IMPROVED POT STILL

**Fig. 14.**

**Fig. 15.**
somewhere in the neighborhood of 25% alcoholic concentration. Since a large volume of wash must be handled to produce a much smaller volume of whiskey, the wash stills are very large, ranging from 7,000 to 12,000 gallons capacity. It is not safe practice, however, to charge these stills beyond 50-75% of their capacity, to avoid foaming and priming, that is, the carrying over of some of the boiling wash into the condenser. A still of the size range indicated may be expected to distill about 600 gallons of wash to low wines per hour.

Figure 15 is an improved pot still, arranged for direct firing and equipped with a rectifier in addition. The vapors pass from the kettle into the rectifier, which is similar to an ordinary con-
denser. The least volatile portions are condensed and returned to the still. The more volatile portions of the vapor pass on to the regular condenser.

A doubling of this arrangement is shown in Figure 16. This kind of equipment is used in the British West Indies for the production of rum. Either Figure 15 or 16 may also be arranged for heating by steam instead of direct firing.

Another type of rectifying arrangement called a “Corty’s head” is shown in Figure 17. Four traps are fitted into the neck of the still. Each trap contains a diaphragm by means of which the direction of the rising vapors is changed, forcing them to circulate around the trap. Cooling water enters the system by means of the pipe (9) and flows downwards through pipes (10) from trap to trap. A fractional condensation occurs in each trap causing progressive rectification of the ascending vapors in an effective manner and resulting in the vapors passing to the total condenser being much richer in alcohol than those evolving from the boiling liquid in the kettle.

**Coffey Still.**—The Blair, Campbell and McLean form of the “Coffey” or patent still, shown in Figure 18 in plan, and diagrammatically in Figure 19, is a much more effective rectifying and distilling equipment. Instead of applying direct heat to a large volume of wash in a kettle, the wash is spread in thin layers over a large surface and heat supplied by the introduction of steam from an external boiler. The wash enters the still at the top and trickles down over a series of perforated copper plates. Steam enters the still at the bottom and bubbles upward through the perforations, each of which is in effect a trap. By this means the wash is heated and the alcohol vaporized so that by the time the wash has reached the lowest plate it has lost all of its alcohol and can be discharged from the still with its dissolved and suspended solids. As the mixture of alcohol vapor, volatile impurities, and steam rises toward the top of the apparatus, the lower becomes its boiling point, more steam is condensed from it, and the richer it becomes in alcohol. The part of the still in which this operation takes place is called the “analyzer.”
Fig. 18.—(From Martin Industrial and Manufacturing Chemistry-Organic, Crosby, Lockwood and Son, London.)
The vapors from the top of the "analyzer" are led into the bottom of a second column of perforated plates which is called the "rectifier." There is a zig-zag tube full of cooling liquid extending the full length of this column to serve as a condenser. Usually cold wash on the way to the analyzer is employed as cooling liquor, while it is thereby preheated, thus effecting economy of heat. The alcoholic vapors on their upward passage through the plates are fractionally condensed in each cooling chamber and lose their water until finally they are condensed on an unperforated sheet at the top of the column (the "spirit plate") as very strong alcohol, and are removed. It is stated that from 94-96% spirit can be continuously obtained from this type of still, whereas a simple still at best and even by repeated distillations will only yield a small quantity of strong alcohol not over 90-92% by volume from each operation.

A mixture of weak, impure alcohol and "fusel oil" ("hot feints") collects in the bottom of the "rectifier." This is returned to the "analyzer" to recover the alcohol. Towards the end of the distillation of a batch, however, instead of completing the purification of all the alcohol, it is found more economical to raise the temperature of the apparatus and distill off the whole residue of impure spirit. This is condensed and collected as "feints" in a separate receiver. Here the fusel oil which has accumulated throughout the process separates, to a large extent, from the weak spirit and is skimmed off. The remaining "feints" are redistilled with the wash of a succeeding operation to recover their ethyl alcohol.

In the United States alcohol is distilled and rectified from its wash by means of continuous stills. In smaller establishments all non-volatile materials and a substantial portion of the water are removed in a so-called "beer still," Figure 20. On account of the partial rectification in the preheater the distillate from a 6% beer will frequently run as high as 40 to 60 per cent alcohol. The crude alcohol is neutralized with some suitable alkali such as soda ash, and then purified and concentrated in an intermittent still, Figure 21. Assuming that the feed runs as high as 60 per cent alcohol, the feed is diluted so as to reduce the con-
centration to 50 per cent and the distillate will run as high as 95 per cent alcohol but is collected in a number of portions of which 70 to 75 per cent can be used as spirits. The neutralization of the distillate from the beer still must be very carefully done, because if the solution is boiled when alkaline, the nitrogenous bodies set free amines whose disagreeable odor is difficult to remove in the finished alcohol, and which also form blue compounds with copper which discolor the alcohol. Another drawback is that they tend to combine with the aldehydes, forming resins which may gum up the column, or impart a yellow color to the alcohol withdrawn from the column. On the other hand,
if the solution is acid, esters will form, and any undecomposed ammonium acetate will react with strong alcohol forming ethyl acetate and setting free ammonia. (See Robinson, "The Elements of Fractional Distillation.")

The operation of the beer still shown in Figure 20 is performed as follows: The alcoholic feed is supplied by a constant level feed tank "A" containing a ball float which controls a steam pump to pump the feed from the storage tank to A as rapidly as it is used. The feed then flows by gravity through the feed heater "B" where it is raised nearly to its boiling point. Continuous stills are often fitted with recuperators in which the incoming feed is heated by the outgoing hot waste from the bottom of the exhausting column. If the liquor contains solid materials that are likely to form deposits on the heating surfaces, recuperators are dispensed with, on account of the difficulty of cleaning the outside of the tubes. The vapor heater shown at "B M" has
the liquor only inside of the tubes, and the fouled surfaces can very easily be cleaned by removing the top and bottom heads of the heater, and passing a cleaning device through the tubes.

The hot feed is introduced into the top section of the exhausting column “C” where it flows downward from plate to plate; the volatile portions are gradually removed as the liquor comes into contact with the steam blown in at the bottom through the perforated sparger pipe “L.” The exhausting column has usually from 12 to 15 plates, each plate being large and deep to give a long time of contact of the feed in the column in order to insure complete removal of the volatile substances. The complete removal of these substances is readily tested by what is known as the slop tester. Vapor is withdrawn from a plate near the bottom at “H,” any entrained liquid removed by the separating bottle, and the vapor condensed in a suitable condenser “I,” from which it flows to a tester “J” where it can be tested, or its specific gravity measured by means of a hydrometer. The exhausted liquor is then discharged from the bottom of the still through a suitable seal pipe “M.” The rate of introduction of steam into the column is governed by means of a suitable pressure regulator.

The vapor leaving the exhausting column to pass to the heater is substantially in equilibrium with the liquid on the top plate of the column. It is partially condensed in the heater, enriched in its alcohol content, and then passes to the condenser where it is completely condensed. The portion of the vapor condensed in the heater is returned to the top plate of the column together with a controlled portion of the vapor condensed in the condenser, from the regulating bottle “E.” The distillate flows, through the tester “F” where its quantity and specific gravity may be measured, to the storage tank “G.” The water supply for the condenser is obtained from the constant level feed tank “N.”

In larger establishments a continuous rectifying still is used in place of the intermittent still for the second operation. Figure 22 is a diagram of such a continuous rectifying still. The still consists essentially of a purifying column “C” and a concentrating
and exhausting column “D.” The function of the purifying column is to remove the volatile head products, which are separated from the alcohol by fractionation. The function of the concentrating column is to separate the alcohol from water, as well as from the less volatile impurities which are not removed in the heads. This rectifying unit will produce an alcohol of higher grade than the best produced by the intermittent still with a recovery of perhaps 75 to 85 per cent. It will avoid the necessity of subsequent purifying treatments with charcoal, etc., and rehandling of intermediate fractions at a considerable saving in time, labor, and expense. The purifying column is fitted with a partial reflux condenser “G” and a total condenser “H” and is independent of the rest of the apparatus except that it receives the hot feed continuously from the recuperator “B” and the feed supply tank “A” and delivers the purified dilute alcohol continuously from its base to the other column “D.” It has its own

Fig. 22.—Ethyl Alcohol Still (continuous). (Redrawn from Robinson’s Fractional Distillation. Courtesy McGraw-Hill Book Co., Inc.)
COFFEY STILL

steam regulator "O" and cooling water supply and its rate of operation can be controlled according to the amount of the impurities to be removed.

A further improvement of this system of alcohol production is shown in the plan in Chapter IX on Whiskey. Here the beer still is connected directly to the rectifying unit so that the feed to the rectifier is in the form of a vapor instead of a liquid. This effects considerable saving of steam for heating purposes and the final product contains not less than 98 per cent of all the alcohol present in the beer and produces 90 per cent of this alcohol as high grade, pure spirits, the remainder as heads, and a washed fusel oil. Chemical analysis cannot determine whether the alcohol produced comes from molasses or grain. These units use about 40 pounds of steam per gallon of alcohol produced. Further improvements now pending will give an even higher yield.

The most modern American whiskey still consists of a column and an extra head which contains two rectifying plates and one washing plate. This still and its mode of operation are described in Chapter IX on Whiskey.
CHAPTER IX

WHISKEY MANUFACTURE

Historical.—Whiskey is essentially an English and American beverage. It was first developed in the United Kingdom and subsequently its manufacture was taken up in this country.

When whiskey was first made is not definitely known. But Usquebagh (from which the word "whiskey" derives) is said to have been made in Ireland in the twelfth century and it is reported that its manufacture there had assumed sizable proportions even before Queen Elizabeth's time. It is also said that distilled spirits were made by the monks prior to the fifteenth century and that they jealously guarded the secrets of their formulae and methods of manufacture. However, commencing with the fifteenth century the process became more widely known. There is a treatise on distillation which is one of the very first of printed books. At first the manufacture was carried on in a small way in the household, but a young whiskey distilling industry was gradually established. At that time spirits were made from malt in Scotland and from wort and sour beer in England. The industry was operated under government supervision in all three countries and its products were taxed. As a result, the history of spirit distilling can be followed fairly accurately by a study of the taxation legislation.

The industry has had a very stormy career and it is interesting to note that in the sixteenth, seventeenth and eighteenth centuries many of its troubled periods and their subsequent developments paralleled conditions under the prohibition era in the United States in the last thirteen or fourteen years. For example, restrictive legislation, high taxation, manufacture under strict government supervision and last, but not least, the bootlegger, or
as he was then called, the illicit distiller, all existed long before our times. Smuggling was often rife, and England had its rum row two or three hundred years before America. In 1556 there was a death penalty in Ireland for illicit distillation.

In the reign of Charles I there was formed the Distillers' Company of London, which received a charter of incorporation and was empowered to regulate the manufacture of whiskey from the point of the quality of materials to be used. A little later, in the reign of Charles II, distilling materials included such varied substances as sugar, molasses, sour wines, sour ales, cider, and wort from grain and malt; and the products included whiskey, brandy, gin, and rum (although much of this was made in Jamaica). By 1694 annual production in England had risen to 900,000 gallons.

The seventeenth, eighteenth and nineteenth centuries were periods of experimental taxation and other governmental regulation in Scotland, England, and Ireland, and the industry may be said to have grown in spite of, rather than because of, these regulations. Prior to 1860 the taxation and regulations were different in all three countries; and in Scotland, during one period, there was even a wide difference in regulations for Lowland and Highland distilleries. At one time taxes were either collected by local authorities or were farmed out to private persons or business houses, who received a percentage of their collections for their services. It was quite common for such tax collecting contracts to be let and sub-let. Later, a fixed minimum of receipts was stipulated for each distilling region. Following this another form of taxation was tried, based on the capacity of the still and its rate of operation, but the legitimate distillers displayed considerable ingenuity in beating the law, often by faster distillation. Morewood (Inventions, etc., in Intoxicating Liquors, 1824) describes a still for this purpose which was built with the unique proportions of 48 inches in diameter and only three or four inches deep!

Thus, three centuries have passed and a satisfactory solution of the problem is still sought. When taxation was high and regulations very restrictive, legitimate production waned and il-
licit distillation and smuggling increased. When taxation was lowered and regulations made less restrictive, legitimate manufacture would prosper and smuggling and illicit manufacture diminish.

In 1730 the laws almost killed the industry, but illicit distilling became so profitable that the government was forced to revise the regulations in 1743. Legitimate production then jumped to 5,000,000 gallons of proof spirit. In 1751, and again in 1756, taxation was increased and legitimate production gradually dropped till it amounted only to 3,000,000 gallons in 1820. In 1760, 500,000 gallons of spirit were smuggled into England from Scotland. About the year 1800, 6,000 illicit stills were seized in Ireland in one year and illicit production exceeded legitimate production three or four times. Taxation was revised in Scotland in 1817, and in England in 1823, and finally in 1860 all legislation was consolidated and restrictions were somewhat relaxed. Since then further concessions have been made from time to time, the greatest being those since the war. At present the tax is about $2.00 per bottle.

The history of whiskey manufacture in the United States is not so easily traced. The date of the building of the first distillery is uncertain, as is the progress of the industry in the eighteenth and nineteenth centuries. However, no book on this subject can omit a reference to the “Whiskey Insurrection” which occurred in Western Pennsylvania in 1792 to 1794, when President Washington was compelled to call out the militia to quell the insurrectionists, so strong was the reaction against the excise regulations put into force about that time.

The prohibition question, especially its legislation and developments in the past two decades in the United States are too well known to warrant reviewing. According to D. S. Bliss, U. S. Commissioner of Industrial Alcohol, only seven distilleries were legally operated during this period for the purpose of manufacturing whiskey for medicinal purposes. They were allowed to manufacture only limited quantities and they started operation during the fall of 1929. On the manufacture of whiskey during the last three decades see also Chapter XV on Statistics.
Definition and Types.—Whiskey may be defined as an alcoholic beverage produced from cereal grains by the following general series of operations:

1. Transformation of the starch of the grains, either malted, unmalted, or mixed, into fermentable sugar.
2. Fermentation of the sugar to produce alcohol.
3. Distillation to concentrate the alcohol.
4. Ripening by aging in oak barrels.

There are available on the market a number of types of whiskey, which as the result of variations in the details of processing or in the raw materials used, possess different flavors and other characteristics of importance to the consumer. In general these may be classified as:

**American**

**Rye:**
Made from a mash composed of unmalted rye and either rye or barley malt.

**Bourbon:**
Made from a mash composed of maize and either wheat or barley malt.

Low grade American whiskeys are made from mashes containing from 10 to 15 per cent malt.
High grade American whiskeys are made from mashes containing from 20 to 50 per cent malt.
Most American whiskeys are made in patent stills.

**Scotch**

**Pot still:**
Made from barley malt and having a smoky taste, obtained by using peat instead of coal as fuel in the kiln drying of the malt. Changes in the variety of peat used materially affect the flavor. This includes scotch whiskeys commonly classified in the British Isles as follows: (1) Highland malts, (2) Lowland malts, (3) Campbelltowns, (4) Islays.

**Patent still:**
Made from a mash composed of unmalted cereals and barley malt. The former may be either rye or oats but commonly is American maize (corn). These whiskeys do not have the smoky taste and are more American in character.
Irish

Pot still:
Made from an all-malt mash or from a mixed mash composed of barley malt and unmalted cereals. The latter may be barley, oats, wheat, rye or variously proportioned mixtures. Malt runs high, from 30 to 50 per cent of the whole.

Patent still:
Made from a mash composed of unmalted cereals and barley malt.

On a different basis all mixed mash whiskies may be classified as either:

Sour or sweet mash

Sour mash:
A whiskey made by cooking the ground, unmalted cereal with spent liquor of a previous mash which has been dealcoholized by distillation.

Sweet mash:
A whiskey made by cooking the ground unmalted cereal in the ordinary way with water.

Blends.—In addition to the straight whiskies described above, both in this country and abroad various blends have come into public favor. Especially in Great Britain blending has become a very large trade as it is stated that the public taste demands a whiskey of less prominent but more uniform characteristics than formerly. To gratify this desire blends are made, in the United States presumably of straight whiskies; but in Great Britain either by the mixture of various pot still whiskies of varying age, etc., with the possible addition of silent spirits from patent stills. In the latter case cheapness is often the purpose of the blend, but it is also stated that it unites the several whiskies in the mixture more completely and enables the blender to produce a whiskey of more uniform character. Blends, even when made from aged spirits of various kinds, are frequently stored in bond for considerable time. The addition of patent still spirits, even those containing very small amounts of secondary products, is viewed as dilution rather than as adulteration. Methods of blending are discussed under that heading later in this chapter.
MANUFACTURE OF WHISKEY

General Outline.—The manufacture of whiskey is essentially a chemical process based on changes in the composition of materials brought about by temperature alterations and the effect of the activity of ferments and other reagents. Very little depends on mechanical manipulation and there is a lack of spectacular features.

Successful operation depends on a complete understanding of the changes taking place in the composition of the materials and on accurate temperature control. Technical knowledge, experience and judgment are required to select and control conditions and materials so that a high yield of uniform product is obtained.

It has been the object of the preceding chapters to explain the theoretical bases on which the process of whiskey making rests. In the present chapter the sequence of the operations and some of the manners of control are discussed. In actual fact, it is very easy to make a sort of crude whiskey by simple performance in regular order of the first three or four basic operations listed in this chapter in the section on definitions and types. The commercial production of whiskey in quantities is very largely a magnification in scale of these operations with the introduction of refinements and modifications designed to facilitate the operation, secure a more uniform product, and obtain a maximum yield. It is to be expected, therefore, that the historical steps in the change from the simple "home still" of earliest times to the largest scale continuous operation of American practice have been preserved and can be seen in the manufacture of whiskey in various establishments in different countries. This is the case to such an extent that the common varieties of whiskey are each identified with a different degree of evolution in the whiskey making process. A number of distinct process sequences can be formulated on this basis, of which the following are outstanding. (See Table VIII).

Mashing.—In all types of whiskey, the process, by which all the starch of the grains used is brought into solution, is called mashing. It involves both extraction and conversion of the starch
into sugars. The process is carried out in an apparatus called a "mash tun" as illustrated in Figure 22a. The essential parts of a mash tun are a vat equipped either with steam coils or means of heating by direct injection of steam, and an efficient agitator. The latter must have both scraper and stirrer arms to ensure that all the ground grain comes into contact with the water.

**Table VIII.—Tabular Comparison of Whiskey Processes**

<table>
<thead>
<tr>
<th>Whiskey type</th>
<th>Scotch or Irish</th>
<th>Scotch or Irish</th>
<th>Scotch or Irish</th>
<th>American small scale</th>
<th>American large scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>All malt</td>
<td>Malt and grain</td>
<td>Malt and grain</td>
<td>Malt and grain</td>
<td>Malt and grain</td>
</tr>
<tr>
<td>Pre-mashing</td>
<td>None</td>
<td>None</td>
<td>Partial acid conversion</td>
<td>Cooking at normal pressure</td>
<td>High pressure cooking of grain</td>
</tr>
<tr>
<td>Filtration of mash</td>
<td>Yes Only wort is fermented</td>
<td>Yes Only wort is fermented</td>
<td>Yes Only wort is fermented</td>
<td>No Whole mash is fermented</td>
<td>No Whole mash is fermented</td>
</tr>
</tbody>
</table>

![Fig. 22a.—Mash tun and apparatus. (Redrawn from Rogers’ Manual of Industrial Chemistry, D. Van Nostrand Company, Inc.)](image)
**Water.—** The quality of water used in mashing is very important both on account of its influence on the quality of the finished liquor and in its own right, since it is used by the distiller in many times greater volume than any other of his materials. As used in mashing it is possible for impurities in the water to cause irreparable damage. It is also claimed that the water used influences the flavor of the finished whiskey. There is even told a tale of a Scotch distillery being built on the banks of a stream and then abandoned and a new distillery built on another stream twenty miles away because the water from the latter resulted in a product of superior flavor. As the Italians say *Se non è vero, è ben trovato.* Certainly it is known that Scotch and Irish distillers emphasize greatly the purity of their water supply. They select by preference, moss water, or some special location such as Loch Katrine or the river Bush, whose name is part of the trade name of "Old Bush Mills."

Lacking such ideal locations, an effective water purification and softening plant may be necessary if the water supply is in the least questionable. The magnitude of the problem is readily seen from the fact that a pot still distillery, on a basis of 1,000 bushels of malt mashed weekly, will require about 240,000 gallons of water, and a patent still distillery, producing 20,000 proof gallons of alcohol per week, will use about 700,000 gallons of water in its production.

**Scotch or Irish Pot Still Whiskey.—** **Preparation of Wort.—** As can be seen from Table VIII (p. 102), the manufacture of this type of whiskey involves the least introduction of modern improved processes. The mashing procedure as shown diagrammatically in Figure 23 consists of three extractions of the ground grain, either all malted or a mixture of malted and unmalted, with separate portions of liquor. Oat husks are added to assist in the drainage or filtration of the wort and the third or final liquor from one batch of grain is used as the first liquor on the succeeding batch. The liquor is heated to the proper temperature, poured over and mixed with the cereals in the mash tun, allowed to soak for a suitable time and drained off. The first two liquors obtained in this manner are cooled to the proper temperature for
fermentation and run to the fermenting vats. The third liquor or "weak wort" is returned for use on the next batch of malt.

Fermentation.—This stage of the process of whiskey making permits of only minor variations in methods of inoculation, time, temperature control, etc. The general practice is the same both in

America and in the British Isles. The principles to be observed have been outlined in Chapters III and VI.

The customary procedure is as follows: The wort coming from the mash tuns, filtered abroad, unfiltered here, is cooled to between 68° and 70° F. Yeast in a vigorous state of activity is added and the fermentation proceeds. The temperature of the fermenting liquor increases and must be carefully controlled by passing cold water through coils in the fermentation vat. The amount of temperature rise permitted has a direct effect on the time of fermentation. In some distilleries the rise is kept small