common process, and that it may be applied to the rectification of beet spirit. The attempt has already been made at Lille and with success. M. Pongoski also applied his discovery to the rectification of pyroligneous acid; he thus avoided many successive distillations and obtained an article of good flavor at the first jet.

His distilling apparatus is like any other; only he adds a second column, in which he effects the absorption of the essential oils. It is proper to state that a little more pressure is necessary. The apparatus of M. Sautel was constructed at Sorgues. It yields 150 litres, at 90°, per hour. This is a little too strong, and is subject to some loss in transportation; but it may be reduced to 90° by the addition of water.

M. Sautel made alcohol of 100° by a process peculiar to himself, and sold it for three francs the litre. By the use of charcoal, he made ether of good flavor at the first operation. His factory is in operation only eight or nine months of the year. The unpleasantness between the states of North America has very much reduced the demand for flowers of madder.

On the day of my visit, M. Sautel paid 48 francs for backings, at 86°, without the barrel. In Paris, at that time, beet spirit was worth 68 francs. The difference between backings (Regnes) and rectified trois-six is always from 20 to 22 francs. The rectification which costs eight or ten francs is always reckoned at fifteen or sixteen francs by the seller. The pipe of six hectolitres costs twenty-four francs; it is reckoned at the rate of six francs to the hectolitre. The sales are made at 90°, as is done with the alcohol of the beet. Backings, as well as rectified trois-six, are stored in stone cisterns.

The production of the department of Vaucluse is, according to M. Sautel, from 1800 to 2000 pipes per annum. This is small when compared with the alcohol formerly produced from the wines of the South of France, which is estimated at 120,000 pipes.

At present, not more than 25,000 or 30,000 pipes are made from wine. In the north, the amount produced is not exactly known, because the beet is sometimes converted into alcohol, and sometimes into sugar. Last year the north produced 190,000,000 kilogrammes of sugar, and 130,000 pipes of alcohol. The 2000 pipes which are produced from madder do not then make much impression on the market.

Madder spirit rectified, according to the process of Pongoski, is sold as alcohol of good flavor, and for the same purposes. At the rate of 68 francs, the 12,000 hectolitres so produced, are worth more than 800,000 francs, which, before the discovery of M. Julian, was suffered every year to flow into the sea. Our gratitude is therefore due to M. Julian for his happy idea, and the more so, since the manufacturers of madder reduce the price of their product by the value of the alcohol obtained from the waste washings. It is in this way that each new discovery tends to lower prices, and improve the condition of the consumer.

General Observations on the Different Kinds of Alcohol.

From what has been said about the different varieties of alcohol, we draw the following conclusions:—
1. That the processes used for distillation are always the same.

2. That they only differ in the methods adopted for preparing the materials for fermentation.

3. That all substances, whether vegetable or not, which contain sugar, glucose, or any principle that may be converted into either, are susceptible of passing through the alcoholic fermentation.

4. That, to obtain this result, it is sufficient to set free the saccharine matter by rasping, pressure, maceration, and saccharification.

5. That this saccharine matter must be diluted, when necessary, with a sufficient quantity of water, to cause the liquid to mark five or six degrees on the areometer of Baumé.

6. And that, in conclusion, alcohol should be extracted only from those substances which, by their moderate price, or the facility of their production, will enable it to compete with spirits of wine, or the trois-six of Montpellier, either in price or quality.

CHAPTER VII. RECTIFICATION.

The object of rectification is to increase the spirituousness or standard of alcoholic liquids, which have already been distilled, and at the same time remove those substances which give them a bad flavor. This operation is based on the difference of volatility between these substances and alcohol.

The spirits obtained by the various processes which we have described do not always possess that purity which is required in trade, although they may be of the proper alcoholic standard; it is important, therefore, to rectify them in order to remove the peculiar and disagreeable flavor derived from the various foreign substances accompanying them. It is frequently necessary to make a second rectification to have the purification perfect.

Before entering into the details of rectification, and in order to have a better comprehension of this operation, it is proper to be acquainted with the substances which mar the purity of the alcohol, and the different causes that exercise an influence on its quality. Among these, the essential oils and acids occupy the first rank; then comes the action of heat. Indeed, the products of rectification are of different natures. The first, that is, those which flow at first, contain highly volatile, ethereal principles, in greater or less quantities, according to the perfection of the fermentation; they have a suffocating and disagreeable odor, due to the presence of a certain quantity of aldehyde, and usually have a light yellow color. The second are generally purer and without color, and are endowed with a sweeter and more pleasant flavor; it is from such products that the well-flavored (bon goût) trois-six is obtained. The third are much less pure; they contain an appreciable quantity of amylic alcohol; that is to say, alcohol mixed with a great quantity of essential oil; their odor is strong and disagreeable. Finally, the last products consist only of essential oils, almost pure and of a repulsive odor.

**Essential Oils.**—We have already said that alcohol is the result of the decomposition of the saccharine principle, which takes place during the vinous or alcoholic fermentation. We should add, that from whatever substance obtained, it is, chemically speaking, identically the same. This truth is incontrovertible; but it is impossible to doubt that if all alcohols have the same chemical properties, their tastes and odors are as various as the substances from which they are obtained. It may be remarked that the various raw materials are distinguished by the peculiar aroma and distinct shades of flavor in the alcohols which they produce. It is by this means that we recognize at once not only the alcohol from cherries, beets, or molasses, together with that from the grape; but we find a decided difference between the brandies
of Languedoc, Cognac, and Montpellier, &c., although all these brandies are produced from the fermented juice of the grape.

Now, to understand the solution of the problem which we have in hand, it will be sufficient to recall the fact that plants, roots, flowers, fruits, &c., owe their perfumes to the presence of an essential oil, soluble for the most part in alcohol, and that this essential oil varies in its perfume not only for each particular substance, but even in the same plant according to soil and season.

The essential oils, so various in their perfume, affect the organs of taste as well as those of smell; the taste of the rose is readily distinguished from that of the orange flower. Therefore, since these oils exert such a decided action on the senses, and as they differ in each substance, it is evident that to obtain a spirit free from peculiar flavor, it is necessary to deprive it of the essential oil which it may hold in solution. We shall describe more particularly the peculiar characters of the essential oils, when we come to treat of aromatic waters and spirits. They are volatilized at a heat not exceeding 100 degrees, and often much below, although they do not begin to boil until heated to 130 or 150 degrees; they are also very soluble in alcohol, and but little so in water.

After what has been said, if we recollect the principles of distillation, it will be easy to separate the alcohol from this essential oil, because it requires a higher temperature to volatilize it than to drive off the alcohol in the form of vapor; and it is ascertained that the more nearly alcohol approaches a state of purity, the more readily it is separated from the essential oil, because a heat of 78 degrees is sufficient for the vaporization of the former. This principle established, we can easily preserve in an alcohol the perfume which is agreeable to the consumers, or extract that which is disagreeable.

If we desire to test the presence of essential oils in non-rectified brandies, it will be sufficient to take Cognac brandy, for example, and rectify it with the necessary care; if this spirit is diluted with water, it will be found that it no longer has the flavor of Cognac; the essential oils have not then been volatilized, and the agreeable bouquet which constituted the real merit of this brandy has disappeared.

Potato spirit may afford another example. Carefully rectified, it yields a considerable quantity of essential oil, which may be burned in a lamp, and a single drop of which is sufficient to communicate to many litres of good brandy that nauseous flavor and harsh taste so recognizable in ill rectified spirits made from amylaceous substances. It is the same with brandy made from the marc of grape (pomace).

The most conclusive example that we can give of the presence of essential oils in non-rectified brandy, and that the quantity which is vaporized is in proportion to the temperature necessary to the vaporization of the alcohol, according as the latter approaches a state of purity, is the nebulous tint of the feints (low wines); for the weaker the alcohol the more nearly must the temperature necessary to vaporize it approach that of boiling water; then the essential oil, finding a temperature better adapted to its vaporization, will pass over into the receiver in greater quantity.

We have said that essential oil is very soluble in alcohol, and but little so in water; it follows, then, that the weaker the alcohol the less essential oil will it dissolve; this occasions the nebulous appearance of the feints; for the great quantity of essential oils and the feeble strength of the alcohol they contain, both concur in leaving the essential oil in a state of suspension. If a proof of this fact is desired, it is only necessary to add a few drops of any essential oil to a rectified alcohol; the oil dissolves at once; if then a large quantity of water is added to this aromatized alcohol, its solvent power being greatly diminished, the mixture will become clouded; this is what happens when cologne, essence of lemon, or fine absinthe is mixed with water.

It has been attempted by an infinite number of methods to remove or destroy the bad flavor which the essential oils give to alcohol, and a number of chemical agents
have been employed for attaining this result; but up to the present time none of these agents have fulfilled the object in view, and most of them communicate to alcohol properties peculiar to themselves which are more injurious than useful. Frequently they only mask for a longer or shorter time the odor which it is desired to remove, and which will reappear with more force than ever.

The alkalies, lime, soda, and potassa, act only to a slight degree on the essential oils, for to convert them into soap it is requisite that they should be resinified by the action of oxygen, which cannot take place in the condition in which they are found with alcohol. In the rectification of alcohol, the use of muriates, silicates, borax, alumina, tannin, charcoal, plaster, magnesia, and clay, produces imperfect results.

The action of some acids upon the essential oils is, it is true, very energetic, but it is necessary that these acids should be concentrated; for example, sulphuric acid resinifies and carbonizes them; hydrochloric acid dissolves them; nitric acid also dissolves them and converts them into a substance very nearly approaching the resinous state, if it is diluted with water in proper proportions; if it is concentrated it causes them to burst into flame. It is necessary, then, that on the one hand the acid should be concentrated, and on the other, the essential oil should be brought in contact with it in a state of purity. But what can be expected of these reagents when they are dissolved in a great quantity of water and the essential oil itself is in a state of minute division?

Chlorine and the chlorides mask the odor of essential oils for a time, but do not remove it, and the liquids which have been treated by them, when exposed for some time to the air, or when kept in store casks not only resume their original odor, but it is increased by the emanations of chlorine, which render them unfit for the manufacture of brandy and liquors.

It is proper to conclude, then, from what has just been said, that rectification conducted with care and intelli-

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gence is the only means of destroying the odor of alcohols in a satisfactory manner.

Acids.—The essential oils, by the agreeable or repulsive odor which they diffuse, are not alone in contributing to the good or bad quality of alcohol. The presence of certain acids may also play an important part, although a secondary one, in giving a sharp and biting taste which will affect the consumer unpleasantly. This fact was established conclusively by Parmentier. The troops had complained for a long time that detestable brandy was issued to them; no other could be had, and the soldiers murmured. Parmentier was consulted; he examined the brandy and found the taste horrible; in seeking the cause, which could not escape his sagacity, he recognized the presence of an acid. He at once saturated it with ammonia, and the brandy became palatable.

All fermented liquids contain acids of different kinds and in variable proportions, according as the acids are the result of the fermentation, or are the product of the fermentable materials. Thus, all grape wines will furnish tartaric acid, and sometimes carbonic and acetic acids; cider, perry, the wines of cherries and gooseberries, yield malic acid; the wines of molasses, beets, grains, potatoes, etc., generally yield acetic acid, although these substances do not contain it; this acid is formed spontaneously during the vinous fermentation, and it may also be the result of a fermentation more or less acidified. These last wines may also contain lactic acid as the product of a vicious fermentation.

Like the essential oils, the acids require for their vaporization a higher temperature than is necessary for water; the result is, that whenever it is desirable to preserve the aroma of a spirit, the acids are also retained, and vice versa.

The presence of acids in liquids which it is desired to subject to rectification, and particularly acetic acid, facilitates their combination with alcohol, and gives rise to different ethereal principles endowed with very great volatility. These principles, as soon as the liquids
are heated, pass off, at first, in a gaseous state, next
they mingle with the first products and bring along with
them a certain quantity of essential oil, especially in
potato and beet spirit. We see then that acetic acid
not only destroys a portion of the alcohol during the
vinous fermentation, but that also, by its presence in
the spirits, it proves very injurious to the quantity of the
mass unless it is saturated by an alkali, especially lime.

**Action of Heat.** — The excessive action of heat on
liquids which are subjected to distillation by the open
fire has been known for a long time, and its influence
on the flavor of the spirits has been well understood
by distillers. Indeed, these liquids contain mucilagi-
 nous substances which attach themselves to the bottom
or sides of the boiler which receive the heat directly
and are decomposed, thus producing acetic acid and an
acid empyreumatic oil; so the peculiar taste of the
still is generally known by the name of empyreuma;
independently of this taste the heat when pushed ac-
tively causes the essential oils to pass over. We may
well conceive that rectification should be employed to
depri ve the alcohol of the products of this decomposi-
tion, for the prevention of which the process of distilling
by the water bath and by steam has been adopted.

Now that we know the causes which produce the
offensive flavor, it becomes our duty to indicate the means,
by the aid of which, we may diminish or remove it.
These means resolve themselves into the saturation of
the acids, and separating the product (fractionnement des
produits).

The saturation of the acids is effected by caustic lime,
in the proportion of fifty grammes to the hectolitre of
spirits to be rectified, having first mixed it with a suffi-
cient quantity of water to make it of the consistency of
cream. This proportion of lime is not absolute. It may
be increased or diminished as the liquid is more or less
acid; nevertheless this is about the quantity that has
succeeded best in our hands in the rectification of alco-
hol from beets.

Soda and potash may be employed for the same pur-
pose instead of lime, but the latter is much cheaper, and
answers exactly the same purpose.

When the liquid has been properly neutralized, as
shown by the use of litmus paper, the rectification is
proceeded with, without drawing off the clear liquor, as
the lime does not interfere with the distillation.

The separation of products resulting from the rectifi-
cation, is the first condition of the quality of the spirits.
This operation requires great skill in tasting, and much
care, for the products which pass over at the beginning,
and at the end of the rectification, are strongly sapid
and odorous, while those which pass over during the
middle of the operation, are more or less free from
taste and smell. M. Ch. Derosne was the first to point
out this important fact, and for a long time it was con-
sidered a great secret by the rectifiers.

It would be very difficult to indicate the moment
when the liquid should be separated, that is to say, when
the pure product should be collected; this is regulated
by the nature of the spirits rectified; some may be pure
twenty or thirty minutes after they have attained the
desired degree, and some others run pure only an hour or
a half, sometimes even more, after they have
attained the required degree. It is necessary to taste the
product frequently, taking care to dilute it with water,
or to pour a few drops into the hands, and after striking
the hands together quickly to see if, by the odor, the
alcohol is acceptable or not; these two means may be
applied simultaneously. The separation is, as we have
seen, a delicate operation, requiring a certain amount of
skill.

**Management and Progress of Rectification.**

Rectification by means of the apparatus described at
page 75, Figs. 1 and 2, Pl. V., is conducted as follows:—

The still A is filled four-fifths full with spirit, of less
than 50°. The condenser E and the cooler G are filled
with water; then the cocks I and V are examined to see
that they are closed. Everything being thus arranged,