Modern Distillery Practice

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Repeal of prohibition ushered in an important new phase of the business of manufacturing whisky. Chemistry, biology, and engineering meant little or nothing to the old industry, occupied as it was with its deep obeisances to age and hoary tradition. To the reborn industry, science and technology have become essential tools.

Age was the fetish of the distillers and of the drinkers of alcoholic beverages of two decades ago and with many it still occupies a sacred niche. Even the niche has vanished before the enlightening discoveries of research which form the basis of today's distilling practice.

Necessarily there are three steps in the manufacture of beverage alcohol: fermentation, distillation, and maturing. For many reasons which will become apparent, the ancient practice of distillers placed particular emphasis on maturing over long periods of time and the fetish of age became the idol of the industry. The crude distillate of old-fashioned stills was harsh and unpleasant and long aging in charred oak barrels was known to accomplish a remarkable change in it. After long maturing, whisky lost its rough harshness, acquired a pleasing aroma, and delighted the palate. Chemists explained this as the removal of certain unwanted constituents and the chemical rearrangement of others to yield a palatable result. Either this fact failed to reach distillers or they were too busy with other matters to heed it. In any case, it has remained for the reborn whisky industry to apply this fact to its operations to the advantage of all. The new technic is exemplified in the operations of Hiram Walker & Sons, in a plant at Peoria, Ill.

In the old practice of the distillery, fermentation was allowed to take place as it would in open wooden tanks which were never sterilized and into which every possible wild yeast was encouraged to come and grow. Distillation was conducted for the prime purpose of recovering every bit of alcohol possible from the mash without regard to other constituents. The result was a distillate which contained all the volatile (with steam) constituents found in the fermented mash and whose maturing required long stretches of time to correct its deficiencies.

The vital importance of the maturing process justified analysis and investigation, and from this came the key to the whole situation. Maturing was found to consist of two parts—(1) corrective aging and (2) maturing. During the corrective aging period the objectionable flavor and bouquet-producing substances, found especially in whiskies made by the "rule of thumb" method, are absorbed and modified through assimilation, while during the second stage (maturing) slow chemical reactions occur between the congeners (nonethanol constituents) of the distillate and the wood extractives, whereby the desired bouquet is attained. Both of these stages of aging occur slowly and the time required for them depends definitely on the kind and quantity of congeners present. The correct age is attained when the wood extract and congener content are balanced. If the distillate has a low congener content, a relatively short time is needed to balance this with wood extract and a light-bodied whisky results. To make a heavy-bodied whisky requires a high-congener distillate, more wood extractives, and a longer aging period.

On this guiding principle, it is easily possible to control the processes of fermentation and distillation to yield any degree of body desired and to adjust the aging conditions to fit.

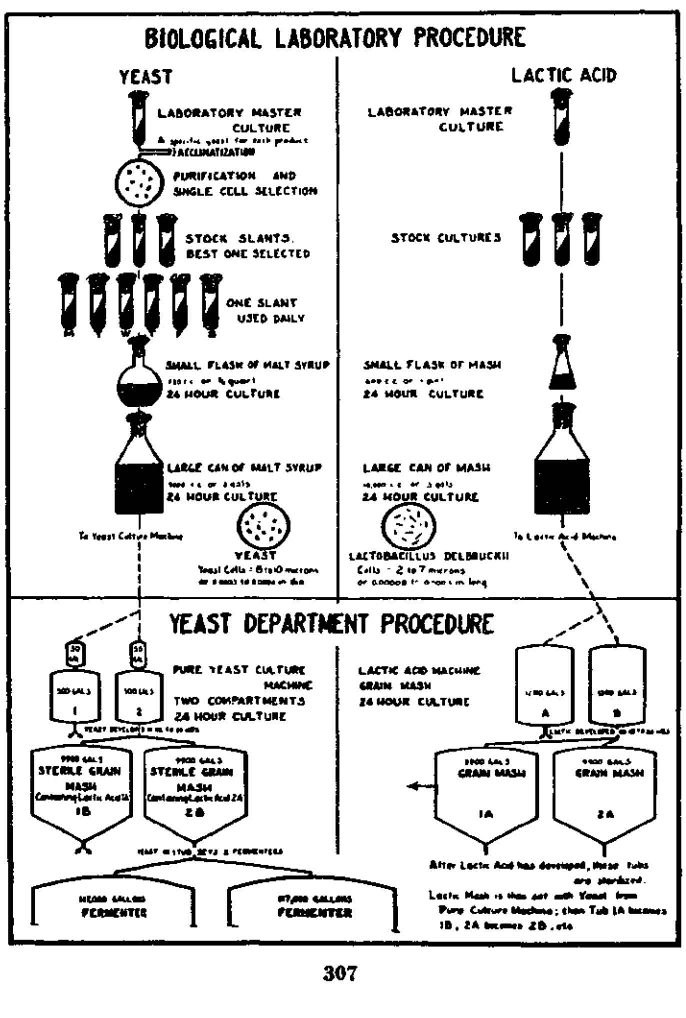
Present Practice

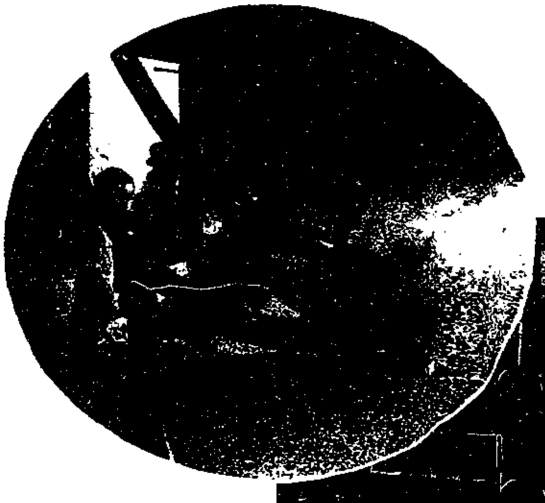
The effect of this idea on practice has been remarkable. Fermentations are conducted on carefully selected raw materials with strains of yeasts known to produce congeners of varieties and in the quantities needed to achieve a desired result in the finished whisky. No longer are yeast cultures permitted to develop wild organisms to make every fermentation batch yield a heavy whisky. Sanitation and exact control keep this part of the operation in line. Modern stills of high efficiency remove the more unruly congeners from the distillate before the aging process is started, instead of throwing the whole load of correction on the barrels as older practices with batch stills did. Finally the extent of maturation required determines the character of the char in the barrels used for maturing. Barrels for distillates intended to yield heavy-bodied whiskies are heavily charred, while refilled whisky barrels are preferred for the maturing of light-bodied products.

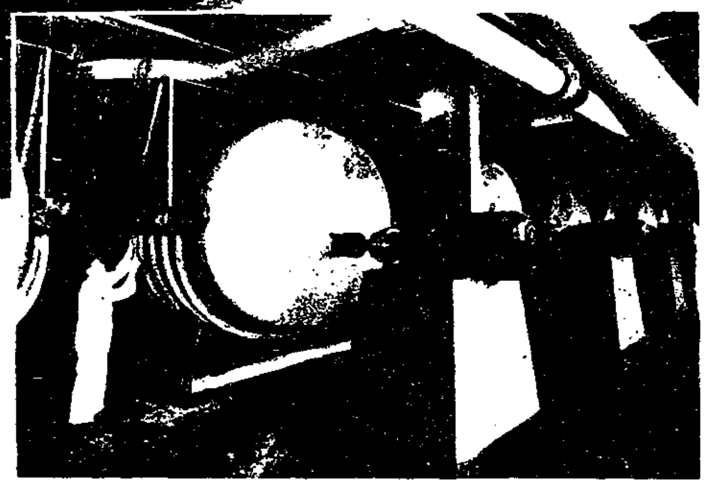
The conception of whisky of two decades ago reached the point of making the product an alcoholic solution of a quantity of congeners—that is, compounds other than ethanol present in whisky. In other words, the congeners themselves became the prime objective of the distillery and the alcohol merely a convenient carrier for these flavors. On this basis long maturing to permit the completion of slow chemical reactions in the distillate and the dissolving of extractives from the oak barrels containing the spirits was essential. The new industry, however, has been built upon the concept that the primary objective is the alcohol in the finished whisky and that such congeners as are present make this potable. The difference between these two conceptions has enabled the new industry of whisky distilling to provide whiskies of high potability and palatability, and yet whiskies which may possess quite different characteristics from those of even a quarter century ago.

In the old art, the fermentation was conducted and the choice made of the raw materials used in it to foster the formation in the ultimate distillate of alcohols, aldehydes, and acids in variety and abundance. This end was accomplished by encouraging the growth in the mash of organisms other than the yeast. When the product of a fermentation of this kind was distilled, the distillate was an extremely unpalatable product, requiring extensive subsequent correction to give it the desired bouquet and flavor. The larger the proportion of congeneric substances, the longer the period of aging required and the greater the quantity of extractives needed to balance their effect. In contrast to this, the new whisky industry has devoted its efforts to finding methods of fermentation and distillation which control the original formation of congeners in the mash and which subject those present to logical treatment. Smaller proportions of congeners are balanced in the finished whisky by smaller amounts of extractive

YEASTING







Upper. Unloading Grain by Vacuum System to Elevated Storage
Center. These Mills Grind Grain to Be Mashed and Fermented
Lower. In These Tanks the Mash Is Made by Cooking Grain Meal with Water

matter, and at the same time, since the extent of the chemical reactions involved is materially reduced, the time required for them to occur is very much shortened. In other words, by making distillates containing predetermined amounts of congeners, the subsequent treatment to make the alcohol palatable is predetermined.

The raw materials of whisky manufacture consist of grain, malt, yeast, lactic acid bacilli, and water. The selection and control of these raw materials initiate the process and are essential parts of the whole. Since we are here dealing with a biological process where wild strains of microörganisms cause trouble, the utmost cleanliness and frequent sterilization of equipment are the second essential. The distillation of the fermented mash must be conducted as carefully as its preparation. The final maturing of the distillate in charred, white oak barrels for a period determined by the extent of maturing necessary completes the job, and yields a product ready to be put in bottles for sale. Strangely enough, the bottling of the whisky is equally essential to the whole, since legal restrictions require the product to be sold only in new, glass bottles. No retail consumer is permitted to buy whisky today in any other container.

Grain supplies starch for the fermentation. Both corn and rye are used for this purpose. In this distillery some 21,000 bushels are consumed daily, an amount used each day equal to the annual product of approximately 720 acres of fertile American farm land. In the selection of the grain the primary consideration is its starch content, since other constituents (proteins, etc.) are always present in ample amounts. In the old days, distillers apparently failed to recognize that differences exist between the starch content of various grades of grain and consequently always bought the cheapest. The fallacy in this has been amply demonstrated and the first and second grades of corn, although selling at higher prices per bushel, have been found actually cheaper sources of starch than the lower-priced inferior grades.

Since fermentation is the primary operation of the plant and it is necessary to keep out unwanted yeast and bacteria, the raw grain is carefully examined from a bacterial point of view before it is purchased. Standards have been set up which must be met by raw grain and the total count of microörganisms must fall below established limits, despite the fact that the corn is cooked and the rye and malt are heated to as much as 71° C. (160° F.). The malt (both rye and barley malt are used) which supplies the enzyme to convert the solubilized starch of the grain into sugar must also meet rigid chemical and bacteriological standards. By applying modern sanitation to the malting operation the count of microörganisms per gram of malt has been reduced from thirty or fifty million to one or two million per gram.

The storage bins for grain are so constructed of concrete as to avoid any pockets in which grain might accumulate and their interiors are coated with a Bakelite varnish to ensure the utmost smoothness. From the bins as each batch is needed, grain is dropped to mills in which it is cut (not crushed) to a fine meal. Each batch of meal is ground when required and goes immediately from the mills through automatic weighing scales to the cooker without intermediate storage in which flavor might be lost. Three hundred bushels of grain make up a cooker charge and this quantity is drawn from the grain meal bins, weighed, recorded, and poured into the cooker by an automatically controlled process started by pushing a button. As the meal enters the cooker it is mixed with water.

The location of a distillery is most often predicated on the availability of a water supply satisfactory, not only in quantity, but more especially in quality. Limestone-bearing waters are preferred because they contain calcium and magnesium bicarbonate hardness and the proper quantity of sulfates to furnish the desired inorganic medium for the yeast fermentation. Since the quantity of water required by this distillery runs as high as ten to thirteen million gallons a day, every economy is practiced to prevent waste which might easily increase this to extraordinary figures. The well water that is used for cooling purposes (mash, condensers, yeast, etc.) is automatically treated with sulfuric acid to a low residual bicarbonate content (pH 6.5 to 6.7) in order to eliminate deposits of carbonate scale. From these points where the principal value of the water is its low temperature, it is conducted to a warm-water storage tank where it is held until needed for cooking, etc. Where hot water is needed it is heated by heat exchangers, using the blowoff from the cookers as the heat supply.

Mixed with the proper quantity of water, the corn meal is cooked to a uniform consistency at a pressure of 80 pounds of steam. The cookers are provided with continuous stirrers and when the cooking operation is complete, they are cooled to a temperature of 68° to 71° C. (155° to 160° F.) by blowing off through heat exchangers and further cooled under vacuum. At this point, the malt, which has been previously mixed to a slurry with water in a Porteus mixer, is run into the cooker. Conversion takes place at a pH of approximately 5. When the malting of the solubilized starch has converted it into sugar, the batch is run into drop tubs for temporary storage and from them measuring pumps deliver the mash through double pipe coolers, where the temperature is reduced to 72° to 75° F., into the fermenters. The charge to a fermenter consists of the malted mash, yeast, water, and a small amount of sterile, screened back-slop from the stills which is received boiling hot and passed through coolers before reaching the fermenters. This sterile back-slop, which is the waste product of the stills, is added to keep the amino acid content of the fermenting mash up to standard and also to introduce some lactic acid into the batch. The proteins in the back-slop are highly available as yeast food and thus assist fermentation.

The special care exercised to ensure the purity and vitality of the yeast culture added to the mash is of vital importance. The accompanying chart shows the steps followed with respect to the two microörganisms which enter the process: yeast and *Lactobacillus delbruckii.*

The function of the yeast is to convert the sugar formed by malting the mash into ethyl alcohol. Consequently any organisms producing other types of fermentation are carefully excluded. To this end the culture is built up by stages from an inoculation consisting of a single selected cell in a sterile medium. Different yeast strains are chosen for use where different products are to be made. Because lactic acid favors the growth of yeast (rather than that of bacteria as acetic acid does), this acidifying agent is used to bring the main mash to the preferred reaction (pH 5.0). The lactic acid bacillus used is a thermophile, *Lactobacillus delbruckii*, chosen for its efficiency in conversion and because the high temperature of optimum growth and activity (49° to 54° C., 120° to 130° F.) discourages the growth of other unwanted organisms. Its purity is assured by using culturing methods similar to that used for developing the pure culture yeast. In making the final culture to go into the 117,000-gallon fermenter charge, the yeast is grown for 18 to 24 hours in a sterile lactic acid containing grain mash in a 9900-gallon batch, which seeds two fermenters. The old method of seeding each fermenter or each yeast tub from the preceding one tended to encourage the growth and accumulation of wild congener-forming organisms. In the most modern practice not only is this taboo but also all pipe lines, vessels, and fermenters are carefully sterilized after each use and idle equipment is kept constantly at sterilizing temperatures by bleeding steam into them. Even the stirring of the fermenter charge, to secure uniformity, is done with carbon dioxide gas instead of air to avoid the effect this might have in introducing or encouraging the growth of unwanted bacteria.

The fermentation is conducted in closed fermenters, each of 117,000 gallons capacity, for 72 hours beginning at a temperature of 72° F. and subsequently rising to a maximum of 86° F. (for ryes) to 90° F. (for bourbons). Temperature is held within prescribed limits (1°) by automatically controlled coils in each fermenter. The fermented mash, or beer, from each fermenter is dropped into a well from which it is pumped by a positive displacement pump to continuous stills. The pumps are so designed and built that the same stroke which supplies fresh beer to the stills simultaneously pumps out the still slop, thus maintaining volume equilibrium in the still. On its way to the still, the beer is warmed by heat exchange with slop and/or vapor so that it enters the still hot.

The distillate from the continuous stills is known as high wines (100 to 150 proof) and goes to the high wines room. Any faulty batches are returned to be redistilled into cologne spirits; and accepted lots go, still as individual lots, to the cistern building where they are reduced in proof and drawn into barrels.

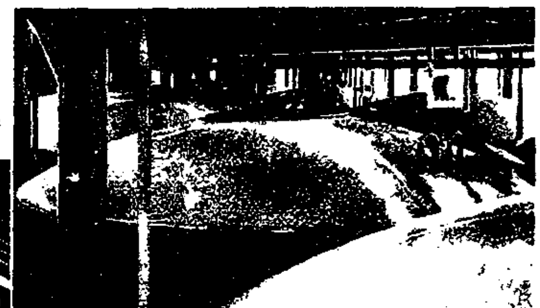
The barrels are quite as important in the whisky manufacturing process as the grain or the distillation. They are made from selected white oak (*Quercus alba* from the Ozark Mountains) and are given an internal char, light, medium, or heavy, adapted to the type of whisky to be matured in them. When filled and marked for identification—for every drop of whisky must be traceable back to the particular batch of grain from which it came to meet government requirements—the barrels are stored in great tiers with free circulation of air around them in air-conditioned warehouses held at summer temperature throughout the year. Here the contents gain in alcoholic strength by the loss of water, extractives are drawn from the wood, and the slow process of chemical alteration proceeds. Ultimately, the aged and matured product is bottled for sale.

Process by-products consist of the carbon dioxide generated by the fermentation, which is collected and converted into dry ice for ultimate sale to consumers, and distillers' grains recovered from the still slop which find ready market as cattle feed of high protein content.

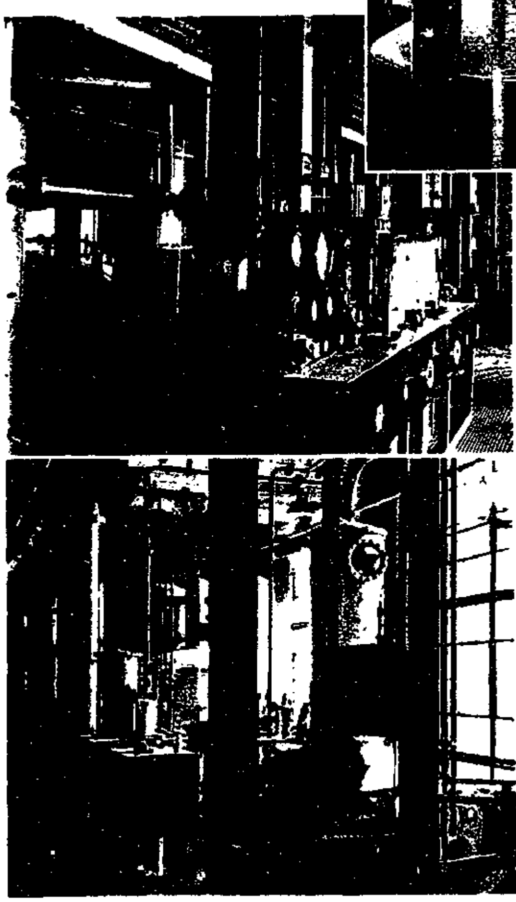
Technical Personnel

If, in this account, the important roles of chemists, bacteriologists, chemical engineers, and other technical men seem to have been neglected, let that impression be promptly erased. Continual research in chemistry, chemical engineering, and bacteriology is actively prosecuted with the view to improving the quality of the product, the economy of operation and the value of the by-products. Every step in the process is carefully checked by analysis from raw grain, water, and fuel, to final bottled product. The control laboratories here are called upon for some 40,000 analyses annually. The plant itself represents the latest word in automatic processing and control, every operation being part of a chain of events set in motion by pressing a button or throwing a lever and progressing to completion without human intervention. Under such circumstances, where improvements are constantly sought all along the line and where imagination is essential to understand the consequences of pushing a button, the main body of the operating force is recruited from technical graduates, mechanical and chemical engineers. In this plant more than one hundred such men form the backbone of the operating crew.

Modern science is moving into this reborn beverage alcohol industry and is destined to replace the rule-of-thumb and empirical methods of the past.



Right-Hand. Twenty-Four 117,000-Gallon Closed Fermenters Convert Mash into Alcohol
Lower. Controls of Still Operation Are Essential to Clean Distillate



Removal of Impurities in Mineral Deposits Converts Waste into Wealth

The conversion of practically worthless mineral deposits into commercially valuable material, through the removal of minute quantities of impurities, is one of the services being rendered to the mineral industries of the Southeastern States by the Southern Experiment Station of the U. S. Bureau of Mines, Department of the Interior, at Tuscaloosa, Ala. Processes developed at the station should make available extensive deposits of barite in Tennessee and South Carolina which were previously of no value.

At the Southern Experiment Station of the Bureau of Mines, in an investigation of possible methods for eliminating impurities from barite, it was found that iron and silica can be removed almost completely from barite by application of the froth flotation process. By this process, barite containing only a fraction of a per cent of iron and silica is obtainable from ore of certain deposits in Tennessee and South Carolina which in their original state are too high in these impurities to be of any commercial value and which, therefore, have been unsuitable for exploitation in the past.

Advance Orders for Symposium on Food Flavors

As already announced, the American Chemical Society Symposium on Flavors in Foods will be published in full in Volume 2, No. 3, of *Food Research*, which is to appear shortly. With this will also be published a critical review of the literature on food flavors.

As it is anticipated that the demand for this issue will greatly exceed the ordinary number published, the publishers are now taking advance orders. Anyone desiring copies should send his order promptly to the Garrard Press, Champaign, Ill., accompanied by a remittance. The price is 75 cents for single copies and 50 cents each in lots of ten.

E. F. Armstrong has been nominated to represent the City and Guilds Institute on the governing body of the Imperial College of Science in place of Sir Arnold Wilson. He is also a member of the Delegacy which governs the City and Guilds College at South Kensington, following Sir Henry Lyons.