

The Carriage Still

An
Advanced Fractionating Still
for Amateurs



by
John Stone

The Carriage Still

Published in Canada in September 2003

by

Saguenay International
17 Hudson Club Rd
Rigaud, QC
Canada J0P 1P0

Second Edition

Copyright © September 2003 by John Stone

All rights reserved. No part of this publication, printed or electronic, may be reproduced or transmitted to a third party in any form or by any means, including electronic, without the prior written permission of the author.

ISBN 0-9682280-4-6

Contact:

John Stone
17 Hudson Club Rd
Rigaud, QC
Canada J0P 1P0

Telephone: (450) 451-0644 Fax: (450) 451-7699
e-mail: pegasus@gin-vodka.com

Photographs and illustrations by Jim Low, Hudson, QC

Foreword

After 17 years of designing small reflux stills for use by amateurs in the home, making major changes here, cosmetic changes there, sometimes doing nothing more than making a change for the sake of change, we feel that it's time to freeze the design and make it available immediately. Amateur distillers around the world can then start to build one for themselves and enjoy the fruits of their labour.

The Carriage Still combines all the best features of the many designs developed over the years and should satisfy the needs of the most fastidious connoisseurs of high quality spirits.

TABLE OF CONTENTS

	Page No.
Introduction	1
Types of still	
• The alembic	3
• Laboratory pot still	3
• Laboratory fractionating still (Vigreux)	4
• Amateur glass fractionating still (Stone)	6
The Principles of Distillation	7
• Simple distillation --- the pot still	8
• Fractional distillation using reflux	8
Health & Safety	
• Poisoning oneself	12
• Headaches & hangovers	13
• Fire & explosions	14
The Carriage Still	
• The evolution of the still	15
• The boiler	17
• Power supply	18
• The column	18
• The stream-splitter	19
• Still-head	20
• Cooling coil	21
• The packing	23
• Water supply	24
• Column support	25
• Collection of alcohol	25
Procedures	
• Production of pure alcohol (vodka)	26
• Stage 1 --- Beer stripping	28
• Stage 2 --- Rectification.	29
• Alcohol-water azeotrope	30
• Temperature measurement	31
• Yield of alcohol	32
• Water quality	32

7.	Alcoholic beverages	
	• Vodka	34
	• Flavoured vodka	34
	• Essences	35
	• Liqueurs	35
	• Chacun son goût	35
	• A flavoured spirits still (for whisky, rum, etc.)	36
	• The flavour	38
	• Comment	39
	• Steeping	39
8.	Amateur Distillation and the Law	40
9.	Costs	43
10.	Future developments	
	• The boiler	44
	• Automatic switch-off	44
	• Cooling	45
11.	References	46
12.	Appendix I Effect of atmospheric pressure on boiling points	47
13.	Appendix II Latent heat of vapourization	48
14.	Appendix III Cooling water requirements	50
15.	Appendix IV Preparing a gin essence	52
16.	Appendix V The Question of Legality	53
	The Author	57

<p style="text-align: center;">NOTE</p> <p style="text-align: center;">Glass still-head and other items available for purchase are described on p.58</p>
--

The Carriage Still

An advanced fractionating still for amateurs

INTRODUCTION

The previous books in this series (1,2,3) have described the construction of several different versions of a highly efficient fractionating still for amateur use, but in writing this text we have had to assume that you have not read them. Consequently, we have included some of the same material here in order to make the present book self-sufficient. What we have omitted is the lengthy discussion of distilling theory, this book devoting much more space to construction details and practical matters. The diagrams are very much larger and more numerous because it is assumed that you may actually wish to build a still and not just read about it. It also concentrates on a single design using a copper column and glass still-head, embodying all the best features of the several designs we have developed over the years.

The book provides sufficient detail for the average handyman to build a still with superlative performance and elegant appearance. It is capable of turning out the purest alcohol in the world, an alcohol which any scientist in a university laboratory, or any commercial distiller, would be proud to produce. And it is capable of doing so very cheaply, e.g. vodka at \$1 per litre. Using exactly the same still, but modifying the procedures somewhat, it can also be used for producing flavoured alcoholic beverages such as whiskies, rum, brandies, schnapps, etc.

So herewith the book which we have dubbed “The Carriage Still”, so-called because it embodies all those features which the “Carriage Trade” would demand. The “Carriage Trade” is a name coined in the Victorian era to describe those snooty people who could afford to travel in their own carriages instead of walking! In the present context it describes those people who demand nothing but the best, a still which is capable of producing the ultra-pure alcohol required for vodka or, by shifting gears, used as a whisky, brandy or rum still.

TYPES OF STILLS

There is nothing very new about stills and distilling, it has been going on for centuries. In terms of equipment you can go to any scientific supply house and they will gladly sell you a variety of glass stills which highly qualified scientists have developed, used and written about. At the commercial level, stills can be found in dozens of tiny villages in Scotland churning out their particular brand of malt whisky. The same holds true for rum distilleries which will be found in most sugar-producing regions like the Caribbean. Or the brandy distilleries of France, the rye distilleries of Canada, the vodka distilleries of Poland or the bourbon distilleries of the United States. Go and visit them. Kick the tires. Talk to the staff. Satisfy yourselves that there are real stills out there, stills where the problems have been solved, stills which have been working for years and producing the various spirits which discriminating souls are buying and drinking.

So is it really necessary for us to start all over again and re-invent the wheel? What's the problem? The problem is that none of these stills is exactly right for the amateur. A commercial still 4 metres in diameter and 40 metres high will not fit conveniently into the average kitchen. A small glass still from a supplier of scientific apparatus might require you to mortgage your house to pay for it, and would barely produce enough ambrosia to stick in your eye. Another problem is that, because amateur distilling is illegal in most countries, there are no popular texts on the subject to be found in bookstores. It is only with the advent of the Internet that we have been able to talk freely to one another about this harmless hobby. A word of caution, however. The dearth of information provides a fertile breeding ground for all sorts of crackpot ideas, so it is important for you to realize that, if you wish to build a still yourself, it is essential to stay with established principles and not wander off into cloud-cuckoo land. Change the hardware by all means, but not the principles.

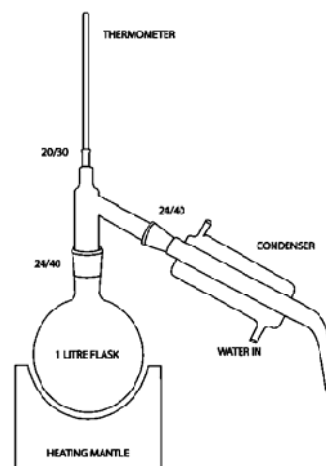
As an example of cloud-cuckoo land, we know of one would-be distiller who tried to make a glass column out of jam jars. He cut the tops and bottoms off, ground them flat and then tried to stick them together. Naturally, the "column" leaked like a sieve so for his next attempt he tried to use a fluorescent light bulb. It shattered as soon as he tried to work it. The moral of this story is that you should save your inventiveness (and this individual was obviously very inventive) for something that really needs inventing and not waste your time trying to make a silk purse out of a sow's ear. Move ahead, not back. There are lots of opportunities for you to display your ingenuity in the field of small-scale distilling and later in the book we'll suggest a few problems for you to get your teeth into.

Pot stills. There are only two essential elements for a still: a) a boiler, and b) a vapour-condensing system. In the diagrams which follow we start where alchemists must have started way back in the Middle-Ages, or perhaps it was the Chinese or the ancient Egyptians several millennia before that who started playing around with distillation. One supposes they started with the alembic, shown in Figure 1.

Figure 1 ALEMBIC



Figure 2 SIMPLE LABORATORY POT-STILL



The alembic. Using an alembic (Fig. 1) the alchemist would add the liquid to be distilled or the solid to be sublimed, heat it with a flame, and have the vapours condense back to liquid or solid in the neck. A long neck with a cold, damp cloth wrapped around it would have helped. This is the most elementary form of pot still, or retort as it's sometimes called, and as with all pot stills the principle involved is this: when you boil a liquid containing two or more components, alcohol and water for example, the vapour is somewhat richer in the more volatile component (alcohol in this case) than the liquid. So when the vapour is condensed back to liquid, this liquid has a higher alcohol concentration than the mother liquid from which it sprang.

Laboratory pot still. A modern version of the alembic is shown in Fig. 2. The refinements are i) the flask and the condenser are separate and joined together by ground-glass joints for easy filling, emptying and cleaning, ii) the condenser is cooled by means of cold water running through a surrounding jacket on the downstream side, and iii) a thermometer is provided for measuring vapour temperature. Otherwise, there hasn't been much change in the last few thousand years. This type of still would be used for simple distillations such as the production of distilled water or for steam-distilling botanicals. With a few modifications it could also be used for producing certain types of distilled spirits.

A pot still such as shown in Fig. 2. may be suitable for a two-component mixture but is less suitable, or quite unsuitable, for a multi-component system. Thus, if you had dirty water, or hard water, a pot still would do a good job of producing distilled water, leaving the impurities behind. No problem. But the fermentation of sugar, or grape juice, or molasses, or hydrolysed starch produces hundreds of different organic compounds in addition to ethyl alcohol, and this is a different kettle of fish entirely (if you'll excuse the mixed metaphor). If you use a pot still on such a mixture you'll get a very crude and uncontrolled separation of the components of the mixture, undoubtedly retaining some very unpleasant-tasting ingredients. The product is known as "moonshine", and although some people profess to like moonshine, or can grow to like it, or will tolerate it because it's cheap, centuries of experimentation have shown that most people prefer to have at least some of the more noxious components removed. Not all, but some. Not

many people seem to enjoy the taste of methanol or the fusel oils for example. So, over the years, people have found ways and means to remove some of the worst material using a pot still and leave behind something quite palatable, e.g. a scotch whisky.

Fractionating stills. What we need instead of a pot still is a still with a performance more under our control, a still which is capable of selectively removing certain compounds in the fermentation brew (“beer” or “mash” or whatever you prefer to call it) while retaining certain others. Fortunately, such a still is available and is known as a fractionating or reflux still. It operates on quite a different principle to a pot still, a principle which will be discussed in the next chapter. To give you an idea of what such a still looks like we show in Fig. 3 a small glass laboratory model of a fractionating still, in this instance a still using a Vigreux column. We shall be discussing this later. We also show in Fig. 4 an all-glass still of our own design which operates in exactly the same way as the Vigreux but looks a little different.

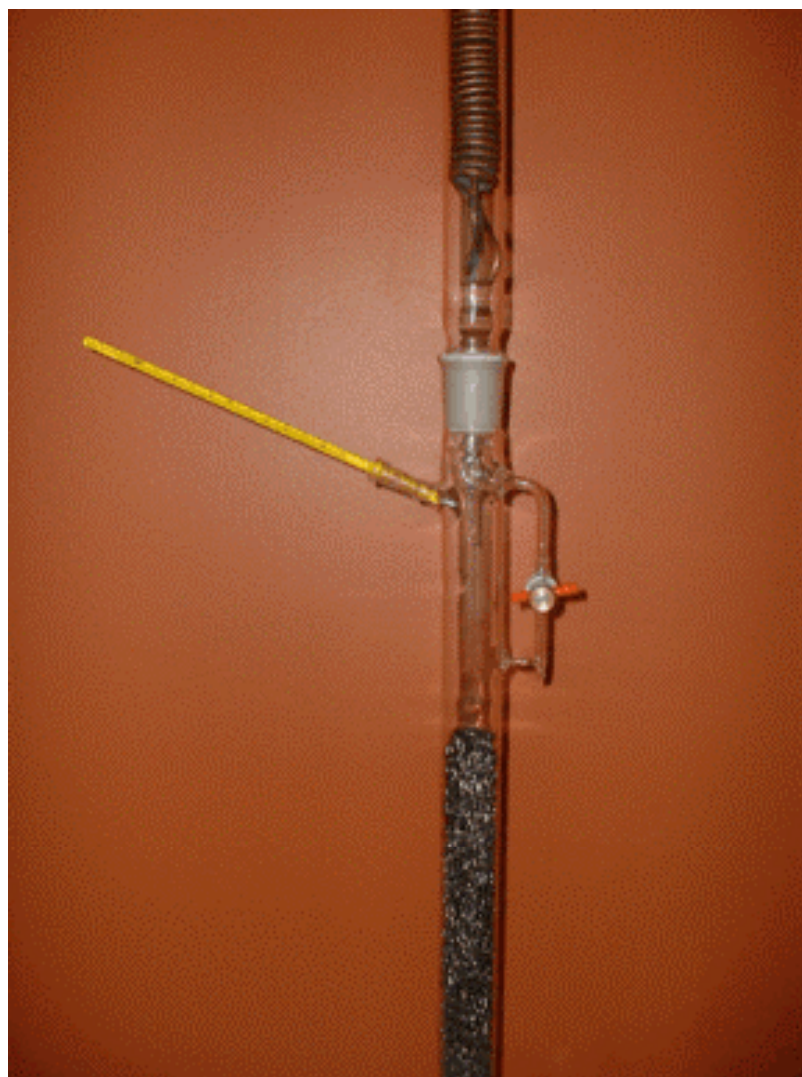
You will note from an examination of Figs 3 and 4 that there is a long tube or column mounted above the boiler. In operation, the vapour rising from the boiler does not do a U-turn and flow back down into a condenser à la pot still but continues upwards into a condenser where the vapour is condensed to liquid. The liquid then runs back down through a device called the “stillhead” where it is divided into two separate streams, one stream continuing on down to the boiler while the other stream is directed to the outside world by means of a valve or stopcock.

Such a procedure will seem strange to those of you who have only been involved with simple pot stills where you collect everything which has boiled off the liquid. Return some of the condensed vapour to the boiler! Whatever next! A bit like taking two steps forward and one step back. However, we shall be discussing this later so will not elaborate upon it at this juncture.

Figure 3. Laboratory fractionating still (Vigreux)



Figure 4. All-glass amateur reflux still (Stone)



THE PRINCIPLES OF DISTILLATION

The principles of fractional distillation are the same whether one is dealing with a small glass laboratory still such as shown in Fig. 3 (Vigreux) or a mighty commercial stainless steel tower 4 meters across and 40 meters high. The principles were discussed in the previous book in this series, but it is necessary to repeat some of the same discussion here. Shamelessly, therefore, we quote almost word-for-word from “Making Gin & Vodka ---A Professional Guide for Amateur Distillers” (4).

As a result of fermenting any natural source of sugar, be it grapes, molasses, potatoes, milk (lactose) or whatever, a whole host of organic compounds will be produced. Among the more important are those listed in the table below. Please note the differences in boiling point.

Compound	Boiling point, °C.
Acetone	56.5
Methanol	64.7
Ethyl acetate	77.1
Ethyl alcohol (96%), the azeotrope	78.1
Ethyl alcohol (100%)	78.4
Propyl alcohol	97.2
Water	100.0
Butyl alcohol	117.5
Amyl alcohol	137.8
Furfural	161.0

Chemicals with different boiling points such as those in the table above have different vapour pressures, the most volatile at the top of the table with the lowest boiling point having the highest vapour pressure at any particular temperature. A liquid boils when its temperature is raised to the point where its vapour pressure equals atmospheric pressure. Thus, if the room temperature is 25° C. and you have a bottle of acetone, you only have to raise its temperature by 31.5° C. and it will boil. Or you can make it boil at room temperature by reducing the pressure, i.e. by applying a vacuum.

It is now necessary to dispose of a misconception concerning distillation which is quite prevalent, so prevalent in fact that it is the basis of several small-scale stills being offered for sale. The misconception goes like this: If you have a mixture of (say) three liquids with different boiling points, e.g. methanol (64.7 °C.), ethanol (78.4 °C.) and water (100 °C.) it is believed that, if you raise the temperature to 64.7 °C., and hold it there the methanol will boil off. Then, if you raise the temperature to 78.4 °C. the ethanol will boil off. This is completely untrue and illustrates the misinformation being disseminated by well-meaning but ill-informed hobbyists. It might be approximately true for liquids which do not mix with one another, such as

gasoline and water, but is totally untrue for liquids which are completely miscible with one another such as those in the above table. Being miscible they associate with one another at the molecular level and no longer act independently as individuals.

Having expunged this misconception from our minds, and hopefully from all future writings on this subject, let's take a look at what really happens. When a mixture of liquids of different boiling points is brought to the boil, the vapour contains ALL the compounds which are in the liquid, but the vapour has become richer in the more volatile components. This can be proved by condensing the vapour to liquid and analyzing it. It is the basis of all distillations --- the vapour is richer than the liquid in volatile constituents.

Simple distillation – the pot still

First let's take a look at the simplest situation --- the events taking place in a pot still such as that shown in Fig. 2 when beer is distilled. The vapour is richer than the liquid in the most volatile constituents, i.e. the ones with the lowest boiling points such as acetone and methanol in the above table. When they distil over they are referred to as the "heads". There is no clear-cut separation of the various compounds so the heads will still be coming over when the ethanol starts to appear. Similarly, before all the ethanol has distilled over, the "tails" will begin to appear in the distillate. These tails are the compounds at the lower end of the above table, i.e. those with the highest boiling points such as propyl, butyl and amyl alcohols. These alcohols are known collectively as "fusel oils" and, like methanol and some of the other compounds, are quite poisonous.

In such a system there may be a tiny fraction in the middle which is pure ethyl alcohol but most of it will be contaminated with either heads or tails. One could discard the first heads and the last tails and re-distil the tiny middle fraction, repeating this process over and over again until the last of the impurities had been wrung out of the ethanol. Unfortunately, apart from being very time consuming, the loss of ethanol on repeated re-distillation would be such that the final yield of pure alcohol would be virtually zero. Fortunately, the very elegant procedure known as fractional distillation can perform these hundreds of re-distillations in a single operation without losing anything while doing so. It does so by using a counter-current flow of liquid and vapour.

Fractional distillation.

Two things distinguish a fractionating from a pot still. One is the equipment while the other is the procedure. We'll take the equipment question first and use the Vigreux column as an excellent and simple example. It was shown in Figure 3. Being made of glass one can see exactly what is going on inside and it's rather pleasant to watch in operation.

The Vigreux column. A typical Vigreux column is 600 mm high and 25 mm in diameter, and has a series of indentations made at intervals up the length of the column to provide the surfaces where liquid-vapour interchanges can take place. The indentations are made with a pointed graphite probe while the glass is softened in a flame. At each level (and there are 13 levels in a 600 mm column), eight indentations are made around the points of the compass, four of them at N,S,E and W being horizontal while in between another four indentations point down at a 45°

angle. These indentations, and there are $13 \times 8 = 104$ of them, take the place of the packing such as used in larger columns.

The purpose of the indentations is to provide a series of surfaces along the length of the smooth glass column where liquid/vapour interchanges can take place. An alternative to the indentations is to pack the column with a lot of loose particles where the same liquid/vapour interchanges can occur. You can see such packing in Fig. 4.

A column with packing.

A fractionating still with a packed column consists of a tall and narrow tube mounted above the boiler, this column being packed with pieces of glass, or ceramic, or metal with the following characteristics:

- a) The packing should be inert and not react in any way with the liquid being purified. Glass, ceramics and stainless steel are ideal in this regard.
- b) The individual elements of the packing should be small in order to provide a large surface area. They should also be of such a shape that they do not pack tightly together, thereby leaving plenty of free space for vapour to rise up against a descending flow of liquid.
- c) They should pack uniformly in order to avoid channelling.

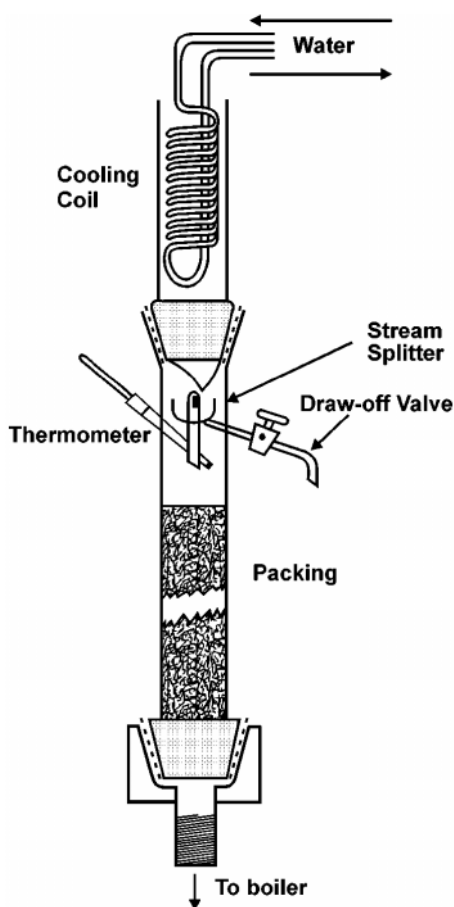
Procedures. So now we come to the procedures involved in fractional distillation, again illustrated with the Vigreux column. In a simple distillation, as with the pot still in Fig. 2, all the vapour rising out of the boiler is condensed and collected. In fractional distillation the condenser is at the highest point in the system, and not off to one side, so the condensed vapour (liquid) drops back down towards the boiler through a stream-splitter known as the “still-head”. The function of the still-head is to divide the condensed vapour into two separate streams, one of which is allowed to continue on down towards the boiler while the other is directed to the outside world via a sidearm and stopcock. In the column, therefore, rising vapour encounters falling liquid in a counter-current exchange. Here’s where the extra surfaces provided by the indentations in a Vigreux column, or the packing in a packed column, come into play.

The liquefied vapour dropping down from the condenser has had its latent heat removed by the cold surfaces in the condenser (that’s why it changed from vapour to liquid), and when this liquid cascades down the column, splashing from one set of glass indentations to the next set below, it meets a stream of vapour, still containing its latent heat, coming up. On each surface the vapour gives up its latent heat to the liquid, which immediately vapourizes. Having given up its latent heat the vapour condenses. So the liquid vaporizes and the vapour liquidizes (condenses). Each exchange between liquid and vapour on one of the tiny glass lobes is equivalent to a mini-pot-still distillation, the vapour becoming richer in the more volatile components of the mixture while the liquid becomes depleted in these volatile components. The vapour is carried up while the liquid falls down towards the boiler. At each interface down the column (the indentations in a Vigreux column) the exchange is repeated, so the rising vapour emerging from the boiler becomes richer and richer in volatile components as it goes up the

column while the falling liquid becomes richer and richer in the least volatile components. In a Vigreux column with 13 sets of indentations at various levels we have the equivalent of 13 re-distillations. As we shall see later, with a long enough column filled with an efficient packing material we can achieve the equivalent of hundreds of re-distillations.

The situation is exactly the same with a packed column where a packing material with a lot of surfaces is used instead of glass indentations in the column wall. The advantage of a packed column, of course, is that it is much easier to make and can have many more surfaces and crevices where liquid can collect. Our own design for such a column is illustrated in Fig. 5 below. We shall refer to this diagram several times in the coming pages because it illustrates the principles of fractional distillation rather clearly. Referring to this schematic you will see that vapour rising from the boiler is condensed by the cooling coil and drips back down into the receiving cup of the still-head. This cup has a bottom drain leading to the outside world and an

Figure 5. Schematic of a reflux still (not to scale)



overflow which comes into play when the drain is closed with a stopcock and the collection cup fills up. By suitable adjustment of the stopcock, therefore, the flow of liquid falling down through the packing towards the boiler can be adjusted from zero to 100%. With the stopcock closed all the condensed vapour returns to the boiler and this situation is referred to as “total reflux”. If the stopcock is cracked open a little so that, say, 10% of the total reflux flows out to the outside world, this situation is referred to as a reflux ratio of 10:1. The other 90% of reflux which is not drawn off flows back down the column to continue the mini-distillations and purification process on all the surfaces down the column. If we drew off all the reflux so that there was none left to flow back down the column, there would be no series of mini-distillations, no purification, and we’d have what amounts to a pot still.

It is tempting at this point to launch straight into a description of the carriage still, but before doing so a few words will be said about health and safety. Legal questions are dealt with in Appendix V. You will take more pleasure in building a still if you feel quite sure that you won’t be poisoning yourself, blowing yourself up, or being dragged off to the slammer.

HEALTH & SAFETY

The three major concerns of people who might be interested in setting up a still at home are 1) the question of legality, 2) the possibility of getting poisoned, specifically of going blind, and 3) the danger of blowing oneself up. These are serious concerns, and people take them very seriously. In Appendix V the legality question is dealt with at length, and if you haven't read it before we invite you to do so when you have a few minutes spare, but for the moment the emphasis will be on health and safety.

Poisoning oneself.

The belief that there is some inherent danger in distilling one's own spirits is widespread and is reinforced whenever the news media report that a number of people have been taken ill, or even died, as a result of drinking homemade spirits. People associate "homemade spirits" with distillation, with moon-shining, but in fact there is no danger whatsoever in drinking home distilled spirits, or even moonshine properly made. The danger lies in buying liquor from a bootlegger because in order to increase his profits he may top up his moonshine with rubbing alcohol (methanol), or stove oil, or antifreeze or paint remover or any other pungent liquid he can lay his hands on. Naturally such a cocktail is poisonous, but don't be misled into thinking that the toxicity is due to simple ignorance or lack of care on the part of the backwoods distiller. It's not. It's due to these gentlemen adulterating their booze and fobbing it off on an unsuspecting public.

Our recommendation is that you never buy moonshine made in an illegal and unsupervised still, possibly adulterated with unknown chemicals. Make your own if it's legal to do so, in which case there will be no danger whatsoever to your health. This is particularly true of fractional distillation, where you have removed ALL the impurities, but also for simple distillation where you have removed at least some of them. Your equipment will be made of glass, stainless steel or copper, and if made from copper the various parts will be joined with lead-free solder. It would be similar to a Scotch whisky distillery where copper stills have been used for centuries. As for dangers in the distilling operation itself, let us follow this through. Sugar is fermented to alcohol using bakers' yeast to make a crude "beer". No danger so far, right? The beer is boiled and the vapours collected. The first liquid to come over will contain some methanol, acetone and small amounts of other substances which were in the original beer, the so-called congeners. They smell like paint remover and will be discarded. Then comes the potable alcohol which has no smell and is collected for use. Finally there arrive the fusel oils with a somewhat unpleasant odour so they, too, are discarded. Remember, the distillation has not created anything, it has simply separated out the noxious substances from the beer --- the heads and tails --- allowing them to be discarded.

So, to poison oneself, it would be necessary to remove the congeners from the beer by distillation, pour the purified alcohol down the drain and then, ignoring the pungent smell and sickening taste, drink the paint remover. This is about as likely as plucking a chicken, throwing away the meat and eating the feathers. It strains credulity to put it mildly.

Headaches and hangovers

Headaches and hangovers are well-known consequences of over-indulgence in alcohol, but what is far less well known is that these unpleasant side-effects are largely due to the impurities, the congeners, and much less to the alcohol *per se*.

This interesting fact will be confirmed by many people who habitually drink gin or vodka rather than pot-distilled spirits such as rye, bourbon, scotch, rum or even wine and beer. More objective proof that the congeners and not the alcohol are the bad actors can be found in the scientific literature. Numerous studies have been made and all investigators find the same thing, i.e. that the symptoms of hangover --- headache, halitosis, gastric irritation, fatigue and dizziness --- were far more severe when the same amount of alcohol was consumed in the form of whisky than in the form of vodka. When you think about it, this is hardly surprising considering the poisonous nature of some congeners.

As an example of such studies, in one clinical investigation 33 men and 35 women were each given 2 ounces of either whisky or vodka on separate occasions. The incidence of after-effects in the group following a single drink of 2 ounces of whisky was halitosis 27%, gastric irritation 25%, headache 9%, dizziness 7% and fatigue 6%. These symptoms persisted during the following day. After the same amount of vodka, temporary headache and gastric irritation were observed in only 2% of the subjects while there were no complaints of halitosis, dizziness or fatigue in any of the cases. It should be noted that all the subjects in this trial were light social drinkers.

The effects described above were produced by a commercial whisky in which the congeners occurred to the extent of about 3%. As part of the study the congeners were separated from the whisky and given to the subjects in the absence of alcohol. The effect was the same as when the whisky itself was imbibed, proving that the congeners and not the alcohol were responsible for the adverse reactions. The chief culprit among the congeners was considered to be one of the fusel oils --- amyl alcohol --- and not methanol as might have been expected.

These results are not really definitive --- for one thing the size of the sample was rather small --- but even without such a trial it is not difficult to believe that drinking such things as methanol and fusel oils, even in small amounts, will be bad for you. If it were a different poison, e.g. arsenic, it would not be surprising if a 3% solution in alcohol, or even in water, gave you an upset tummy. 3% is not a trivial amount when one considers that nowadays the authorities are concerned about parts per billion of contaminants in foodstuffs.

One of the conclusions to be drawn from such studies is that whisky production should be handled carefully by amateurs. As mentioned in earlier sections, pot-distilled spirits involve the retention of some of the congeners in order to give taste to the whisky, but some of these taste-providing congeners are poisonous so don't overdo it. It would be wiser, perhaps, and certainly easier, to remove all the impurities by fractional distillation to give a pure alcohol and then add a flavouring agent. The physiological effect of an alcoholic drink, the 'buzz', is due solely to the alcohol, and everything else is merely moonlight and roses!

A final comment concerns the question of alcohol concentration in beverages. In beer the concentration is about 5%, in wine it is 8 to 13%, while in distilled spirits it is usually 40%. Only a moment's thought is required to appreciate that the concentration of alcohol in a drink is irrelevant, it is the amount consumed which is the determining factor in determining whether or not someone becomes inebriated. Drinking a bottle of beer is not less harmful than a 1½-oz. drink of 40% scotch just because it is weaker. They both contain identical amount of the same alcohol, i.e. 17 ml. Adding tonic water to a shot of gin dilutes it from 40% to maybe 6% but this has not rendered the gin less intoxicating --- the amount of alcohol has remained unchanged.

This is all so obvious that it may seem a little absurd to even mention it but, in most countries, the concept appears to be somewhat too difficult for the official mind to grasp. This is shown by the fact that governments put a much higher tax per unit of alcohol on distilled spirits than on beer and wine. The reason for doing this, it is claimed (somewhat piously) is to discourage people from drinking something which could be harmful to their health. A more likely reason is that they see it as an opportunity to increase tax revenue. If a government wished to base their tax grab on a rational argument they should start by basing it on alcohol amount (so much per unit of alcohol) instead of on alcohol concentration. And then, if health were the primary consideration as they claim, an additional tax would be levied based on the amount of poison (congener) present. Vodka would then attract the lowest tax of all and we would all live happily ever after!

A final note for environmentalists and watchdog groups on health matters: Is it not time to demand that governments require all manufacturers of alcoholic beverages to list the composition on the label? This would enable us to choose the ones with the lowest levels of toxic ingredients. They do it for food so why not for drink, particularly for drink which is *known* to contain several poisons.

Fire and explosions.

This may sound a bit melodramatic but when you are dealing with a procedure for the first time, and know that alcohol is inflammable, you may wonder. Let's take the explosion issue first. At no time, from beginning to end, is there any pressure in the equipment used for distillation. It is always open to the atmosphere. Fully open. Completely open. You will see that this is so when you look at the equipment diagrams later on and read the description of the procedures involved. So don't worry about it --- an explosion is impossible.

As far as fire is concerned you are dealing with an aqueous solution of alcohol which is non-inflammable right up to the time you collect the pure 96% alcohol dripping from the draw-off valve. This is inflammable, but most people will be using an electrically heated boiler so there is no open flame. Secondly, in the remote possibility that a fire occurred, alcohol fires can be instantly doused with water because alcohol and water are miscible. For this reason it is much safer than gasoline, and in the fuel alcohol industry this fact is always quoted as one of the benefits associated with ethanol when it is used alone as a fuel --- in Brazil for example.

THE CARRIAGE STILL

The evolution of the still

Having been involved in scientific research for many years we naturally started thinking in terms of conventional laboratory equipment when deciding to develop a still for amateur use, and the Vigreux column seemed straightforward enough to warrant consideration. However, it had two strikes against it. One was that it was too small to supply even a modest party with enough alcohol for a round of weak martinis, the other being that it was made of glass and therefore not something your average man-in-the-street could handle, including us. Scientific glassblowing needs a lot of special equipment and years of training. So we decided to use copper tubing and a propane torch. Over the years we produced a number of designs and they all worked splendidly, but there was something missing. We had developed several sturdy workhorses doing an excellent job whereas a beautiful, glossy, thoroughbred racehorse was more what we had in mind.

We had started with an offset arrangement of column and condenser made of 1 ¼" copper tubing which we whimsically referred to as the "Mexican Cactus" because it had a bent arm and looked rather like that well-known feature of the Mexican landscape --- the *seguaro*. It is described in the book "Making Gin & Vodka" (1) and has worked extremely well since 1993. It can still be highly recommended from a practical standpoint, even though aesthetically it probably leaves something to be desired. From the "Mexican Cactus" we progressed to the "Hatstand" or linear model, also shown in reference (1). Like the Mexican Cactus it was made of copper, but internally was different, the design being that shown in Fig. 5 on p. 10, --- a vertical tube with a cooling coil at the top, a still-head for splitting the condensate into two streams, and a column packed with stainless steel filaments.

It has worked perfectly, doing an excellent job of producing pure alcohol, and being made of copper can be easily constructed by any handyman with a few lengths of copper tubing and a propane torch. And it was (and is) very rugged. But it still suffers from the big disadvantage that you can't see inside it. Seeing inside is not really necessary, not necessary at all in fact, but it adds a lot to the pleasure derived from distilling if you can see something going on. Otherwise the still is simply an inert lump of uninteresting metal. Boring. But if you can see sparkling liquid dripping inside, the whole operation comes alive.

It was at this point that we experimented with glass and had the glass still shown in Fig. 4 made for us by a professional glassblower. And because of its appearance we enjoyed using it, and still do. This, surely, is what a hobby is all about --- the aesthetic and material pleasures which the hobby can bring to you. And also to your friends, who probably know little about distilling but will happily watch the alcohol dripping in your still as you explain to them the mysteries of reflux ratios, etc. And when you hand them a shot glass of your very own vodka they'll sip it appreciatively, happy in the knowledge that they've seen the purification process

with their own eyes. They trust the liquid dripping from a glass still much more than they would if it had simply appeared from inside a length of copper pipe.

When changing to glass our copper stills were not wasted. They were converted into research stills for studying the effect of different reflux ratios and different packings on the temperature profile within the column. This was accomplished by installing small ports up and down the length of the column through which the probe of a digital thermometer could be inserted to measure temperature.

The all-glass still we had made for us (Fig. 4) was a pleasure to use but for general amateur use it suffered from two disadvantages. The first was that it involved some fairly sophisticated glassblowing, so it's unlikely that any of us could make it for ourselves and it is not easy to find someone who can. Having found such a person you would find that he'd charge quite a few hundred dollars for it. Maybe it would be worth it. After all, we went to the trouble and expense so why not you? But then there's a second problem. Glass is somewhat fragile and you have to handle the still with kid gloves. Then, if you happen to break something, it's back to the glassblower for expensive and time-consuming repairs.

Which brings us to the carriage still. The goal we set for ourselves was that it should be a) state-of-the-art in performance, b) attractive in appearance, c) the inner workings of the still should be visible during distillation, and d) most of the work could be performed by a handyman in his workshop. The purpose of c), of course, was to give the hobbyist and his friends something to look at. Visibility requires glass tubing, and as we've said repeatedly, glass-fabrication is not something which the vast majority of hobbyists can handle. So we were presented with a dilemma. But we believe it can be solved quite effectively and cheaply by making it a joint project between you on the one hand and a professional scientific glassblower on the other. You'll be quite at home soldering copper tubing and making an attractive wooden cabinet while we'll supply the missing (but critical) glassware.

This will all be explained with the aid of diagrams and photographs a little later but we'll keep you in suspense a few moments longer by starting at the beginning of still construction and take everything in logical order, starting with the boiler.

The Carriage Still

The boiler

When it comes to amateur distilling there seems to be a burning desire on the part of the handyman to improvise a boiler out of some odd vessel which happens to be available, and no-one should be surprised to learn that everything from pressure cookers to beer kegs to milk churns to vacuum cleaner tanks have been adapted by ingenious do-it-yourself types for this purpose. However, we strongly recommend that you save yourselves a lot of time, trouble and expense by using an ordinary domestic hot water heater. In N. America these are available in all sizes from 9 litres up to several hundred litres, and are ideally suited for acting as the boiler in all amateur distillation systems. They are rugged, glass lined, already have an immersion heater installed, they are insulated, they have pipe fittings in all the right places, and are housed in attractive white-enamel steel housings. What more could you wish for? If you had drawn up the specifications yourself for the ideal boiler required for a still it would not be very different from a hot water heater. In N. America they cost around \$150 in all sizes up to 100 litres.

A few simple modifications to the hot water heater are required. Firstly, remove or bypass the thermostat. We need the contents of the boiler to boil, so a thermostat which switched off at a temperature of, say, 75° C. would obviously defeat our purpose. Removing the thermostat may seem dangerous, and it would be if we had a closed system, but the system is open to the atmosphere at all times so there can be no pressure build-up. It is just like a tea-kettle. For this reason you also can dispose of a pressure-relief valve if one is installed because the pressure inside the boiler is never above atmospheric.

The location of pipe fittings on water heaters vary from manufacturer to manufacturer, but whichever one you choose you'll find a fitting at the bottom (the cold water inlet) and several on or near the top. If you need another ¾" pipe fitting at the top, or if there isn't one on the model you have chosen, you may find one by removing the sheet metal cover and fiberglass insulation from the top of the housing. This is where in some models the magnesium rod used as an anti-corrosion device is installed. It can be removed because it is not essential in our application and the ¾-inch female pipe fitting may be useful to you for mounting the column.

The lower connection, the cold water inlet when the tank is used for domestic hot water production, will become the inlet for beer from the fermenter and also the drain for the exhausted beer (the stillage) after stripping. Fit this connection with a ¾" ball valve and screw into it an adapter for connecting a short length of rubber garden hose. Use a ball valve at the drain, and not an ordinary faucet, because the yeast in beer can form sticky lumps when boiled and there should be a wide opening for any yeast clumps to exit to drain.

As far as size is concerned, we recommend a 45 litre model, which is about 12 US gallons.

Power supply.

The packed column which will be mounted above the boiler (see later) has only a limited capacity to allow vapours to rise up through the packing against the downward flow of condensed liquid so the boil-up rate must not be too great or the column will choke (flood). The Carriage Still uses 1 ½-inch diameter copper tubing for the column, a size which may permit the use of a 1,500 watt heater. The higher the wattage the greater the rate of vapour production, but there is an upper limit due to a couple of factors. One is the ability of the column to carry the volume of vapour being generated, and this will depend upon its diameter and the volume of free space taken up by the packing. The second is the amount of cooling surface available for condensing the vapour back to liquid.

In N. America hot water heaters with a volume of 45 litres (12 US gallons) are available with either a 1,500 watt, 115 v. or a 3,000 watt, 230v. element. The former may be usable, although 1,500 watts is somewhat on the high side if you want to be absolutely sure that the column won't choke. What we recommend is that you buy a 3,000 watt, 230 v. model and use it on 115 volts. By using a 230 v. element on 115 v. you will cut the wattage to ¼, i.e. to 750. This is because you will have ½ the current and ½ the voltage, and since watts = volts x current we have ½ x ½ = ¼, and 3,000 x ¼ = 750. A 4,500 watt, 230 v. element (also available) used on 115 v. would give you 4,500 x ¼ = 1,125 watts. You'll be comfortable with either of these two lower wattages.

Incidentally, you do not need to measure either the temperature or the pressure in the boiler ---- the pressure is atmospheric and the temperature is the boiling point of beer, i.e. about the same as water, or 100° C. Another point is that, although the ¾" connection from the boiler constitutes a bottleneck, it has no bearing on possible choking in the column. All it may do is create a very slight pressure in the boiler.

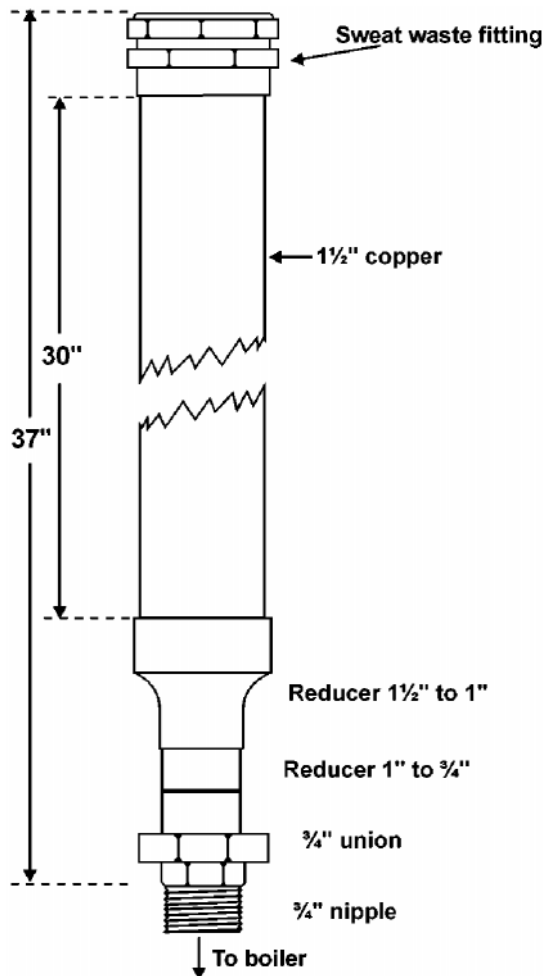
The column & stream-splitter

The column is made from copper tubing while the stream-splitter and condenser housing (which is where you can see something happening) is made of glass. If you have access to a glassblower then by all means have him make the stream-splitter for you, but if not then you can purchase it from us. The design is best described by reference to Figs. 5 and 6 and by the several photographs which follow.

The column.

The column consists of a 32" length of 1 ½" diameter copper tubing. It is connected to the boiler by means of a pair of reducers to bring the diameter down to ¾", and then a ¾" union to permit easy removal of the column from the boiler. At the top of the column a "sweat-waste" fitting is soldered on. These are the compression fittings used under a sink to connect the washbasin tailpipe to the drain plumbing. It so happens, by a delightful coincidence, that this is a perfect fit for the 38 mm o.d. glass tubing used for the still-head. It is also inexpensive.

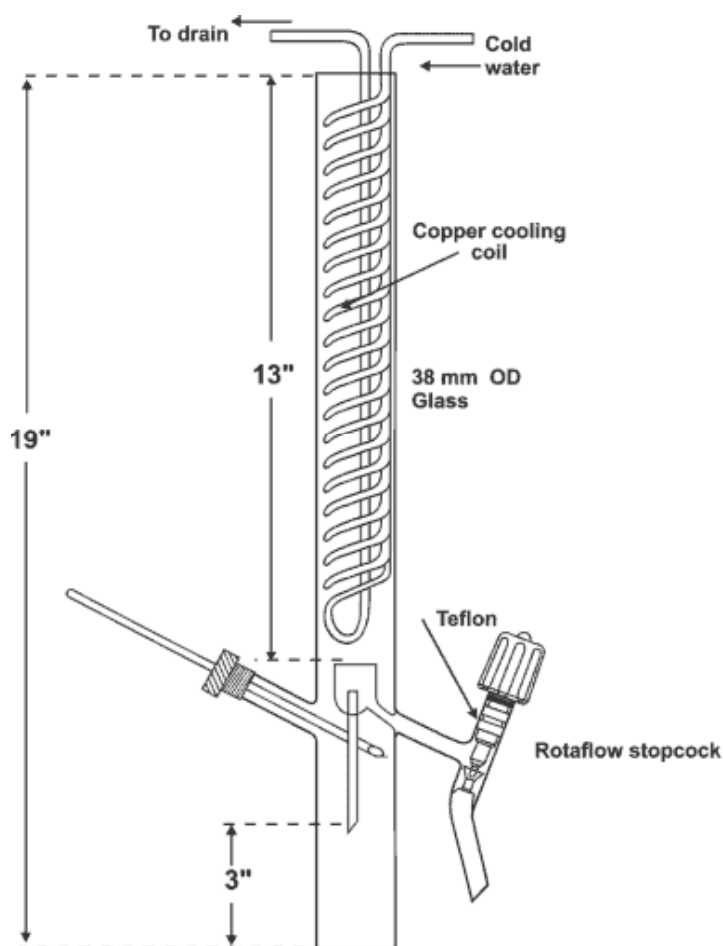
Figure 6. The column



The stream-splitter

This is the part fabricated by our glassblower and is the heart and soul of any fractionating still. It consists of a 19" length of 38 mm glass tubing. A collection cup is situated 3" to 6" from the bottom, this cup having a side-arm at the bottom leading to the outside world and a central overflow tube or "downcomer" to direct the overflow onto the top of the packing. The side-arm has a rotary glass/teflon needle-valve fused on to control the draw-off rate. This valve can control the flow from zero to 100%. A diagram of the still-head is shown in Fig. 7 and a photograph in Fig. 8.

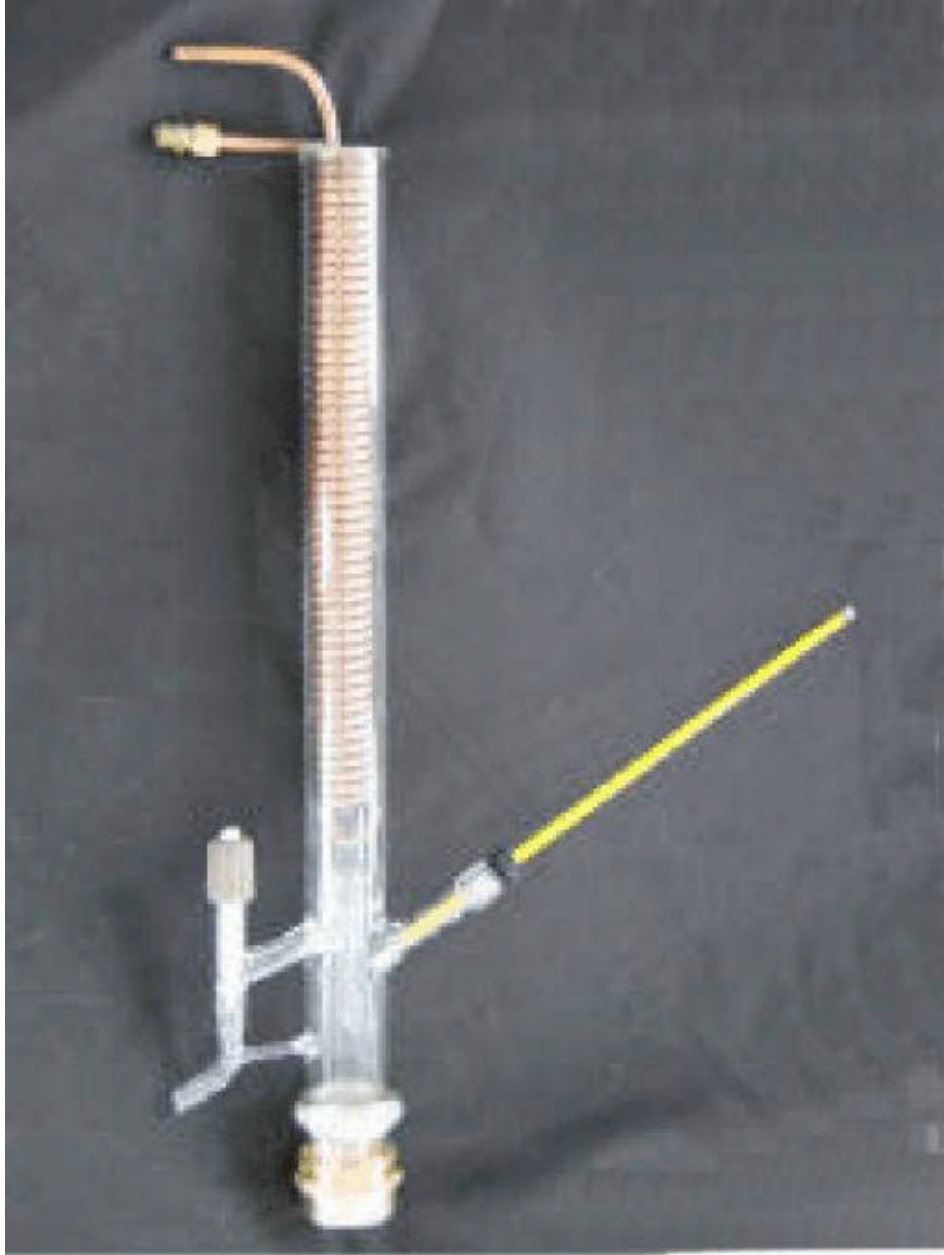
Figure 7. Glass still-head



The diagram is pretty-well self-explanatory. All the dimensions are given so you could take it to a glassblower and have him make one for you. Note that the tip of the downcomer is 3" above the bottom end of the still-head so that if you insert 2 1/2" into the top of the column you will be able to see the overflow liquid pouring from the tip onto the top of the packing.

Opposite the draw-off valve a thermometer port is provided for a mercury/glass thermometer sealed with an O-ring. It is offset so that the thermometer bulb misses the downcomer and measures vapour temperature rather than liquid condensate temperature.

Figure 8. Photograph of glass still-head



Note the ferule and screw cap for clamping the 38 mm glass tubing inside the top of the column. It acts like a standard compression fitting.

The cooling coil

This is made from about 13 feet of 3/16" copper tubing which fits inside the 38 mm glass tubing above the stream-splitter. The loop at the bottom should be arranged so that condensate falls into the collection cup (it doesn't matter if a little misses the cup as it will still find its way down to the packing). It helps the connection of a water line if you solder a short length of 1/4" copper tubing to the inlet and outlet ends of the coil. (See Fig. 9).

The alcoholic vapours rising from the boiler are condensed by means of cold water running through the copper coil inserted into the glass condenser housing sitting above the stream-splitter. To make this coil you will need about 13 ft of 3/16-inch tubing and wind it into a tight coil which will fit inside the glass. Use a length of 3/4" copper tubing as a mandrel and support it vertically by clamping in a vise. Stick one end of the 3/16" tubing up the inside of the 3/4" tube and wind the remainder around the outside. Such small diameter tubing is not usually found in plumbing supply stores but it is used in refrigeration and air-conditioning so you will be able to obtain it from an appropriate service outlet.

Figure 9. Cooling coil



The packing.

The packing inside a fractionating column is very important and many articles in the scientific literature are devoted exclusively to this topic. Everyone has his own ideas on what constitutes the ideal packing and the writer is no exception. Unlike scientific texts, however, cost is a consideration here provided performance is not compromised. As previously mentioned on p.9 what is needed are pieces of glass, ceramic or metal which are inert to the liquid being refluxed and which have the following characteristics (mentioned earlier but repeated here):

- a) they should not pack tightly and should be of such a shape that they leave plenty of free space for vapour to rise up against a descending flow of liquid;
- b) they should pack uniformly in order to avoid channeling, and
- c) they should have a large surface area and crevices where liquid can be trapped.

Scientific glass columns frequently use short, e.g. 6 mm lengths of 6 mm glass or ceramic tubing called Raschig rings. Ceramic saddles are another popular shape. Glass marbles might be used in large diameter columns but do not have sufficient surface area for a small diameter column such as ours. Also, unlike Raschig rings, they do not have any pockets where liquid can be trapped, so are rather inefficient.

The packing which we recommend has a very domestic origin but is cheap and highly effective. It consists of the scrubbers or scourers used for cleaning pots and pans and found in any supermarket. These are not the fine steel wool pads impregnated with soap but the much coarser scrubbers made from lathe turnings which usually come in a ball. They are available in copper, brass and stainless steel, and the best ones to choose are the stainless steel although the others would work very well. Several will be required for the column. Commercial packings using the same principle are available (at a price), and are very neat and uniform in surface distribution because the stainless steel filaments are woven into a blanket and the blanket is then rolled into a cylinder to exactly fit the inside of the column. Photographs of both types of packing (Raschig rings and s/s scrubbers) are shown in Figure 10.

Packing the column is relatively simple. Pull out the balls of tangled filaments into sausage shapes and cut each sausage into two or three equal parts. Carefully shove each into the column from the top end with a little, but not too much, compaction. Dipping them in dilute soap solution reduces friction and makes the job much easier. The soap can be rinsed out afterwards. Remember, your objective is to produce a uniform matrix of filaments across the diameter of the column and from top to bottom. This will reduce the chance of channeling and improve the efficiency of the column.

Comparison of Raschig rings and s/s filaments. There are those who swear by Raschig rings and tend to disparage s/s filaments for packing, so even though we have used s/s filaments successfully for many years we thought we'd make a comparison. We found the following: Raschig rings for this column would cost \$150 at a scientific supply house. The s/s filaments cost \$8 at a supermarket. The solid content of Raschig rings occupied 26% of the free space within the column whereas the filaments occupied only 2.2%. This means that there is far less danger of the column flooding when generating a lot of vapour by increasing the wattage input. Which in turn means you could increase production rate if you wished. The filaments also have a much

larger surface area and consequently are many times more efficient, so it's no wonder they are widely used in small commercial distillation systems.

Figure 10. Packing



Water supply

It is worth mentioning that there is considerable resistance to the flow of water through 4 metres of 3/16" tubing and you may find that friction alone will be insufficient to hold plastic tubing in place to connect the cooling coil to the household water supply. There is nothing worse than having the water line blow off in your absence and finding your workshop flooded when you return. So play it safe. The best solution to this problem is to use a length of 1/4" high-density polyethylene tubing such as employed for connecting a humidifier to the household water supply line. It is inexpensive, costing just 13 cents/ft in Canada. Use 1/4" compression fittings at each end, with tiny inserts to prevent the tube collapsing when you tighten the nut to compress the nylon ferule. It can easily withstand the full water pressure.

The drain from the cooling coil involves no pressure at all so any type of tubing will do.

Column support

A fractionating still is rather tall and needs a firm support, particularly one involving glass. You could build your still close to a wall and use brackets to support the column and the collection bottle. A far better method, however, although more expensive, is to make or purchase a kitchen cabinet 36" high, put the boiler in the cupboard and bring the column up through a hole in the counter-top(see Fig. 11). This hole either should be large enough to accommodate both the column and the insulating sleeve around it, or be just the size of the column with separate insulating sleeves above and below the counter-top. A 2 3/4" hole will accommodate both column and insulation. The purpose of the insulating sleeve is to maintain a steady temperature gradient from top to bottom, which is important. Use a spirit level to ensure that the column is vertical.

Not only does the tabletop support the column very firmly but it can also support the stand on which you place the collection bottle. Additionally, a table is useful for holding any instruments you may be using such as a digital thermometer read-out, and also for writing up your notes.

There are many refinements you can make to this set-up. For example, a set of built-in drawers is very useful and such an arrangement is shown in Figure 11. Then, if you put the whole thing on castors, with the boiler resting on the floor of the cupboard, you can wheel the still from one part of the room to another or even into a closet or another room.

Collection of alcohol.

The draw-off valve where the alcohol emerges from the still will be about 600 mm above the counter-top so there is plenty of room for collection bottles of various sizes. We use a length of 3/8" copper tubing from the draw-off valve to the receiving bottle so that the emerging alcohol, which is hot, is air-cooled as it runs down the metal tube into the bottle. By using a small clamp on this tube and resting it on the rim of the bottle, any height of bottle can be used.

So there's The Carriage Still in all its glory. In the next chapter we'll take a look at how to use it.



Figure 11. **The Carriage Still - Cabinet mounted**

PROCEDURES

The use of the carriage still will be illustrated by making vodka. Vodka was chosen for several reasons:

1. It is the least complicated of all alcoholic beverages, with no subjective judgements involved with regard to flavour. As defined by the Bureau of Alcohol, Tobacco & Firearms (BATF) in the United States, vodka is “a neutral spirit so distilled as to be without distinctive character, aroma, taste or color”. This means that the procedure involves nothing more nor less than the complete removal of all extraneous substances and all congeners to leave pure, unadulterated ethyl alcohol. This is very much simpler than the selective removal of some congeners but not others in order to leave a few which have a pleasant taste.
2. Ethyl alcohol is the common denominator in all alcoholic beverages. Speaking simplistically, they all----- from beer to wine to whiskey----- are nothing but flavoured alcohol. As we shall read later, the dozens (hundreds?) of different vodkas available nowadays all start life as pure 40% ethyl alcohol and then have their unique flavour added.

Production of pure alcohol (vodka).

Before alcohol can be purified in a still you have to make it. This is pretty obvious, particularly to you brewers and vintners who have been making beer and wine for years. The point we wish to make here is that you are not making beer or wine --- you are making alcohol. Since any and all flavours will be removed by distillation, you don't need to worry about whether this was a good year or a bad year for grapes, or the strain of yeast you use, or the temperature, or whether the sugar came from sugarcane, potatoes, corn, or milk (lactose). What we're looking for is the cheapest, fastest and least troublesome way to make alcohol. No need for airlocks, or nutrients, or special yeasts which ferment rapidly (unless you are keen to get the job over with or have a big party coming up). So this is a different operation to the one you are used to and you may be depressed by how crude it is. Cheer up! The fun comes later when you start distilling.

The fermenter. No doubt the beer- and wine-makers among you will wish to use the carboys (or whatever) you have used successfully up to now for the fermentation, and there's nothing wrong with that, but if you're starting from scratch we suggest that a cheap and effective alternative is to use a laundry-tub. It stands on 4 legs so is at a convenient height, holds about 50/60 litres of sugar solution, and has a convenient tailpipe underneath for transferring the beer to the still. Attach a 3/4" ball valve and hose bib to the tailpipe of the drain. Airlocks not being so vital one can simply cover the tub with a well-fitting sheet of plate-glass. For a fast, efficient fermentation a heater to maintain the temperature in the optimum 30° to 35° C. range is required, and an aquarium heater does a good job. A submersible aquarium pump works beautifully for circulating the liquid and is particularly helpful at the start when dissolving the sugar.

Procedure. We recommend using 10 kg sugar (ordinary supermarket table sugar) as carbohydrate source. It's cheap, pure and readily available. Close the ball valve on the drain line

and put a rubber stopper in the drain hole (if undissolved sugar gets in there it will never dissolve). Dump the sugar into the laundry tub, add 50 litres of cold water, put in a hydrometer, start the circulating pump, switch on the heater and slowly sprinkle 150 grams of dry, active, powdered baker's yeast (in Canada this costs \$4.50 per 450 g. so each fermentation costs you \$1.50) onto the top of the water. Keep the heat on until the temperature has risen to 30° to 35° C., the optimum temperature range for fast fermentation, and maintain it at this level for 5/6 days. The SG will drop from about 1.06 to about 0.99 and you'll have 50 litres of a crude 8% "beer". The reason for starting with cold water and adding the yeast before the sugar has dissolved is to prevent too vigorous a reaction at the start and foaming. Vacuum-packed baker's yeast is very satisfactory, but make very sure that it is fresh with a "use-by" date at least a year ahead. Refrigerate the unused portion.

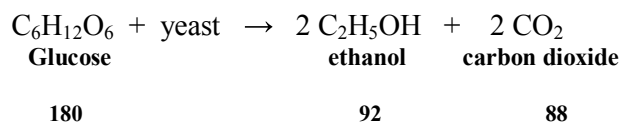
You can speed up the fermentation somewhat by adding a small amount of yeast nutrient such a Fermaid K but it will not, of course, give you more alcohol. It will give you the same amount of alcohol a bit faster. The same thing can be said about special yeasts which can use stronger sugar solutions (less water) and thereby get stronger alcohol solutions ---- no more alcohol is produced. The amount of alcohol you get is determined by the amount of sugar you've used and the amount of water you use is unimportant. After all, you will be going up to 96% alcohol when you distil so what does it matter whether you start with 5, 10 or 15% alcohol?

After the S.G. has dropped to about 0.99 stop the circulating pump, switch off the heater, remove the hydrometer, remove the rubber drain-stopper and substitute a 1/2-inch high dam made from 1 1/4" copper tubing. Let stand for a few hours (or even overnight) to allow most of the yeast to settle out on the bottom of the fermenter.. Connect a short length of rubber hose between the fermenter and the boiler. A washing machine hose with two female ends is ideal for this.

Concentration vs amount.

There is a very great deal of confusion in the minds of government officials about the difference between concentration and amount --- shown by the fact that they put a higher tax on spirits than on beer, even for the same amount of alcohol. The same confusion exists, unfortunately, in the minds of the general public.

The theoretical maximum yield of alcohol from sugar is based on the following equation:



180 grams of glucose will lead to 92 grams of ethanol using ordinary baker's yeast (provided it's fresh and used properly) and there's nothing you can do and no yeast you can use which will increase this yield. That's because the alcohol comes from the sugar, not from the yeast. Special yeasts may speed up the fermentation, reducing the time from, say, 5 days to 3, which could be important to some people, but they shouldn't expect to get more alcohol because they won't.

Distillation procedures

The purification of beer by distillation requires at least two stages if all traces of impurities are to be removed. The first stage is known as beer stripping and consists of a slightly less-than-perfect separation which removes most of the water, most of the impurities and all the yeast. The second stage continues and completes the purification process, and with less volume to handle and with fewer impurities it can be carried out a little more slowly and carefully.

The purer and simpler the mixture of chemicals associated with the alcohol the purer the final product, so the more rubbish one can get rid of during the first stage of beer stripping the better. An analogy would be cleaning up a room after a party: You first get rid of the dirty plates, bottles, napkins, etc., clearing the decks for action as it were, and then you get down to removing the lint from the carpet and the peanuts from behind the cushions. You may even have to go over it a third time if you want a really spotless room. It is significant that two or even three stages of distillation are always carried out in commercial distilleries.

The boil-up rate must not be greater than the column can handle. A packed column provides only a limited path for liquid to flow down against a rising stream of vapour so, if the boil-up rate is excessive, the column will choke with liquid and become ineffective. This is unlikely to be a problem with the 1¼-inch diameter column and the type of packing described in the equipment section, especially if the heat input is reduced to 750 watts by changing the immersion heater in the boiler as recommended. With a glass column choking is easily detected because liquid can be seen bubbling away in the packing, but with a metal column this is not possible. So listen. Choking or flooding may be detectable by a slight rumbling noise. The other method of detection is to look at the thermometer. Liquid rising from the boiler is much hotter than the vapour so, instead of registering 70+°C. the thermometer may register 80+°C. If this happens, switch off and try again. It is somewhat like a smoking chimney --- once the chimney has warmed up the smoke stops billowing into the room.

Note. If your boiler has a 3,000 watt, 230 v. heating element and you have handy access to 230 volts, e.g. a baseboard radiator, you can reduce the heating-up period four-fold by using 230 volts. Then, just before the beer comes to the boil, immediately switch to 115 volts and 750 watts. Which means you have to stick around! Don't walk away while the input is 3,000 watts or your column will choke --- it can't handle such a volume of vapour.

The first hour or so of distillation is spent equilibrating the column. This is the period during which the various components of the mixture sort themselves out with the more volatile components moving to the top of the column and the least volatile moving to the bottom. To understand why this takes time consider the following homely analogy. A long corridor is packed with people of different heights waiting to get through a door at the end in order to enter the store. The store manager announces that before he lets anyone in he wants everyone to sort themselves out by height, the short people at the front and the tall people at the rear, with a uniform height gradient between. There is a lot of shuffling about and it takes quite a while for a perfectly even gradient from shortest to tallest to be established. The same is true of a mixture of liquids of different B.P. in a packed column.

The progress of equilibration can be followed by watching the temperature of the vapour at the top of the column. Ethyl alcohol has a boiling point between 78 and 79 deg. C., the exact figure depending on the atmospheric pressure (see Appendix I), while the heads such as acetone and methanol have a lower B.P. The thermometer will register this and, although a temperature of 78°C. might be registered at first it may fall slightly as the acetone and methanol find their way to the head of the queue. Periodically crack open the valve in the stillhead a fraction to bleed off these heads into a spoon, sniff them, and if they have a bad smell discard them. Referring back to the analogy of people of different height shuffling about, if you let some of the shorter people through the door, even if the sorting out isn't quite complete, you will make it easier for the remainder to get organized. A suitable withdrawal rate would be 2 or 3 drops per second.

These heads not only have a strong smell but also a terrible taste so you can congratulate yourself that you're getting rid of them and not drinking them. They are highly inflammable and make an excellent fondue fuel or starter fluid for the barbecue. As the heads are bled off the temperature will rise slightly to 78+ deg. C. indicating that most of the heads have now been drawn off and ethyl alcohol is beginning to appear.

The alcohol-water azeotrope.

Water is an important constituent of the fermentation broth and with a boiling point of 100 deg. C. lies intermediate between the least and the most volatile components of the mixture. It has one important difference from the other components, however, in that it forms an azeotrope with ethanol. An azeotrope is a mixture of two liquids with a boiling point lower than either constituent. In the case of ethanol and water the azeotrope occurs at a mixture of about 96** percent ethanol (v/v) and 4 percent water. The boiling point of this azeotrope is 78.1° C. whereas the B.P. of 100% ethanol is 78.4 °C. As far as the system is concerned it "thinks" that this mixture of ethanol and water is a single liquid with the lower boiling point of 78.1° C. and proceeds to separate it on that basis. The ethanol which is purified by a fractionating column is not, therefore, pure 100 percent ethanol but pure 96 percent, the "impurity" being pure water. No amount of re-distillation under the conditions we are using will influence this percentage.

If it is absolutely essential to remove all the water, for example if it is to be mixed with gasoline to produce gasohol, then benzene can be added to break the azeotrope, followed by re-distillation. For our purposes, however, where we are going to dilute the alcohol with water to 40 percent anyway, the presence of 4 percent water is of no consequence.

Note: In the literature you will find slightly different values for the azeotrope composition, all hovering around 96% alcohol. One reason for this is that the percentage can be expressed either volumetrically (v/v) or by weight (w/w). Plus v/w and w/v! There is a difference because ethyl alcohol has a specific gravity of 0.8 compared to 1.0 for water. For example, 96% ethanol v/v works out to 95% w/w. If so inclined you may worry about this, but a more important question is --- should a good martini be shaken or stirred!

First stage --- beer stripping

We have about 50 litres of beer which need purifying and the boiler has a volume of 35-45 litres (10 to 12 US gallons). It is important not to put too much beer in the boiler because it

foams quite a lot and foam might enter the bottom of the column and be swept over into the collection bottle by the rush of vapour. About half full would be satisfactory, so we have to strip the beer in two separate 25 litre batches.

Proceed as follows: Run half your beer (about 25 litres) into the boiler, start the flow of cooling water, switch on the boiler and close the collection valve. With only 750 watts it will take a couple of hours to come to the boil, at which point it should be allowed to reflux for 30 minutes or so to allow the volatiles to rise to the top and the foam to break.

When you can no longer detect a pungent odour in the alcohol when you draw off a few drops into a teaspoon, put a collection bottle under the spout and open the draw-off valve to the point where you are operating at a reflux ratio of about 10:1. With 750 watts the boil-up rate will be about 45 ml/min so the draw-off rate should be about 4.5 ml/min. The vapour temperature in the still-head will be close to 78°C. You can try opening the draw-off valve a little in an attempt to speed up the process, but if the vapour temperature starts to rise you should close the valve slightly to bring the temperature back down again. The reason the temperature may rise when you start collecting faster is that insufficient condensate is running back down through the packing to give complete separation of the various components.

When the temperature starts to rise above 78°C. and there's nothing you can do to bring it back down again it means that all the ethyl alcohol has been stripped off and tails are beginning to rise up into the still-head. Switch off, allow to cool somewhat, and then send the contents of the boiler to drain. While the boiler is draining, it's not a bad idea to close the draw-off valve and direct your cooling water into the top of the still-head where it will run down through the packing and flush out the tails.

Add the second 25 litres of beer to the boiler and repeat the process. After the second batch is complete, allow cold water to run down through the packing into the boiler for a little extra time to dilute the stillage which is still sitting in the boiler below the drain valve. It contains a lot of impurities and you may as well get rid of most of them before the second stage of high-purity distillation. The total volume of "high wine" obtained in this first stage should be about 4 litres and the alcohol strength close to 90%.

You are now ready to proceed to stage-2, the high-purity distillation. Pour into the boiler the high wine produced by both beer strippings and add maybe 10 litres of water (approx.). There are two reasons for doing this: one is to ensure that the heating element is still covered with liquid at the end of distillation (it mustn't run dry), while the second is that a purer alcohol is obtained when distilling from a dilute alcohol solution than from a concentrated one. There's more water for the impurities to remain behind in.

Second stage ---fractional distillation

The procedure is almost identical to that during beer-stripping. The chief differences are that in the case of stage 2: i) total reflux is continued for a longer time (at least an hour) to obtain a more complete separation of the sheep from the goats; ii) the reflux ratio is never allowed to diminish from about 10:1; iii) the first 250 ml or so of product are put to one side for later re-distillation in case they contain traces of heads; and iv) towards the completion of distillation the

collection bottle is switched to a fresh one every now and then so that only the last one is contaminated by tails when the temperature starts to rise above 78°C.

You will appreciate that we use the figure 78°C. not to mean an exact figure to strive for but simply to indicate the steady temperature you achieve following equilibration.

Briefly then, proceed as follows: Operate under total reflux for a couple of hours to equilibrate the column, bleeding off the heads periodically into a spoon and sniffing them until there is very little smell and until the temperature remains constant at just over 78°C. Then start to collect the distillate at a 10:1 reflux ratio by gently opening the valve in the still-head.

It is not very convenient to set the collection valve each time you carry out a distillation by using the volume which flows out in one minute. It is too cumbersome. A better method is to laboriously find a valve-setting which does deliver 5 ml per minute and then count drops using a stopwatch. Thus, 10 ml per minute might represent, say, 30 drops in 10 seconds. Knowing this you can quickly adjust the collection valve to the right setting by counting drops with a stopwatch. A note of interest is that the size of a drop depends upon the radius of curvature of the surface from which it is dropping, so a thick spout will give you nice fat drops and a smaller number to count.

Collect at least 250 ml of this first distillate and put to one side for future processing and then start to collect the purest alcohol in a clean receiver. Throughout this early phase test the distillate with your nose to see if you can detect any trace of heads.

The 250 ml or so of early distillate which have been put aside may be perfectly pure but the nose and the palate are extremely sensitive organs, particularly the palate, (and particularly your wife's palate!), and she would quickly detect an off-flavour if it got through into her final drink. Even commercial producers, with a laboratory full of sophisticated analytical equipment such as gas chromatographs, rely on taste and odour panels to judge the quality of their product. It has the grand name of "organoleptic" testing and is the ultimate in testing for palatability. Play it safe, therefore, and put aside a generous portion of the initial distillate, even as much as 500 ml. It will not be wasted because, in a few weeks time, when a number of distillations have been completed and several litres of doubtful distillate accumulated, water can be added before redistilling and really pure alcohol recovered from it. It will amount to a triple distillation and be exceptionally pure.

When all the ethyl alcohol has distilled over, which may take as long as 10 hours, the temperature will start to rise as the higher boiling point "tails" appear. Experience will tell you when to expect this to happen and you should be present and start switching receivers well ahead of this point so that only a small volume of alcohol will be contaminated. The last receiver containing a trace of tails can be added to the discard bottle for later purification.

When the fractional distillation is complete the packing in the column will be flooded with tails. These should be washed from the column by pouring water down from the top.

When carrying out a fractional distillation for the first time the rate of production of pure alcohol may seem to be rather slow. At a few drops per second one can believe that it will take forever to produce a reasonable amount and there will be a tendency to open the collection valve

a little wider to increase the flow. Resist this temptation and be patient. The apparatus requires no attention and it is surprising how much alcohol is produced at a flow rate of 2 or 3 drops per second for several hours. Thus, with 750 watts input to the boiler and a draw-off rate of about 230 ml. per hour, about 3 litres of pure, 96% alcohol would be obtained in a 12 hr day (overnight?). This, when diluted to 40% with water, will provide over 7 1/2 litres of vodka.

Temperature measurement

A word must be said here about the accuracy of thermometers. A thermometer purchased from a scientific supply house should be accurate to 0.1 deg. C. but don't count on it. Thermometers purchased at a drugstore or a winemaker's supply store can be off by as much as 2 degrees. We recommend that you always check the accuracy of a thermometer by placing it in boiling water and recording the temperature. You also need to know the atmospheric pressure. You may be lucky and find you have purchased one which registers the correct value but if it doesn't, simply make a note of the deviation and apply the appropriate correction whenever you use it to read a temperature. Digital thermometers are useful in that they are much easier to read than the glass type, sit right in front of you on the bench and are accurate enough for our purposes, more accurate in many cases than the other sort.

Fortunately for us it is not necessary to rely on the exact temperature during a fractional distillation in order to indicate when the heads have finished coming over and it is safe to start collecting ethanol. For one thing, as we've said before, the temperature is influenced markedly by atmospheric pressure (see Appendix I). Constancy of temperature is the most important indicator. Thus, if the temperature has risen to just over 78 deg. C. and has stayed there for 15 minutes or so you can be fairly sure that all the heads are gone.

Yield of alcohol

The theoretical yield of pure, 100 percent alcohol from 10 kg of cane sugar is 6.25 litres. This is equivalent to 6.58 litres of 96 percent alcohol or 15.63 litres of 40 percent alcohol. While it is possible to approach such a yield, you will find in practice that you only reach 70-80% of this value due to various losses along the way. One place where you can expect losses to occur is in the fermentation process ----for example, you may not have left the brew long enough for all the sugar to have been completely used up. Or the yeast may have lost some of its activity. And then there are all those unwanted side reactions which produce the congeners such as methanol, fusel oils, etc., instead of ethanol. As a result, the practical yield of 96 percent alcohol is likely to be no better than about 5 litres which is a yield of 73% of the theoretical value. This is equivalent to 11½ litres of vodka or gin, which is not too bad coming from \$11-worth of sugar and \$1.50-worth of yeast.

In commercial practice such a low yield would not be tolerated, but for us it should be quite acceptable, particularly on economic grounds. Higher yields, which are certainly possible, offer an interesting challenge to the dedicated amateur.

Water quality

A word must be said about the quality of water used to dilute pure 96 percent alcohol to the 40 percent which is characteristic of most spirits. Unless the water is very soft, hardness will precipitate out when it is added to alcohol because the calcium and magnesium salts which constitute the hardness are less soluble in an alcohol-water mixture than they are in water alone. Depending upon the degree of hardness the effect will vary from a cloudiness to a white precipitate which falls to the bottom of the bottle.

The effect described above is perfectly harmless, the white precipitate being nothing more than the hardness present in the original water before the alcohol had been added. It is actually quite good for you. However, it is aesthetically unpleasing and should be avoided by using distilled or demineralized water obtainable very cheaply from supermarkets and from certain stores which make distilled water on the premises. If you have a water-softener in your house, or if your water is naturally soft, you'll have no problem. In that case simply use tap water.

Storage: Store your pure 96% alcohol in glass, not in plastic. A few 1½ litre wine bottles with screw caps are ideal. There is, of course, no need to "mature" vodka; it is ready for drinking the day you make it.

Alcoholic beverages

Up to now we have been dealing with the technology of distillation, and explaining just how to remove all the congeners, all the taste, all the character to leave a pure “unadulterated” ethyl alcohol. And this has been said proudly, as though taste or flavour was something to be ashamed of and shunned at all costs. So now it’s time to back off a little and talk about taste.

Vodka.

As mentioned previously, the BATF definition of vodka is “a neutral spirit so distilled as to be without distinctive character, aroma, taste or color”. Aleksander Orekhov, the Russian-born owner of Red, a Soho bar that offers some 40 different vodkas, makes no apology for saying that the best vodka is one that has no real flavour at all. When you have swallowed it, he says, “there should be no aftertaste”. We find the same thing. Our pure ethyl alcohol, diluted to vodka strength (40%), sure enough had no taste, just an astringent feeling on the tongue. Naturally, however, having no taste doesn’t mean that it’s completely innocuous --- it has the normal physiological effect on the human body, producing the “buzz” which is so characteristic of all alcoholic drinks.

There are many who will contest the above definition of vodka and the statement that a true vodka has no taste. Aficionados will point to the well-known differences between vodkas from Russia, Poland, Ukraine, Finland, N. America, or the differences between vodkas made from grain, potatoes, wine or milk (lactose). They have a point. European vodkas do have a slight taste whereas N. American vodkas have very little, but the explanation may be as follows:

A hundred years ago flavourless vodka was something of a novelty. The distillers of the day did not have the technical means or know-how to remove all the congeners, so the spirit tasted rough and fiery. To combat this they macerated fruit or herbs in the vodka or, in the Zubrovka brand, bison grass. Nowadays, with much better equipment available, it is easy to make pure and tasteless vodka, as we ourselves do, and add the flavouring afterwards. The modern method also extends the range of flavours greatly because there is no rank flavour to cover up and you can add whatever you like. So, although “true” vodka may have no flavour by BATF definition, in practice most of them do, but a purist would then say that, as a consequence, they properly should be referred to as “flavoured vodkas”.

Flavoured vodka.

When a distiller flavours his vodka he does it very lightly using certain grasses or herbs, so delicately that it can barely be detected, in which case the source of the flavouring is not mentioned. Or glycerine is added to give the vodka smoothness and body. The use of such additives is allowed to remain a subtle mystery in order to tempt the palates of vodka aficionados around the world and to give the advertising department something to work with.

Recently, however, much more strongly flavoured vodkas have been introduced into the market, and not just by newcomers but by venerable and highly respected Russian distillers such as Stolichnaya. They are now all the rage and flavours include everything you can think of ---- raspberry, strawberry, peach, vanilla, coffee, cinnamon and so on. For a first class pepper vodka place a number of small, dried, hot red peppers into the pure vodka you've made with the carriage still and wait for several weeks. Decant and enjoy. And remember, what you can do with red peppers you can do with dill, or coriander, or cardamom, or raspberries, etc., etc., etc. No-one pretends that these flavoured vodkas come from some special potato grown in a secret field in a remote part of Poland --- they are boldly proclaimed as "lemon vodka", "pepper vodka", etc.

Another, more traditional way to make a delicately flavoured vodka is to carry out a slightly "imperfect" fractional distillation so that trace amounts of the natural flavours in the original source of carbohydrate --- potatoes or grain --- are retained. This procedure will be discussed a bit later but is quite tricky because you're involved with subjective judgements as to which congeners to retain and which to discard. It is doubtful whether any commercial distiller uses this method nowadays.

Essences.

It may seem like a cop-out but you can buy essences with just about every flavour known to man or beast. Several companies make and sell these essences but two of the best known are the Noiro brand from France, and the Prestige brand from Sweden. You can get everything from lemon vodka to dark rum to various schnapps to whiskies. Many of them are excellent and you'd be hard-pressed to do better yourself. All you have to provide is the alcohol, and of course it should be a pure and tasteless alcohol so it won't impart any flavour of its own. Just the kick.

As an example of an essence you can make yourself, using natural ingredients and steam distillation, we include in Appendix IV the recipe for making a gin essence. By adding a few ml of this essence to vodka you will convert it to London Dry Gin. This could serve as a model for the production of other essences based on other botanicals. One of the big advantages of using essences with vodka is that the product never contains a trace of harmful congeners such as methanol and fusel oils. It will be pure alcohol plus pure flavouring.

Liqueurs.

There are many books available on making your own liqueurs, and usually the recipes involve two different procedures. One involves steeping the fruit in vodka to extract the flavor and then adding sugar. The other involves the use of a purchased essence, again with vodka as the alcoholic base. In both cases vodka is involved, and if you know how to make it yourself for \$1+ per litre (which you do) you're home to the races.

Chacun son goût

Is there such a thing as a "bad" taste or a "good" taste? Or should we talk about tastes we like and tastes we don't like? Not everyone likes the taste of curry whereas others dote on it. Are there any absolutes? Or are we being influenced by what people say, by the price, by the label, by the opinion of "experts", by the history and provenance? No-one set out to make a scotch

whisky or a rum or a schnapps such as found in liquor stores; they set out to make a strong drink using the primitive equipment they had at the time and gradually refined it over the years as a result of their own experience and feedback from customers. We now drink what we've been "taught" to drink. Some scotch whiskies are advertised as being made with water which has trickled over rocks a million years old, and the unpronounceable names given to single malts makes us certain that these must be very rare and beautiful whiskies indeed. We sip them slowly and appreciatively. Some vodkas are advertised as pure alcohol diluted to 40% with melted ice from glaciers tens of thousands of years old which originated in the high arctic.

We are not trying to be argumentative or cynical in making these comments. They are very relevant to anyone trying to emulate a commercial alcoholic beverage. Our advice to you is to do what everyone else has done over the centuries and play around with your equipment and raw materials, experiment until you produce something which pleases you. Your equipment and knowledge is far superior to anything your ancestors had available, and they managed to produce something palatable. Of course in those days they didn't have a lot of choice so were forced to make the best of it, and now, in the year 2003, their potions have become hallowed by tradition. Not knowing how to make vodka they made a rot-gut whiskey, worked on it, eventually learned to love it, gave it an exotic name and with a little help from the spin-doctors (advertising department), sold it.

Enough of these philosophical musings. Let's get down to cases. The carriage still was specifically designed to remove all traces of extraneous substances --- that is to say congeners or flavours (both good and bad) --- from the original beer, so obviously we have to back off a bit to let some of these flavours get through. That shouldn't be too difficult --- if we know how to eliminate congeners completely we ought to know how to retain a few of them.

A still for flavoured spirits.

To start with, Fig. 12 shows a commercial rum still taken from "The Alcohol Textbook" by Dr. John Murtagh (4).

There are many different types of rum still. Also brandy and whiskey stills, but this diagram illustrates a point we wish to make, i.e. that to retain flavour a pot still may be used but some reflux must be provided in order to reduce the amount and type of congeners distilling over. Note the small number of bubble-cap trays and the somewhat primitive reflux condenser system at the top which is nothing more than a tank of water. The vapours which manage to get past the reflux system are condensed in a coil immersed in a cold water tank.

Turning now to the carriage still, it is clear from everything written up to now that we have to modify the operation in some way if we want some of the congeners to get through. There are two ways to do this. One would be to remove some of the packing from the column, thereby reducing the number of liquid/vapour interchanges which take place during reflux in the column. It would be equivalent to the commercial rum still shown in Fig. 12.

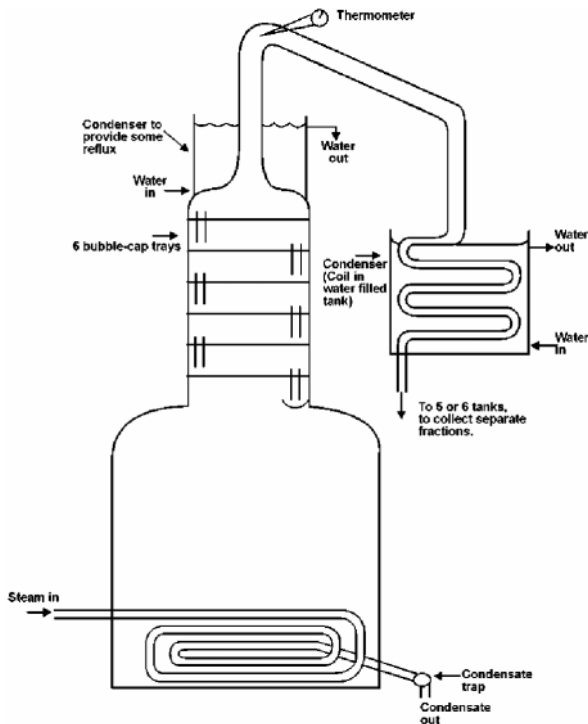
The second method would be to leave the packing intact but change the reflux ratio. You will remember that during high-purity reflux distillation for vodka we used a reflux ratio of 10:1, that is to say we returned 9 parts of the condensed vapour to the column while drawing off 1 part for use. If we changed the reflux ratio to, say, 10:5, we'd be drawing off 5 parts of condensate

for every 10 parts rising from the boiler. Obviously the separation of congeners in the column would be greatly impaired and the product would contain some of them --- and taste of them. It would be exactly like the conditions we used for beer stripping.

None of the above tells you precisely what reflux ratio to use. Nor does it tell you how much of the first material (the heads) distilling over you should discard. You'll have to indulge in that well-known scientific procedure known as "trial-and-error" or "suck-it-and-see". Collect the distillate in a dozen or more separate receiving bottles and sample each one by taste and smell. Probably the first bottles of distillate will contain acetone and methanol and should be discarded, and the same holds true for the tails --- you won't want to go on distilling and collecting the product when the really noxious, high B.P. material e.g. fusel oils, is coming over. But take your time assessing the various middle fractions and solicit the help of your friends in arriving at a consensus of what is palatable and what is not.

This is what is so unsatisfactory about making whiskey, in fact about making anything other than pure alcohol. There are no fixed points to aim for, no absolutes, no rules nor general principles. It is strictly a matter of opinion as to what is an acceptable beverage and what is paint remover. About the only generalization one could make is that the very first stuff to distil over, consisting of methanol, acetone and a few other very volatile and toxic compounds, probably should be discarded. But for all we know there are people who enjoy the taste of acetone. We have tasted some of the rot-gut whiskey made by amateurs, and attempted to repress a shudder of revulsion, but when it is suggested that the noxious liquid is "an acquired taste" we wonder why anyone should bother to acquire it.

Figure 12. Pot still with bubble-cap tray section



The flavour.

Where does the flavor come from? We've been talking about the retention of flavor but what is the source of this flavor? The source is the fruit, berries, vegetable or other plant material which you fermented. For corn whiskey you would start with corn. Brandy is made from wine, which of course is derived from grapes. Then there's tequila which comes from the agave cactus, and a whole range of schnapps are made where the starting point is plums, or pears, cherries (kirsch) or, indeed, any fruit you can think of. What a wealth of experimentation there is ahead of you! An old lady we knew in Switzerland had a lot of cherry trees and each year used to fill a large wooden barrel with them, put on the lid and leave them for a month. Occasionally we'd help her roll the barrel around and then heave it upright again. The cherries would ferment, using the wild yeasts present on their skins. Fermentation being an anaerobic reaction she made sure no air entered the barrel. At the end of the month she would filter the mash and distil it in a quite primitive pot still, a still having lots of surface on the upstream side of the contraption to get a little condensation of vapour and reflux. The clear liquid which dripped from her still is called kirsch and was not at all bad.

Comment.

The above discussion is very brief. Nowhere do we give the detailed information required to make a schnapps, an eau-de-vie, a liqueur, a rum, brandy or whiskey. The reason is that the preparation of a palatable beverage by distilling is very much a matter of trial-and-error. This is what it's all about. This is how it becomes a fascinating hobby and one of which you will never tire. Trial-and-error is the rule of the game.

Steeping

Perhaps the simplest method of flavouring alcohol is to make some vodka (40% alcohol) and steep something in it. Thus, you will find in most books on making your own liqueurs a number of recipes in which fruit such as raspberries, oranges, cherries, etc. is steeped in vodka for several months. At the end of this time a lot of the flavour in the fruit and some of the colour has passed out into the alcohol. Then a large quantity of sugar is added to give the sweetness and syrupy consistency characteristic of liqueurs. If you don't add the sugar you'll have a flavoured vodka, and the longer the steeping time the stronger the flavor. And the shorter the steeping time the more delicate the flavour.

AMATEUR DISTILLATION AND THE LAW

There is not much point in building a beautiful still if you're not allowed to use it, and the law in N. America is quite definite about this. Read about it, they say, but don't do it. However, in Canada at least, the penalties don't seem to be too severe. In a recent case (January 2001) a man who was caught not only making stills but selling them via the Internet was fined just \$575 or 10 days in jail. He chose jail on the grounds that, if Gandhi and Nelson Mandela were prepared to go to jail for their principles, then so was he.

In Appendix V, taken verbatim from the previous book in this series (3), the whole subject of legality is dealt with at some length, particularly analyzing why governments are so opposed to a simple purification procedure, using a perfectly legal substrate (beer) as the starting point. The case of New Zealand, which legalized amateur distillation in 1996, is cited frequently since it is obviously a model which N. America and Europe should study carefully. And emulate.

One of the most important reasons for prohibiting amateur distilling may be the perceived harm which such a move might cause commercial distilleries ---- with the attendant drop in sales and loss of government tax revenue. A potential loss of tax revenue brings governments officials out in hives.

If this is one of the reasons why the law remains in force today we would like to draw attention to the figures in the following table, derived from the Annual Statistical Report of the Association of Canadian Distillers. It gives the statistics for sales of alcoholic beverages in Canada from 1981 to 2000, breaking them down into beer, wine and spirits, and putting all the figures on the same basis of "litres of absolute alcohol", thereby making allowances for alcohol concentration.

Litres of Absolute (100%) Alcohol (LAA)

Year	Beer (000's LAA)	Wine (000's LAA)	Spirits (000's LAA)
1981	100,353	25,205	77,949
1985	103,672	29,516	67,447
1990	105,676	28,254	57,344
1995	100,752	26,700	45,286
2000	101,735	28,565	48,093

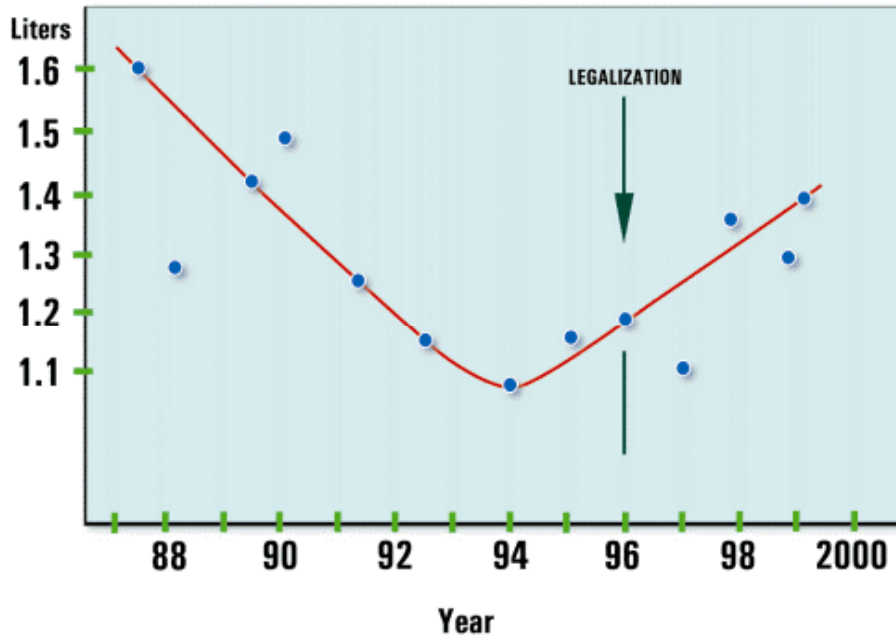
What this table shows is that while beer and wine sales have stayed fairly level, spirits sales have dropped dramatically. On a per capita basis spirits sales over the same period dropped from 4.46 to 2.06 LAA, much less than half. Such figures naturally give rise to great concern among distillers, and the thought of amateur production making further inroads into their sales produces what may be termed “a negative reaction”. This negative reaction is then passed on to governments, and we should remind ourselves that the distilling companies have lobby groups in Ottawa and Washington to make their case. It would be unfair to suggest that they may be tempted to contribute to party funds.

So we invite commercial distillers in Canada to consider this point. Beer and wine sales have not been affected during a period when amateurs have been making lots of beer and wine. Litres of it. Gallons of it. During the same period spirit sales have dropped while amateurs have not been allowed to distil a single drop. How do we explain this? Could the explanation be that the home production of an alcoholic beverage increases interest in that beverage? Increases, not decreases. There are all kinds of magazines available on beer- and wine-making, stores where you can buy the ingredients, bottles, corks, labels, etc. for the home brewer and home vintner, discussion groups on the Internet where enthusiasts discuss their likes and dislikes, home-brew shops, brew clubs, wine-tasting gatherings, and so on. It's a fun hobby and particularly appeals to the young and the young at heart. By contrast, spirits remain a cold, distant, commercial product, completely divorced from the interests and activities of fun-loving youth. They aren't involved. They're not part of the action.

This situation is changing rapidly in New Zealand where amateur distilling has been legal since 1996. It is now a hobby, with all the interest, discussions and get-togethers which any hobby generates. There is considerable activity on the Internet as people discuss the merits of one type of equipment compared to another, an improved procedure someone has discovered, the differences between different types of yeast, the substrates required for various whiskies, rums, brandies, schnapps, etc. The figures for spirits consumption in New Zealand are quite revealing and are plotted in Figure 13. There are a couple of anomalous years but the trend seems very clear ---- consumption was dropping prior to the legislation which allowed amateurs to distil spirits for their own use (1996) but was steadily rising thereafter.

Just allow N. Americans to embark on a voyage of discovery into the uncharted waters of amateur distilling and you'd find there'd be an upsurge of interest in the whole subject of spirits. The big question, of course, is whether such amateur production would cut into commercial sales? It didn't in New Zealand. It had the opposite effect. And the more likely result would be that a hobbyist who had tried to make corn whiskey would go out and buy himself a commercial bottle to see how successful he'd been. He'd become interested in the difference between a scotch, a rye and a bourbon. Between a Cognac and an Armagnac. Between a single malt and a blended whiskey. Between a Russian vodka and one made in N. America. It is likely to stimulate sales, not reduce them.

Figure 13 New Zealand –Per capita spirits consumption



When dealing with the sale of a consumer product it is necessary to take into account human psychology, and the influences around him which affect his choice. For example, what decides a man to order bottled tap water from France when he takes his girl friend to a restaurant?

If this hypothesis has any merit then it is important to draw it to the attention of commercial distillers. We fully intend to do this. If they then subscribe to the hypothesis that amateur involvement in making an alcoholic beverage may actually increase interest in that beverage you can be sure that they'll beat a hasty path to the government's door and suggest that they should change the law toot sweet.

COSTS

The costs shown below (which are approximate) apply to Canada in the year 2002 and are in Canadian dollars with no tax added.

Cabinet (vanity), 36" wide with 2 doors and 2 drawers	\$140
Countertop, 36" wide	\$87
Boiler (50 litre hot water heater)	\$150
Column. 1 1/2" copper tubing 36" long	\$15
Brass and copper fittings for column	\$20
Glass stillhead, materials & labour	\$200
Stainless steel packing	\$9
Column insulation	\$3
Cooling coil, 16' of 3/16" copper tubing	\$20
Cooling water connection (humidifier kit)	\$12
Thermometer	\$10
Ball valves (3/4") for boiler, 2 x \$6	\$12
Replacement element for boiler (if needed)	<u>\$12</u>
Total: Cabinet mounted:	\$690
Wall mounted:	\$463

Most of the above costs are unavoidable, but it is possible to eliminate the cabinet and countertop and thereby bring the total cost below \$500 (Cdn). The glass stillhead, the really critical item, can be obtained from us. To order, contact John Stone at: pegasus@gin-vodka.com

FUTURE DEVELOPMENTS

In this book we have described the principles which must be followed in designing a reflux still and have shown several examples ---- from a small laboratory glass still using a Vigreux column to the much larger carriage still suitable for the home production of spirits. Undoubtedly you will wish to develop your own ideas, and there is plenty of room for improvement, so to start the ball rolling we'll discuss a few possibilities below.

The boiler.

A commercial hot water heater is difficult to beat for price, appearance and convenience, but a wish-list would include the following:

- a). A dish-shaped bottom with a drain outlet in the centre so that the boiler could be completely drained of its contents after a distillation run. As it stands at present it is necessary to tilt the boiler to empty it completely, or flush with a lot of water to avoid stale stillage sitting in the bottom.
- b). An access port on the top large enough to accept a basket or muslin bag containing plant material. This would enable the boiler to be used for the steam distillation of botanicals and production of essential oils.
- c). Two heating elements, each of 1,500 watts. A simple switching system would then provide 750, 1,500 and 3,000 watts. This would be much cheaper than a variable transformer and provide the wattage control desirable for rapid start-up heating followed by the more gentle distillation.

Automatic switch-off

The procedures described in this book and previous books in the series require the distiller to be present at the end of a run in order to switch off manually. It would be much more convenient if the end of a run could be detected with a sensor and the boiler (and perhaps also the cooling water) switched off automatically.

During the first stage of beer stripping such an automatic cut-off would be comparatively simple to arrange because there is no sharp end-point, and if the boiler is left on a few minutes longer than necessary no harm is done. But in the second stage it is necessary to switch off before the end-point or the product will be contaminated with tails. To avoid this we have suggested switching receivers towards the end so that only the last receiver is contaminated.

For the beer stripping stage a simple bimetallic cut-off similar to those used in electric kettles could be installed at the top of the column. When the vapour temperature reached the set-point, e.g. 98 °C., the apparatus would switch off. It would, however, be useful to be able to vary this set-point by a few degrees because, with the different reflux ratios you may select, the temperature where beer stripping has reached the point of diminishing returns will change somewhat.

For the second stage of high-purity distillation the vapour temperature remains constant right up to the point where tails begin to appear, so to avoid having tails contaminate the product it would be necessary to place the sensor below the top of the packing in the column. In this way the sensor would detect the change of composition from pure 96% ethyl alcohol to tails ahead of time and in sufficient time to terminate the distillation. The sensor would need to be very sensitive, however, detecting changes as little as 0.1°C. if it were to do its job properly. Also, because the boiling point of ethanol varies with atmospheric pressure, it would be necessary to be able to adjust the set-point to the B.P. of the ethanol azeotrope on that particular day. Otherwise, if a cold front moved across your region, you'd have a problem.

No attempt will be made to suggest the type of instrumentation you would need for the above. We leave that to you electronic whiz-kids.

Cooling

There are a couple of disadvantages to the use of tap water for condensing alcohol vapour in the still-head. One is that you use a lot of water and the other is that you need a drain. This makes it difficult to locate your still in the garden shed or in your bedroom.

Another cooling medium, always in plentiful supply, is air. This is how we drain off the considerable heat generated by an automobile engine so there's no reason why we shouldn't use the same principle for our still. All we need is a radiator, a fan, and a pump circulating water through the cooling coil in the still. We are currently working on this.

References

1. Making Gin & Vodka ---- *A Professional Guide for Amateur Distillers*. by John Stone. Published by Saguenay International, Canada, May 1997
2. *ibid.* Reprinted with revisions. January 1999, February 2001 and September 2002
3. The Distillation of Alcohol ---- *A Professional Guide for Amateur Distillers*. by John Stone & Michael Nixon. Published by Saguenay International, New Zealand, February 2000.
4. The Alcohol Textbook. Chapter 15 – Rum Production. by J.E. Murtagh . Published by Nottingham University Press, 1995
5. Making Pure Corn Whiskey ---- *A Professional Guide for Amateur & Micro Distillers*: By Ian Smiley,

Appendix I

Effect of atmospheric pressure on boiling points

The boiling points of liquids quoted in reference books refer to the values measured at a standard atmospheric pressure of 760 mm mercury. As we all know, atmospheric pressure changes, varying considerably from day-to-day as weather patterns change and cold or warm fronts cross the region. Atmospheric pressure also changes with elevation. Not everyone lives at sea level under a stable air pressure of 760 mm Hg so the following table will allow you to interpret any temperature readings you might get in terms of ambient atmospheric conditions.

psi	mm Hg	Pressure			Elevation Feet	Boiling point	
		inches Hg	kPa	millibars		Ethanol °C.	Water °C
16.5	853	33.6	113.7	1137	- 3280	81.5	103.3
15.6	806	31.8	107.5	1075	- 1640	79.9	101.7
14.7	760	29.9	101.3	1013	Sea level	78.4	100.0
13.9	716	28.2	95.4	954	1640	77.0	98.3
13.0	674	26.5	89.8	898	3281	75.6	96.7
12.3	634	25.0	84.5	845	4921	74.2	95.0

Not too many of us live below sea level but quite a few must live at elevations of several thousand feet, and it will be seen from the above table that the effect on the boiling point of ethanol is far from trivial. The same holds true of changes in atmospheric pressure at a fixed elevation, due in this case to the movement of air masses.

You will recall from the discussion of temperature changes during fractional distillation that, after the column has reached equilibrium, the heads are bled off until the temperature remains constant, indicating that pure ethanol is now distilling over. Clearly, to avoid being misled, it is useful to have some idea of what the boiling point of pure ethanol is on that particular day. The table will help in this regard.

Appendix II

Latent heat of vaporization

In order to know how much pure alcohol can be produced per minute or per hour by a 750 watt immersion heater we first need to know the rate at which the alcohol in the boiler is being vaporized and condensed in the stillhead, i.e. the boil-up rate. When we know this volume we take 10 percent of it. That is the amount we can draw off and put into our martinis.

As discussed in the text, there are two methods of determining the rate of vaporization from the boiler --- by direct measurement and by calculation. The calculation method is outlined below.

The rate at which liquid is vaporized is dependent upon two quantities; a) the energy input to the boiler, and b) the latent heat of vaporization of the liquid in the boiler (LHV). The LHV is the amount of energy required to convert a boiling liquid into vapour at the same temperature, and it is a surprisingly large quantity. The reason why energy is required to convert a boiling liquid into vapour without any rise in temperature is that molecules in a liquid are much more closely packed than in a vapour, and to convert one into the other the molecules must be wrenched away from the clutches of their fellows and push against the atmosphere. It takes energy to do this.

The energy required to vaporize water, i.e. the latent heat of vaporization (LHV), is 540 calories per gram. For ethyl alcohol the energy required is 220 calories per gram, the lower value being a reflection of its greater volatility. The composition we are involved with is 95% alcohol w/w. Simple arithmetic gives 236 calories per gram for the LHV of the 95% w/w alcohol azeotrope.

Why, you might ask, are we concerned with the energy required to vaporize 95% alcohol when we know very well that the contents of the boiler are mostly water and this water is being vaporized along with the alcohol? The explanation is this: 95% of the water vapour going up the column, carrying with it its latent heat of vaporization, is condensed in the column by the descending flow of liquid from the stillhead. The 5% water which does get through only does so because it is associated with ethyl alcohol in the azeotrope. When the 95% water condenses in the column it gives up its energy, this energy being known as the latent heat of condensation (LHC). It has the same value as the latent heat of vaporization. Therefore, the only energy escaping into the stillhead is the latent heat contained in the 95% alcohol and the 5% water. That's all there is in the stillhead and all that is being condensed by the cooling coil. Most of the water never gets there.

It is known that 860,000 calories/hour = 1 kilowatt. Therefore 860 calories/hour = one watt and 236 calories/hour = 0.27 watt

What this means is that 0.27 watts of electric power are required to vaporize 1 gram of a 95% alcohol/water mixture in one hour, so 750 watts would vaporize 2,778 g/hr. or 46 g/minute. Ethanol having a S.G. of 0.8 the volumetric figure for the total reflux rate is 58 ml/minute.

When we measured the rate of reflux at total reflux with 750 watts input to the boiler we found a value of 45 ml per minute. This is less than the calculated value of 58 ml per minute because of heat loss due to imperfect insulation. This loss is equivalent to 168 watts.

If you cannot or do not wish to measure the rate of reflux yourself, you could use our figure of 46 ml. The insulation used for your boiler and column may be better or worse than ours, but is unlikely to differ very much, so you'd be pretty safe to use this figure of 46 ml. This would mean that you could draw off 10% of this, or 4.5 ml per minute, as usable alcohol. This is particularly true since the reflux ratio of 10:1 is not critical anyway.

A footnote to this discussion is that the rate of reflux does not change during the course of a distillation, even though alcohol is steadily leaving the boiler and changing the composition and the boiling point of the liquid in the boiler. The composition of alcohol vapour in the stillhead remains constant from the time the heads are finished until the arrival of the tails, and that's all that matters; the composition of the liquid in the boiler is irrelevant.

Appendix III

Cooling water requirements

A number of people have expressed concern about the volume of cooling water required to condense the vapour from a 750 watt heater operating over many hours. It is not all that great, but if water is scarce or expensive where you live you will be interested in the following calculations.

The calculations cannot be exact because there are many imponderables. For example, the temperature of the cooling water, the permitted rise of cooling water temperature, the desired drop in the temperature of condensed alcohol, the rate of heat transfer between the cooling water and the alcohol (affected by thermal conductivity of coil material, e.g. copper, stainless steel, glass, and the thickness of the coil walls), so please read the following with these things in mind.

We are going to assume the following: The cooling water enters the coil at 10° C. and leaves it at 30° C., a 20° rise in temperature. By increasing the flow of cooling water you could decrease this rise in temperature, and by accepting a greater temperature rise you could reduce the flow of water. We also assume that the alcohol vapour is condensed in the stillhead and, following condensation, is cooled from 78.1° C. to 68.1° C., a drop of 10° C., before withdrawal.

The cooling water in the stillhead is condensing 45 g/min of a 95% w/w alcohol-water mixture (see Appendix II). The latent heat of this mixture is such that 10,620 calories per minute of energy must be drained off by the cooling water. The latent heat of vaporization of the cooling water is not involved, only its sensible heat, and this is 1 calorie per gram per degree C., the specific heat of water. So, just to condense the vapour without changing its temperature we require 10,620 grams of water per degree C. per minute. Let's call it 10 litres. The collection of alcohol from a particular run will occupy (let's say) 20 hours. So the number of litres of cooling water would be $10 \times 60 \times 20$ litre = 12,000 litres. This is just to condense the alcohol, not cool it. If we decrease cooling water flow so that its temperature rises, not by 1° C. but by 20° C. then the volume of water would be reduced to $12,000 \div 20 = 600$ litres. A large drop.

You might wonder why the still-head doesn't cool the alcohol to room temperature. It is a matter of experience that, using the type of stillhead with cooling coil described in this book the alcohol vapour condenses on the lower turns of the coil, turns into liquid, and immediately drops off, avoiding further cooling. It is so hot, in fact, that some people suggest cooling it further by having the condensed liquid flow through a secondary heat exchanger before dropping into the collection bottle. Otherwise, they say, a lot of alcohol will be lost by evaporation. There is some truth in this but we have found it sufficient to draw off the hot alcohol and let it fall through a copper tube before entering the collection bottle. In effect, this is an air-cooled condenser.

We have calculated that 600 litres of cooling water are required just to condense the vapour. Now let us assume that the condensed liquid, before dropping off the bottom turns of

the cooling coil, is further reduced in temperature by 10° C., i.e. from 78.1° C. to 68.1° C. This will require additional cooling water as follows:

We are concerned here with, not latent heat of condensation but the specific heat of alcohol. This varies a bit with temperature but is about 0.6 calories per gram per degree C. So the number of calories to be withdrawn for a 10° C. drop in temperature is:

$10 \times 0.6 \times 45$ grams per minute = 270 g/min or 324 litres of cooling water over a 20 hour distillation period.

Therefore, $600 + 324 = 924$ litres of cooling water are required *in toto*. To this, of course, must be added the water consumed while the column is being equilibrated. And then there's the water consumed during beer stripping. Whether or not you consider this a lot of water depends on your particular circumstances. If you feel it is a lot then you might wish to experiment with air cooling by circulating the cooling water through a car radiator and blowing air through it. This would also avoid the need for a drain. We discuss this in the chapter on future developments.

Appendix IV

Preparing a Gin Essence

In the book “Making Gin & Vodka” (2) there is a description of the little pot still used for steam-distilling various botanicals to give a pungent essence which, when added to vodka, converts it into gin. A recipe for the type and amount of each botanical is given, but the following recipe, while similar, may be a little better.

905 ml / 285 grams.....juniper berries
15 seeds..... white cardamom
1 ¼ tsp..... orris root
1 ¼ tsp ground coriander
lemon peel.....1/4 lemon. Just the yellow zest
2 ¼ litres of pure water

Crush the juniper berries in a blender.

Split the cardamom seeds open and discard the shells, only using the insides.

Carefully carve the yellow zest from ¼ lemon, meticulously avoiding the white pith. This pith will impart a bad flavour.

Place all ingredients in a 5 litre flask of the botanical still (see Fig. 2 in the present book for the type of still to use) and bring to the boil. When it comes to the boil, switch off and swirl, letting it steep for 45 minutes.

Swirl and bring to the boil again, reducing heat to simmer

Collect the first 375 ml of distillate and place in a bottle marked #1

Collect the second 375 ml and place in a bottle marked #2.

Switch off. Distillation complete. Add 375 ml of 96% ethyl alcohol to each bottle. This will dissolve the oily drops in the bottle (the essential oils) and also act as a preservative.

Notes.

It is best if the juniper berries are fairly fresh. They may sit around in a health-food store for years and lose much of their flavour. Buy them when the store has just stocked up.

To make the gin, add 15 ml of the essence in bottle #1 to 1 litre of 40% alcohol (vodka). With bottle #2 you'll need 20 ml of essence to provide the same degree of flavour. Quality-wise there's not much to choose between them.

Between bottles #1 and #2 there's enough essence to flavour about 45 litres of gin.

Appendix V

The Question of Legality

This chapter is written specifically for those readers who live in countries where it is currently illegal for amateurs to make their own home-made spirits. This means almost all of us. It is also written for government officials, politicians, law enforcement agencies, the news media and any advocacy groups with an influence on public policy.

The conflict between governments and moonshiners has been going on for centuries and the reasons are not hard to find. From the government point of view alcohol in one form or another is in such demand that it can be heavily taxed without fear of killing the goose that lays the golden egg. From the moonshiner's or smuggler's point of view the spread between the cost of manufacture of alcohol and cost to the consumer after tax is so great that the incentive to circumvent the law is considerable. This incentive grows greater and greater with each tax hike until a point is reached where people are driven by taxation policy to smuggle liquor or make their own, the net result being that tax revenues actually decrease while crime is encouraged.

The dollar figures involved are informative. When alcohol is made on a large scale, as it is for the fuel-alcohol industry (gasohol) its cost of manufacture is about 25 cents per litre. This is for 100% alcohol. If diluted to the 40% commonly used for vodka, gin and other distilled spirits a litre would contain about 10 cents (U.S.) worth of alcohol. The retail price of a litre of vodka will lie somewhere between \$10 and \$20 depending on the country and level of taxation. The mark-up is enormous. To be fair, some of the difference is due to the scale of manufacture, the purity of the product, transportation, the profit margin, etc., but even allowing for these factors the tax burden on the consumer is extremely high. In an attempt to justify their actions and to persuade consumers to accept them, governments promote the idea that drinking is not only sinful but harmful to your health, so (they say) the tax is made deliberately high in order to protect you! As Scrooge would say, "Bah, humbug"

In light of the above, is it any wonder that an unscrupulous operator will attempt to sell his alcohol direct to the consumer, perhaps at half the normal retail price which would still give him a very handsome profit? Or is it any wonder that the authorities crack down hard on anyone attempting to interfere with their huge source of revenue, their milch cow?

This battle between the law enforcement agencies (the good guys) and the smugglers and bootleggers (the bad guys) has been a perfect subject for stories and movies, and one which turned into real life drama during Prohibition in the United States in the 1920's. Police and gangsters fought it out with bullets, bombs and bloody mayhem, one gang slaughtering another to gain control of the market, and while all this was going on the law-abiding citizens of the world sat on the sidelines, took it all to heart and shivered in their shoes. The average person is now convinced that the production of spirits is inherently evil, something to be tightly controlled by the authorities or blood will run in the streets.

Beer and wine do not suffer from such a bad press. Being of a philosophical turn of mind the author has speculated on the underlying reasons for this. One reason may be that beer and wine-making are traditional activities and therefore hallowed by tradition. It is an activity which poets and shepherds and decent country folk might engage in as they play their flutes and dance around the Maypole. Distilling, by contrast, invokes an image of unholy forces at work --- alchemists and necromancers. Or the satanic mills of industry and the callous face of science.

A more prosaic reason based on dollars and cents is that it would be uneconomical for smugglers and bootleggers to transport a lot of water. So they concentrate the alcohol by distilling it and thereby reduce the weight and volume 8-fold. In this way much more can be loaded into a ship or truck.

Unfortunately, the “wickedness” of home distilling is now so ingrained in the social psyche that this alone is enough deterrent to make many law-abiding citizens not only refuse to engage in it but even to discuss it. We have experienced this revulsion personally. Thus, it has become self-policing.

Amateur distillation.

It is understandable why a government would wish to put a stop to smuggling and moonshining for commercial purposes, that is to say in order to sell the product and avoid the payment of taxes, but why would there be a complete ban on distillation by amateurs, on a small scale and for their own use? And why, commercially, should a distilled spirit attract a higher tax per unit of alcohol? At the risk of being tediously repetitious it is worth reminding ourselves again that distillation is one of the most innocuous activities imaginable. Unlike beer- and wine-making it doesn't produce a drop of alcohol. Not a drop. What it does is take the beer which you have quite legally made by fermentation and remove all the noxious, poisonous substances which appear inevitably as by-products in all fermentations. Strange really that the purification of a legal beverage by removing the poisons is illegal. Instead of prohibiting it, the authorities should really be encouraging distillation by amateurs. And the general public, which is so rightly health-conscious these days, would be more that justified in demanding the right to do so.

Governments surely wouldn't do something without reason would they!! There must be a reason for the ban on amateur distillation. Surely! In attempting to find this reason the first thing which comes to mind is the potential loss of tax revenue. After all, if everyone started making their own spirits at home the loss of revenue might be considerable. However, this cannot be the real reason because the home production of beer and wine for one's own use is legal, and both are taxable when sold commercially, so the authorities must not be all that concerned about the loss of revenue when people make their own alcoholic beverages.

A possible, and somewhat cynical, explanation for the prohibition of home distilling is based on the following reasoning. Home-made beer and wine are often a bit inferior to a good commercial product, and their preparation takes quite a bit of time, so only the most enthusiastic amateurs will go to all that trouble. Consequently there is no real threat to the sale of commercial products nor to the revenues generated by taxation. If, however, home distillation

were permitted, every Tom, Dick and Harriette would be in a position to make a gin or vodka which was every bit as good as the finest commercial product on the market, and could make it in quantity in a short time. This could, it might be argued, make serious inroads into commercial sales and into government revenues.

Further thought, however, makes it very unlikely that amateur production of spirits would have any appreciable effect on commercial sales. For one thing the equipment is moderately expensive (several hundred dollars) and it is necessary to follow directions rather carefully when using it so it is unlikely that the practice would ever become really widespread. Moreover, many people prefer scotch, rye, rum, etc. to either gin or vodka and it is only these two which can be made by amateurs with a quality approaching that of commercial brands. So if distillation were legalized for amateurs it would probably become nothing more than an interesting hobby, just like making wine, and offer little competition to commercial producers.

No, we have to look deeper than this in our search for a reason why governments have such a hang-up about distillation. You see, it is not just amateurs who are penalized. Commercial producers also feel the heavy hand of government prejudice and disapproval. This is illustrated by several restrictions which apply in many countries. One is the fact that the advertising of beer and wine on television is permitted whereas the advertising of distilled spirits is prohibited. Another concerns the tax imposed on distilled alcoholic products --- per unit of alcohol the tax on spirits is much higher than it is on beer and wine. A third restriction on spirits can be seen in the alcoholic beverage section in the supermarkets of some countries ---- beer and wine may be sold, and possibly fortified wines such as vermouth, but raise the alcohol concentration to 40% and the ancient shibboleth of 'hard spirits' comes into play. This is grossly unfair discrimination and naturally of great concern to distillers. As they point out over and over again, in advertisements and representations to governments, a glass of gin & tonic, a glass of wine, and a bottle of beer all contain similar amounts of alcohol, so it is inequitable to tax their product at a higher level.

So why is there this blatant discrimination on the part of governments which pride themselves on being non-discriminatory when it comes to race, religion, colour, gender, age and so on and so forth? Irrational attitudes are always difficult to deal with but in order to reform the law we have to deal with it, and this requires that we try to understand the thinking behind it. The drug involved is ethyl alcohol, C_2H_5OH , an acknowledged mood-modifier, and it is this drug which governments seek to control, but the alcohol in beer, wine and gin are identical and imbibed in similar quantities will have identical effects in terms of mood modification. So why are they taxed differently?

The only explanation which seems to fit the facts is that governments and their officials cannot understand the difference between concentration and amount. As a matter of fact quite a lot of people have this difficulty. Just because beer contains 5% alcohol whereas spirits contain 40% does not mean that the gin-drinker is 8 times more likely to over-indulge than the beer-drinker. To believe this is to be naïve. The fact of the matter is that anti-social behaviour such as hooliganism at sporting events is almost invariably caused by beer drinkers. And many studies of drinking and driving have shown that the vast majority of those pulled over have been drinking beer, not spirits. Usually they are young men who happen to prefer beer to a vodka

martini with a twist of lemon. And after the first beer they'll have another, and another, always drinking 5% alcohol but increasing the amount with each can. The 5% alcohol content is comparatively low but this is irrelevant when you drink one can after another. It is not the alcohol concentration which is the issue here, it is the amount of alcohol.

An attempt has been made by the author to bring this rather simple point to the attention of officials in the Customs & Excise Branch but the argument falls on deaf ears. We pointed out that alcohol is made by fermentation and that amateurs are allowed to make as much as they like within reason for their own use. So why not allow them to distil it? We pointed out that distillation doesn't make alcohol, it merely purifies it. Ah, is the reply, but it makes it stronger. So we're back into the confusion surrounding concentration and amount. When all else fails, the hoary old argument about amateurs poisoning themselves and going blind is trotted out. Really!

The above discussion has been argued at some length because it is important for the reader to feel comfortable with the "moral" aspects of distillation and with the supposed dangers to health. There is no need for him to be furtive about it or feel like some sort of back alley abortionist. The so-called "offence" has no moral dimension to it. It is not sinful. But it is necessary to illustrate the difficulties which would be encountered in any attempt to change the law. There would be no point in approaching government officials who may be sympathetic to the arguments but are powerless to do anything about it. No, it would be necessary to first air the subject in the news media to get the public (the voters) up to speed and then work through politicians. The approach could be based upon two issues, both of which are important to many people nowadays. One is the question of health --- governments should respond favorably to any suggestion which will lead to more healthy drinking habits (and make no mistake about it, gin and vodka are much less harmful to health than beer and wine). The other concerns our basic rights and freedoms --- it should be an absolute right for anyone to remove the poisonous substances from a legally produced beverage (beer) in order to produce another legal beverage (vodka).

The Author

The author has his Ph.D. in physical chemistry from the University of London, England and has published over seventy scientific papers. These have largely been concerned with the chemistry of plant materials, the internal structure of the plant cell wall and the structure of membranes. Applied research concerned the production of fuel alcohol from agricultural and forest residues.

Before retiring he was the Director of the Forest Products Laboratory in Ottawa and the Director of Research Services at the University of Ottawa. He is now spending his retirement years in a small village in eastern Canada on the shores of The Lake of Two Mountains.

His interest in the theory and practice of small-scale distillation of alcohol stemmed from a botched attempt at making wine many years ago. It was so awful that it should have been poured down the drain. However, he decided to try and recover the alcohol by distillation and found to his chagrin that it was not as simple as it seemed. This book, like its predecessors, is the result.

NOTE

ITEMS AVAILABLE FOR PURCHASE

Nowadays, several countries allow amateurs to distil alcohol for their own consumption. New Zealand is the most recent example, recognizing in 1996 just how innocuous a hobby it is and, as a consequence, lifting the age-old ban. Now the United States may be on the brink of bringing in similar legislation (see 107th Congress of the United States. Bill H.R. 3249).

Encouraged by this softening in official attitudes, many hobbyists are considering building their own still. It is not only a fascinating hobby but can also be quite profitable, much more so than making your own beer or wine. This is illustrated by the fact that a litre of excellent gin or vodka can be made for about US \$1.

When mulling over the best still design to follow you might wish to consider the hi-tech fractionating still described in this book --- The Carriage Still. It is the culmination of 17 years of small-scale still design, is tried and true, is elegant in appearance and highly efficient in its performance. Moreover, it incorporates a unique feature in amateur still design ---- a glass still-head and stream-splitter. This adds enormously to the pleasure of distilling because you can see exactly what is going on inside. It is no longer an inanimate collection of metal tubes but is alive and sparkling, a real conversation piece when shown to your friends.

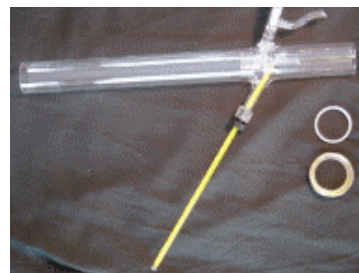
Glass is virtually impossible for amateurs to work with, unfortunately, so we have solved this problem by making the construction a joint project. Our professional glassblowers make the still-head while you do all the rest. Although it is primarily the glass still-head we are offering for sale, there are a few other components listed below which the hobbyist may prefer to buy rather than make.

The glass still-head can be made available within a couple of weeks following receipt of an order. It, and any of the other components, would be shipped to US customers by UPS from a location in upstate New York. This ensures a simple and trouble-free transaction. Payment is by credit card, but for this purchase a secure order form is unavailable so please provide c/c information by telephone call or ordinary mail.

The following items are available for purchase:

1. Glass still-head, incorporating a stream-splitter, a precision Teflon/glass needle valve, and a thermometer port. The kit includes the thermometer and the brass compression fitting to join the glass still-head to the top of the copper column.

US \$195.00



2. Cooling coil. 16' of 3/16" copper tubing with 1/4" ends. Machine-wound. \$40
3. Stainless steel column packing \$10



cooling coil

Shipping by UPS is extra and may vary from an estimated \$10 to \$30 depending on distance.

The column itself, which is simply a 32" length of 1 1/2" copper tubing, is easily purchased locally so is not included in the kit. Neither, of course, are the boiler and cabinet.

For the time being these will be one-off purchases and should be ordered from John Stone by e-mail at:

pegasus@gin-vodka.com

or by regular mail,
telephone or fax at:

John Stone
Saguenay International
17, Hudson Club Road
Rigaud, QC
Canada J0P 1P0

Telephone (450) 451-0644

Fax: (450) 451-7699