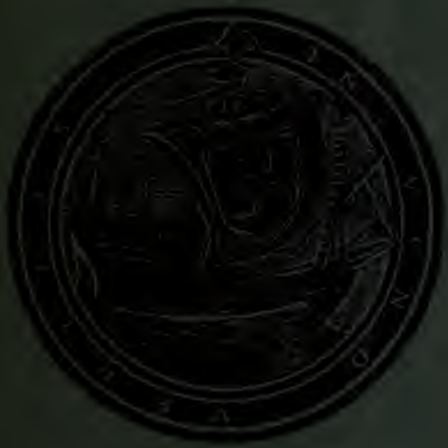
THE ART OF DISTILLATION.



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THE ART
OF
DISTILLATION.

A LECTURE

DELIVERED AT

VINTNERS' HALL,

BY

THE WINE TRADE CLUB

On Tuesday, the 23rd April, 1912.

THE ART OF DISTILLATION.

I. HISTORICAL.

THE art of distillation, taken in its most comprehensive sense, was known to the Ancients who distilled sea-water and certain perfumes. But the process of distillation does not appear to have been applied to wine before the end of the eleventh century, when a certain Marcus Græcus gave us the earliest known recipe for the distillation of Aqua Ardens or Ardent Water, in a manuscript entitled *Liber ignium ad comburendos hostes*, and which is preserved at the Bibliothèque Nationale, Paris, under the Nos. 7156 and 7158.

A certain Doctor Albucasis, who lived at Cordoba, in Spain, during the twelfth century, has also left us a detailed description of the distilling apparatus then in use for the distillation of rose water and of wine.

In the thirteenth century, R. Lulli, in his *Theatrum Chemicum* and Arnaud de Villeneuve, in his treatise *De Vinis*, show us that the distillation of wine had then been placed on a more scientific basis, and that the virtues of distilled wine were beginning to be appreciated. "Some people call it Eau de Vie," wrote Arnaud de Villeneuve, "and this name is remarkably suitable, since it is really a water of immortality. Its virtues are beginning to be recognised, it prolongs life, clears away ill-humours, revives the heart and maintains youth."

At that early period, distillers were so much impressed with the marvellous qualities of distilled wine that they imagined it contained some of the attributes of the fire which had helped to make it. They sought to prolong distillation as much as possible, on heated sand, and they endeavoured to let the contact between the liquid in the still and the heat of the fire be as long as possible, thinking that such was the surest means of obtaining a more fiery spirit.

During the fourteenth century, much progress was made in the art of distillation, both in France and Germany, and wine spirit was used medicinally and sold by apothecaries at prices which were then considered prohibitive.

In 1307, an entry in the account book

of the Comtesse Mahaut reads thus:—"For wine bought by Girard to make burning water of, for our daughter, ten sous and ten deniers."

In 1358, in his *Pratica Alchimica*, Ortholaus gives very exact di ections for the distillation of wine, and for rectifying the spirit obtained first.

From the publications, at Augsburg, in 1483, of a treatise by Michel Schreik, *Verzeichniss der Ausgebranden Wasser*, and, at Bamberg, in 1493, of a poem dealing with the merits and demerits of alcohol, it is evident that, in Germany, the use of spirits was, during the fifteenth century, no longer restricted to medicinal purposes.

In 1496, the municipality of Nuremberg was already taking measures to check the abuse of spirits, a decree issued that year "forbidding the sale of

distilled waters on Sundays and other holidays, in private houses, as well as by druggists and other merchants, in their shops, in the market, in the street, or elsewhere, so as to put a stop to their abuse and excessive consumption."

Liquids fermented from grain appear to have first been distilled on a large scale in the fifteenth century, and it was due to this fact that the consumption of spirits rapidly became more general, particularly so in Northern Europe, where wine was comparatively expensive and out of the reach of the majority of the people.

Ever since, the consumption of spirits has grown more popular and more considerable all the world over, whilst the industrial utilisation of alcohol has opened a practically unlimited field to the energies of the distiller.

Aqua Vitæ does not appear to have enjoyed any popularity in England before the sixteenth century. Some knowledge of the art of distillation may have been brought to this country by Raymond Lulli, during the reign of Edward III. The inventor of the *Universal Art* had great faith in "the marvaylous use and comoditie of burning waters even in warres, a little before the joining of batayle, to styr and encourage the souldiours' mindes." No record has been found, however, to show that distilled spirits were consumed in England before the sixteenth century, although they were commonly used in Ireland, and probably also in Scotland at a much earlier date.

In 1525, a translation of Jerome Braunschweig's important work on distillation was published in London,

under the title of *The Vertuose Boke of Distyllacyon of the Waters of all maner of Herbes,* "for the help and profit of surgeons, physicians, pothecaries, and all manner of people." This seems to have been the earliest book of any importance, in this country, published with a view of rendering the science of distillation more popular. The *Vertuose Boke* bestows great praises on *Aqua Vitæ*, the use of which, however, was chiefly recommended medicinally. "Aqua Vitæ," according to the *Vertuose Boke*, "is commonly called the mistress of all medicines, for it easeth the diseases coming from cold. It giveth also young courage in a person, and causeth him to have a good memory and remembrance. It purifyeth the five wits of melancholy and of all uncleanliness, when it is drunk by reason and meas-

ure; that is to understand five or six drops in the morning, fasting, with a spoonful of wine . . . . . , it comforteth the heart and causeth a body to be merry, etc."

In 1559, when Peter Morwyng published his *Treasure of Evonymous,* wine was no longer distilled solely by apothecaries for medicinal purposes. There were already a certain number of distillers in London, whose trade consisted in distilling spirits from wine-lees and unsound wine obtained at very low prices from the vintners and coopers, a practice which Morwyng does not find fault with. "Burning water, or Aqua Vitæ," he writes, "is drawn oute of wyne, but, wyth us, out of the wyne lies (lees) only, specially of them that sel it, and by this onely almost get their livying. And perad-

venture it is never a whit the worse that it is drawne oute of lees; for Lullus teacheth that it may be wel destilled of corrupt wine, yea, if it be distilled often it shal be made the more effectuall (that is to say), hotter and drier, etc."

The rapidity with which the popularity of the crude, home-made spirits spread in England is evidenced by the numerous editions of the works on distillation. Two editions of the *Treasure of Evonymous* were printed in 1559; a litle later, another treatise on the same subject by Conrad Gesner and translated by George Baker, was published under the title of the *Newe Jewell of Health*, and the demand was so great that several editions had to be issued within a short space of time.

In the *Jewell of Health*, we read

that good wine was sometimes used for distillation, but the process was then considered very wasteful. "The burning water, or water of life, is sometimes distilled out of pleasant and good wine, as the white or the red, but oftener out of the wine lees of a certain eager-savour or corrupt Wine.

"Further, when out of pure wine a water of life is distilled, I hear that out of a great quantity of good wine, a little yield or quantity of burning water is to be distilled, but out of the lees of wine, a much (greater) yield and quantity (are) gathered."

It was not, however, until the reign of Elizabeth and after the expedition to the Low Countries in 1585, that the taste for spirits became prevalent amongst the lower classes.

The taste for strong liquor and fiery

spirits appears to have made rapid progress in England during the seventeenth century; the distillation of home-made spirits was repeatedly encouraged by legislation, and it soon attained considerable importance, whilst the imports of brandy, rum and arrack increased very rapidly during the same period. Rum from the West Indies and arrack from the East were only imported at the close of the seventeenth century, and, even then, in insignificant quantities only. Brandy from Bordeaux, Rochelle or Nantes, Spain, Portugal and even from the Canaries, was the staple foreign spirit, whilst Aqua Vitæ and strong waters were chiefly supplied from wine-lees or strong ale distilled in England and flavoured with spices or other ingredients.

Previous to the reign of Charles I., there does not appear to have existed any control whatever over the manufacture of spirits in England; everybody was then free to distil spirits from whatever source they pleased and in whichever way they chose. This liberty was undoubtedly the cause of much unpalatable and unwholesome trash being sold as spirits, which had been distilled from sour wine dregs or putrid beer-wash. It was in order to prevent as far as possible the manufacture and sale of such injurious products that Charles I. granted the first Charter of the Distillers Company, in 1638. The person who seems to have been primarily instrumental in promoting the movement for the incorporation of the Distillers was Sir Theodore de Mayern, physician

to the King. In conjunction with Dr. Thomas Cademan, medical adviser to the Queen, and the first Master of the Distillers Company, Mayern prepared a series of regulations and bye-laws for the management of the new scheme which were published in 1639 under the following title:—

"*The Distiller of London:* Compiled and set forth by the Special Licence and Command of the King's Most Excellent Majesty. For the sole use of the Company of Distillers of London. And by them to be duly observed and practised."

To protect the public from unwholesome spirit, it was decreed:

"That no Afterworts or Wash (made by Brewers, etc.) called Blew John, nor musty unsavoury or unwholesome tills, or dregs of beer or ale; nor unwholesome or adulterated wines, or Lees of Wines, nor unwholesome sugar-waters; musty unsavoury or unwholesome returned beer or ale; nor rotten corrupt or unsavoury fruits, druggs, spices, herbs, seeds; nor any other ill-conditioned materials of what kind soever, shall henceforth be distilled, extracted or

drawn into small spirits, or low wines, or be any other ways used, directly or indirectly, by any of the Members of this Company, or their successors at any time hereafter for ever."

The regulations enacted by the Distillers Company failed to ensure greater purity in English-made spirits because the Company never enjoyed any of the trading monopolies which alone would have made it possible to control the conduct of the trade. Charles II., James II., and William III., encouraged the distillation of home grain, in order to promote agriculture, allowing every Englishman to distil and retail spirits from English-grown corn. The most important measure passed by Parliament to that effect was the Act II., William and Mary, which begins:

"An Act for the encouraging the distillation of brandy and spirits from corn. First, the trade and commerce of France being prohibited, and all their

goods from being imported in the kingdom; And whereas good and wholesome brandy, aqua vitæ, and spirits may be drawn and made from malted corn; For the encouragement therefore of the making of brandy, strongwaters, and spirits from malted corn, and for the greater consumption of corn and the advantage of tillage in this kingdom. The King, Queen and Parliament then assembled have thus ordained it. . . ."

In 1673, a petition was presented to Parliament, praying that brandy, coffee, mum (a strong ale brewed chiefly from wheat malt), tea and chocolate might be prohibited, on the ground that these beverages greatly hindered the consumption of barley, malt and wheat, products of the land; and the petition went on to say:

"Before brandy which is now become common and sold in every little alehouse, came over into England in such quantities as it now doth, we drank good strong beer and ale, and all laborious people (which are far the greatest part of the kingdom), their bodies requiring, after hard labour, some strong drink to

refresh them did therefore every morning and evening used to drink a pot of ale or a flagon of strong beer, which greatly promoted the consumption of our own grain, and did them no great predjudice; it hindered not their work, neither did it take away their senses nor cost them much money, whereas (the petition continued) the prohibition of brandy would . . . prevent the destruction of His Majesty's subjects, many of whom have been killed by drinking thereof, it not agreeing with their constitution."

In 1684, the whole of English-made spirits on which excise was paid amounted to 527,000 gallons, whilst there were 202 tuns, 36 pieces, and 19 casks, equal to about 29,000 gallons of foreign spirits imported in London during the month of February, 1683.

In 1694, the produce of all the stills in England amounted to 1,885,752 gallons of low-wines, or 754,300 gallons of spirits. In the same year, in spite of the prohibition of French spirits, there were imported from Holland, Spain,

Portugal and the Canaries, in the port of London alone, 706 tuns, 223 pipes, 425 casks, 70 hogsheads, 52 butts and 8 pipes of foreign brandy, about a million and a quarter gallons.

Home-made Aqua Vitæ had nothing in common with Brandy or distilled wine; it was a spirit made from the lees of wine or ale and flavoured with a very great variety of herbs or roots. In his English House-Wife, Markham has the two following recipes for making "an excellent Aqua Vitæ":

"Take of rosemary two handfulls, of marjerom winter savory, rosemary, rue, unset time, germander, ribwort, harts-tongue, mouseare, white wormwood, bugloss, red sage, liver-wort, hoar-hound, fine lavender, hyssop-crops, pennyroyal, 1 red fennell, of each of these one handfull; of elicampane roots, clean pared and sliced, two handfulls; then take all these aforesaid and shred them, but not wash them, then take four gallons or more of strong ale, and one gallon of sack lees, and put all these aforesaid herbs shred into it,

and then put into it one pound of lycoras bruised, hal a pound of aniseeds clean sifted and bruised, and of mace and nutmegs bruised of each one ounce; then put altogether into your stilling pot, close covered with rye paste, and make a soft fire under your pot, and as the head of the limbeck heateth, draw out your hot water and put in cold, keeping the head of your limbeck still with cold water, but see that your fire be not too rash at the first, but let your water come at leisure, and take heed into your stilling, that your water change not white; for it is not so strong as the first draught is; and when the water is distilled, take a gallon glass with a white mouth, and put therein a pottle of the best water and clearest, and put into it a pottle of *rosa solis*, and half a pound of dates bruised, and one ounce of grains, and half a pound of sugar, half a pound of seed pearl beaten, three leaves of fine gold; stir all these together well, then stop your glass, and set it in the sun the space of one or two months, and then chlarifie it, and use it at your discretion, for a spoonfull or two at a time is sufficient, and the vertues are infinite."

The second way indicated for making an "excellent Aqua Vitæ" is not quite so fantastic as the preceding, although

Markham might have more rightly said of both recipes "take it at your peril," than "at your discretion."

"Fill a pot with red wine, clean and strong, and put therein the powders of cammomile, jilley flowers, ginger, pellitory, nutmeg, gallengal, spicknard, quenebus, grains of pure long pepper, black pepper, cummin, fennel seed, smallage, parsley, sage, rue, mint, calamint, and horshow, of each of them a like quantity, and beware they differ not the weight of a dram under or above; then put all the powders abovesaid into the wine, and after put them into the distilling pot, and distill it with a soft fire, and look that it be well luted about with rye paste, so that no fume or breath goe forth, and looke that the fire be temperate; also receive the water out of the lymbeck into a glass vial. This water is called the water of life. . . ."

Then follow directions how to make *Aqua Composita,* distilled from "the best ale that can be brewed," the *Imperial Water,* from Gascony wine, *Cinamon Water,* from Sack, and "Six

most precious waters" which are said to possess remarkable virtues.

Markham further indicates a few of the strong-waters which a provident house-wife should always keep for cases of emergency.

"Therefore first I would have her furnish herself of very good stills, for the distillation of all kinds of waters, which stills would either be of tin, or sweet earth, and in them she shall distil all sorts of waters meet for the health of her household, as sage water, which is good for all rheums, and collicks; raddish water, which is good for the stone; angelica water, good against infection; celandine water for sore eyes; vine water, for itchings; rosewater and eye-bright water for dimme sights; rosemary water for fistulæs; treacle water for mouth cankers; water of cloves for the pain in the stomach; saxifrage water for gravell and hard urine; allom water for old ulcers, and a world of others, any of which will last a full year at least. Then she shall know that the best waters for the smoothing of the skin, and keeping the face delicate and amiable, are those which are distilled, from beanflowers, from strawberries, from vine leaves, from goates-milk, from asses milk, from the whites of

eggs, from the flowers of lilies, from dragons, from calves feet, from bran or from yelks of eggs, any of which will last a year or better."

In the *Britannian Magazine* (1691) W. Y. Worth tells us that "Aqua Vitæ is nothing else but well brewed beer, that is strongly hop'd and well fermented" distilled and rectified; he asserts that "Brandy" made from beer, cider, perry or fruit wines is "little inferiour to that of France," and he also gives full particulars for the manufacture of strong-waters of aniseed, caroway, cardamum, hearts-ease, angelica, wormwood, mint, etc.

J. Lightbody, "Philomath," published at about the same time a treatise on brewing and distilling, entitled *Every man his own gauger,* in which he gives the recipe "to make the best sort of Right Irish Usquebaugh," as follows:

"Take of good spirits, 12 gallons. Put therein of aniseeds, nutmegs, sugar, carroway-seeds, of each four ounces, distil the whole to proof spirit, put thereto liquorish, raisins of the sun 2 pound, and 4 lb. of sugar, let it drain through a flannel bag, and fine it down with the whites of eggs and wheat floor. This is the only way that natives of Ireland make this liquor, which is approved of to exceed all the other new ways of making it, being but imitations of the original."

The Gin riots in the eighteenth, and of the rise of the Whisky trade in the nineteenth centuries, belong to modern times and will be described at a later date. The story of the progress made in the art of distillation at home and abroad during the last two centuries will be told in later Lectures dealing with each separate class of spirits. All we need say now is that the more important the art of distillation became, the more attention it received, both commercially and

scientifically, with the result that many improvements were from time to time introduced into former methods of distilling ; these have gradually been perfected to such a degree that the industry of distillation is now, in all civilised countries, one of the most important and one of the most profitable as far as State Exchequers are concerned.

II. The Theory of Distillation.

Strictly speaking, the art of distillation as applied to spirits, consists in isolating, by heat, the different elements of which any alcoholic liquid may be composed.

The marked differences, however, which exist between various potable spirits are due, in the first instance, to

the differences existing between various fermented liquids from which such spirits are distilled, and, in the second place, to different methods of distillation.

It is by fermentation, not by distillation, that alcohol is obtained, so that the first care of the distiller is to obtain by fermentation the alcoholic liquid he will have to distil.

What is alcohol? Some call it a food and others a poison; some say that it is a stimulant and others an irritant; some condemn its use and many more praise it, but no one can possibly give a definition of alcohol which will be acceptable to all, no one but the chemist, who will tell you that alcohol is a compound of carbon, hydrogen and oxygen in certain proportions.

Chemists recognise 65 simple bodies, all others are compound bodies. A simple body is one which cannot be divided, and a compound body is one that is formed of a combination of two or more simple bodies. One may crush pure sulphur, for instance, or treat it by fire, water, electricity or acids without obtaining anything but sulphur; Science is unable to subdivide sulphur, and so it is called a simple body. The same applies to carbon, oxygen, hydrogen, etc. On the other hand, water is a compound body, because it can be divided and can easily be proved to be a combination of two simple bodies, hydrogen and oxygen. In chemistry, hydrogen is known by the letter H, oxygen by the letter O, and carbon by the letter C. If water were a combination of one

part of hydrogen and one part of oxygen, chemists would simply call it HO; but it so happens that the proportion of hydrogen to oxygen is as two to one, so that water is designated by H^2O. If we take away from water —H^2O—one of its atoms of hydrogen and replace it by a hydro-carbon radical, that is to say, a compound of hydrogen and carbon, we shall obtain different combinations of hydrogen, carbon and oxygen, corresponding to different types of alcohol. If, for instance, we add a compound composed of one atom of carbon and three of hydrogen to HO, we shall have the formula CH^3HO or CH^4O, a compound body known as methyl alcohol or wood alcohol. If we were to add to HO two atoms of carbon and five of hydrogen, we should have the formula C^2H^5HO

or C^2H^6O, which corresponds to ethyl alcohol or wine alcohol. In the same way, the formula of amyl alcohol or fusel oil, is $C^5H^{11}HO$; that of propyl alcohol C^3H^7HO; that of butyl alcohol C^4H^9HO, etc.

The member of the large family of alcohols which interests us most and the only one we shall deal with to-day is ethyl alcohol, a compound body consisting of two atoms or molecules of carbon, six molecules of hydrogen and one molecule of oxygen.

To make ethyl alcohol, therefore, it suffices to put together two molecules of carbon with six molecules of hydrogen and one molecule of oxygen. Theoretically, such a feat is possible, but practically it is not only difficult but also absolutely unnecessary, since that same combination is the natural

result of alcoholic fermentation. Fermentation, as you know, is a phenomenon which transforms the sugar contained in the juice of the grape and produces principally carbonic acid gas and ethyl alcohol.

The juice of the grape ferments naturally and thus becomes wine, which was the first alcoholic liquid to be distilled, and for a long time the only one. Natural wines, however, never contain a large proportion of alcohol, so that much wine must be burnt or distilled to obtain a comparatively small quantity of spirit. On the other hand, climatic conditions render viticulture perforcedly limited, so that the production of wine has never been greatly in excess of the consumption thereof. Both the short supply and the higher cost of grape-spirit have thus placed

Brandy or distilled wine beyond the reach of the masses in all but wine-growing districts.

Had not the ingenuity of man discovered any other material to distil except the naturally fermented juice of the grape and of a few other fruits, spirits would be as scarce now as in the twelfth century, and much more costly. As a matter of fact, grape spirits are very much less plentiful and much dearer, whilst their consumption is considerably smaller than that of other spirits.

Grape juice contains natural yeast and sugar, and the former, as we know, transforms the latter into alcohol; if, therefore, we obtain by some direct or indirect means a liquid containing sugar, and if we add yeast to it, we shall provoke a similar phenomenon;

fermentation will set in and transform the sugar into alcohol. Barley, maize, rice, molasses, beetroot, potatoes, and practically all vegetal products, contain either some sugar or some other matter, such as starch, which can be transformed into sugar; they can be thus caused to ferment, to yield some alcohol, which may be separated later by distillation.

Sugar-cane, molasses, beetroot and those tubers, commonly called Jerusalem artichokes, all contain a fairly large proportion of sugar; they have only to be crushed or mashed and diluted; yeast is then added and they are thus fermented in a direct way.

Wheat, barley, rye, oats, maize and rice contain no sugar, but starch in varying proportions, and by malting, starch is transformed into glucose;

yeast will cause the glucose to ferment, and alcohol is thus obtained.

In a similar way, the starch contained in potatoes is transformed into glucose, which, by the addition of yeast, is caused to ferment and to produce alcohol.

Having obtained by fermentation an alcoholic liquid, it only remains to distil it.

Different elements are affected differently by heat. You all know, that the heat which will melt butter, will not melt lead, and that the heat which will suffice to melt lead, will not melt copper; if you had, for instance, a piece of mineral composed of lead and copper, you could separate them by heat, because the lead would melt first.

In the same way, the boiling point

of water being 100° Centigrade, if you were to heat some sea water to 100°, the water would be vaporised, that is to say, it would become vapour—or steam—but the salt contained in the water would remain intact because salt only vaporises at a temperature of 1,000°.

In the same way, again, heat vaporises alcohol at a temperature of 78° centigrade; so that if we put in a saucepan some wine or any other alcoholic liquid, and place it on the fire, vapours of alcohol should be obtained as soon as the liquid reaches 78° and no water vapours should be emitted, if we are careful not to allow the temperature of the liquid to reach 100°.

If this were the case, distillation would be very much simpler than it is; but it is not so, because such an

affinity exists between alcohol and water, that it is very difficult to separate the one from the other at any given temperature.

Pure alcohol (anhydre) will be vaporised at 78°, but a temperature of 83·1 is required to vaporise an alcoholic liquid containing 50 per cent. of alcohol and 50 per cent. of water; and, if an alcoholic liquid, such as wine, contained only 10 per cent. of alcohol, a temperature of 92·6 would be required to vaporise the said liquid; 92·6 is very near the 100° when all the water vapours will come over.

The vapours which are emitted by the wine placed in the saucepan will therefore contain both water and alcohol, although more of the latter and less of the former than originally.

If we now put a lid on that saucepan,

the steam or vapour will at once be condensed into a great number of small drops which will adhere to the cold surface of the lid and we can cause them to run into a glass. The alcoholic liquid we have thus obtained, first by vaporisation and then by condensation, still contains a large proportion of water, but being placed over the fire once more, it will again emit vapours which we shall condense again, and which will contain a greater proportion of alcohol than before, but too much water still. We can then do the same thing, again and again, further rectifying our spirit, until we have reduced the proportion of water as much as we wish or can.

Distillation, therefore, may be said to necessitate three distinct essential operations:

Firstly: VAPORISATION, to produce alcoholic vapours.

Secondly: CONDENSATION, to collect the said vapours.

Thirdly: RECTIFICATION, to free the said vapours from any excess of water or other matters they may contain.

These three principal operations are quite distinct from each other in theory, but not always so in practice.

We must remember that, although pure alcohol becomes vaporised at a temperature of 78°, the boiling point of water is 100°, and that the greater therefore the proportion of water in any alcoholic liquid, the greater will have to be the heat to vaporise the alcohol, according to the following scale:—

% of Alcohol.		% of Water.		Boiling point.
100	...	0	...	78° Centigrade.
90	...	10	...	78°·8 „
80	...	20	...	79°·7 „
70	...	30	...	80°·9 „
60	...	40	...	81°·9 „
50	...	50	...	83°·1 „
40	...	60	...	84°·1 „
20	...	80	...	88°·3 „
10	...	90	...	92°·6 „
1	...	99	...	99°·06 „
0	...	100	...	100° „

Bearing this in mind, let us take a glass vessel composed of a chamber to contain the liquid we wish to distil, and fitted at the top with a pipe or tube to lead off the vapour into a receptacle placed at the end of it; we shall then have a still in its simplest form, but a still all the same. If we fill our still with some alcoholic liquid containing, for instance, 20 per cent. of alcohol, and place it over a fire, as soon as the tem-

perature of the liquid reaches 88°·3, vapours of alcohol will be produced which will go up the tube, but which will be followed by water vapours. The vapours which reach the tube will contain a greater proportion of alcohol than the liquid they came from; and if they contain 40 per cent. of alcohol instead of 20 per cent., the alcohol they hold will be vaporised at 84°·1. When they have travelled some way along the glass tube, they are further from the fire, and the temperature of the lower part of the tube will probably be four degrees cooler than that of the mass of the liquid. As a temperature of 84°·1 is sufficient to vaporise alcohol, the alcohol contained in the vapours which have come from the mass of the liquid, will still remain vaporised, and will go

further up the tube; but the water present in the same vapours will find it too cold to remain vaporised, and a good deal of it will be condensed into water again, and fall back into the mass of the liquid whence it originally came. So that when the vapours reach the top of the tube, they contain a greater proportion of alcohol than when they first entered it. They may then contain 50 per cent. of alcohol, and we know that, in that proportion, the alcohol will be vaporised at a temperature of 83°·1; on the other hand, the top of the tube, being further away still from the fire, will probably be one degree cooler than the lowe part, and the same phenomenon will repeat itself; some more of the water contained in the vapours will be condensed at the lower temperature,

and will fall back into the liquid it came from, whilst the alcohol will still be vaporised, and will pass on further in the shape of alcoholic vapours into a receptacle where the temperature must always be kept well below 78°, so that, even if vapours of pure alcohol entered, they would be condensed immediately.

Now, if this pipe or tube through which the alcoholic vapours have to travel were long enough; if it could be separated inside in a series of compartments; if the temperature of each compartment could be regulated and graduated from 100°, the boiling point of water, down to 78°, the boiling point of alcohol, we should be able, theoretically, to isolate from any alcoholic liquid all the alcohol it contains.

In practice, however, this is not possible, and, in most cases it is not even desirable, since the object of distillation, when applied to potable spirits, is not to separate all or nearly all the alcohol contained in any alcoholic liquid from all the wate , ethers, essential oils, and other matters the said liquid is composed of.

A light white wine and strong beer, for instance, are very different alcoholic liquids, although both contain some ethyl alcohol. If both wine and beer could be distilled, rectified and re-distilled until all the ethyl alcohol contained in each had been completely isolated, the spirit obtained would be identical in each case; it would be simply plain spirit or pure spirit, plain or pure because it would be free from all such by-products as are always con-

tained in grape juice or malted barley.

On the other hand, the object of distillation being principally to reduce the proportion of water contained in such liquids, if both wine and beer have been caused to contain each 50 per cent of alcohol, the result will be a grape spirit and a grain spirit as distinct as the wine and beer they have been distilled from. The alcohol, from a chemical standpoint, will be the same in each case but the by-products or impurities will be very different, and it is these by-products which are responsible for the distinctiveness of all spirits other than highly rectified spirits, which should contain none.

In other words, it may be asserted that the quality and distinctiveness of spirits vary according to the nature and proportion of the by-products they

contain, and not owing to any differences in the chemical composition of their alcohol.

Wine distilled until it contained 99 per cent. of ethyl alcohol would be purer as spirit, but worse as Brandy, than wine distilled only to 50 per cent. On the other hand, a liquid fermented from potatoes, if distilled to 50 per cent., would be 49 per cent. worse, as well as less pure, than a spirit obtained from the same liquid distilled to 99 per cent.

In all alcoholic liquids, the ethers, essential oils, acidity, mineral matters, and other component parts, vary greatly, some being retained with advantage after distillation, whilst others must be eliminated altogether.

The nature and proportion of the by-products contained in different

spirits vary considerably, according to two main causes:—

1º According to the nature of the alcoholic liquids from which different spirits are distilled.

2º According to the strength at which spirits are distilled, and according to different methods of distillations.

Taking, for example, a mash made from malted barley, if we distil part of it until it contains 50 per cent. of alcohol, and if we distil another part further until it contains 90 per cent. of alcohol, we may then add to the latter some water and thus reduce it to 50 per cent. of alcohol, or in other words, to proof; the two spirits will then contain the same percentage of alcohol, but they will differ considerably in every other respect, because the first will possess

a much larger proportion of the distinctive by-products of the malted barley it was distilled from.

It is, unfortunately, impossible in the very limited space of time at our disposal to do more to-day than indicate the main principles which govern the art of distillation. How Whisky, Brandy, Rum, Gin and Plain Spirits are distilled, rectified, treated and matured, are subjects we must reserve for a future date.

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