

Oak Barrels: Where They Come From and How They Are Made

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Editor's Note: At The Second International Oak Conference in San Marino, California, Mel Knox, a barrel broker from that state, graciously agreed to host a wine-tasting session with a variety of wines matured in different types of oak barrels. He also gave us a delightful talk on where the oak comes from to produce these barrels, how the barrels are actually made, and what the important properties of the wood are that lends so much to the quality and character of the wine. Mel's talk is reprinted here.

Normally I give speeches about wine barrels to people who know a lot about wine, but not too much about oak. Perhaps today the opposite is true. But just as forest rangers and botanists have become successful wine-makers, I imagine that many of you know which end of the bottle the cork comes out of.

Until about 50 years ago wooden barrels were used to hold everything from salted fish to beer, wine and distilled spirits. Nowadays metal and plastic have replaced the wood barrel for nearly everything. When I tell people I sell barrels, they oftentimes tell me that their grandfather made barrels. However, it's a profession that has largely disappeared.

The history of barrel making is somewhat shrouded in mystery.

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The French like to say that the first use of barrels took place in 51 BC when the Gauls filled barrels with burning oil and hurled them at the Romans during the Battle of Uxellodunum. So perhaps the wine business is an example of turning swords into plowshares. Probably the most famous cooper in American history was John Alden, who delayed the departure of the Mayflower when he refused their first offer. As some of the mechanical principles involved in cooperage are similar to those used in shipbuilding, some people think there is a connection between the two crafts.

Today, barrels are primarily used in the booze business, mostly for wine, whisky and brandy. Whereas wooden beer barrels used to be a big item, now you can count the number of breweries using wood without taking your shoes off. Once all sorts of hardwoods were used for barrels; nowadays it's primarily oak because it has an excellent combination of flavor and mechanical attributes. Chestnut, acacia and other hardwoods have been used, but with these other woods, either the astringent flavors have to be leached out of the wood, or the insides of the barrels need to be coated.

Numbers in the barrel business are not like those in the auto or electronics world where analysts have access to all sorts of

statistics. True numbers are hard to come by and are usually not that up-to-date. Large quantities of barrels are generated primarily in two places: France, and the Bourbon-producing part of the USA. By law Bourbon whisky must be made in new, freshly charred barrels, so usually somewhere around 800,000 to one million of these "used" barrels are emptied every year and then sold on to customers in Spain, Scotland, Asia and North America. Around 300,000 French oak barrels are also made every year, primarily for wine and Cognac. The use of oak from Eastern Europe has been growing.

Oaks Used for Barrels

As you all know, oaks are divided into two main groups: the red oaks and the white oaks. The wood from red oak leaks so will not be discussed further. Coopers divide the white oaks they use for barrels into two primary categories according to the location where the trees are grown: the American oaks and the European oaks.

The primary American species is *Quercus alba*, also known as American white oak. However, this general name is also applied to other American oak species, including *Quercus bicolor*, swamp white oak; *Quercus lyrata*, overcup oak; *Quercus durandii*, Durand oak; *Quercus michauxii*, swamp chestnut oak; and

Quercus montana, chestnut oak. Some of these species can hybridize with each other. European species, often referred to as French oaks, include *Quercus petraea*, also known as sessile oak or *Quercus sessiliflora*, and *Quercus robur*, also called pedunculate or variously, English, French and Russian oak.

The anatomy of different oaks has implications for barrel-making. A trunk can be thought of as a bundle of tubes or vessels (xylem vessels) and fibers running parallel to the trunk with groups of fibers called rays running radially from the outside towards the center of the trunk. Oak is non-storied so the longitudinal tubes and fibers overlap so as to give strength. With soft woods like pines, on the other hand, the tubes and fibers are stacked so the wood is softer. Oak is also ring-porous and there are distinct bands of large and small tubes laid down at different times of the year.

Oak as a species is also rich in tyloses, which are gummy structures that plug the xylem vessels. This is what makes the wood particularly good for holding liquids, as the path of the liquid through the wood is blocked by these tyloses. The American white oaks are the richest in these tyloses, which is why the barrel staves can be quarter-sawn without risk of leakage. With European oaks there are fewer tyloses so the wood is more porous and must be split to follow the tubes and then bent so that all the tubes are parallel to the stave, which helps minimize leakage. American oak also tends to be seasoned more crudely than European oak. American oak has a much

more obvious flavor, vanillin in character, and more aggressive tannins than the smoother, subtler oaks of Europe.

American Oaks - In 1987, according to a report published by the U.S. Forest Service, there were 24,497 million cubic feet of commercially important selected white oaks in the eastern United States. Only a certain proportion of this would be suitable for cooperage, where the quality criteria are much higher than for pulp. *Q. alba* grows in most of the eastern United States, and extends east from Minnesota, Iowa, Missouri, and Arkansas, north of Mexico, and south of Canada and Maine.

There is no general agreement as to which American regions provide the best oak for wine or whiskey barrels. Some people feel that oak from Minnesota and Wisconsin is best for wine barrels. Others feel that wood from these regions is too tannic. Wood from the more southerly parts of the U.S. is condemned by some for being too sappy. Oregon white oak, *Quercus garryana*, has also been used experimentally for wine barrels. This tree grows about 50 to 90 feet tall, and around 24 to 40 inches in diameter. There are approximately 6,000 million cubic feet of various species of oak in California, Oregon and Washington. But other than Oregon white oak, little is suitable for barrels. Oregon, or garry, oak has more tyloses than European oak, but not as much as American white oak. American oak is used widely by both makers of distilled spirits

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and wine in Spain, America, Asia, South America and Australia.

Western European Oaks - Oaks grow throughout Europe, as far east as the Urals, as far south as Sicily, as far west as Ireland, France, and Portugal, and as far north as southern Norway. *Q. petraea*, or sessile oak, can reach a height of 25 m and can live over 300 years. Branches form high up on the relatively straight trunk. Wood from this tree is usually tight-grained. This species grows particularly well in sandy, silty soil with good drainage, but also grows well in a variety of other soil types. In Europe it is found throughout the United Kingdom, from France east to Poland and the Baltic States and as far south as Italy and Yugoslavia.

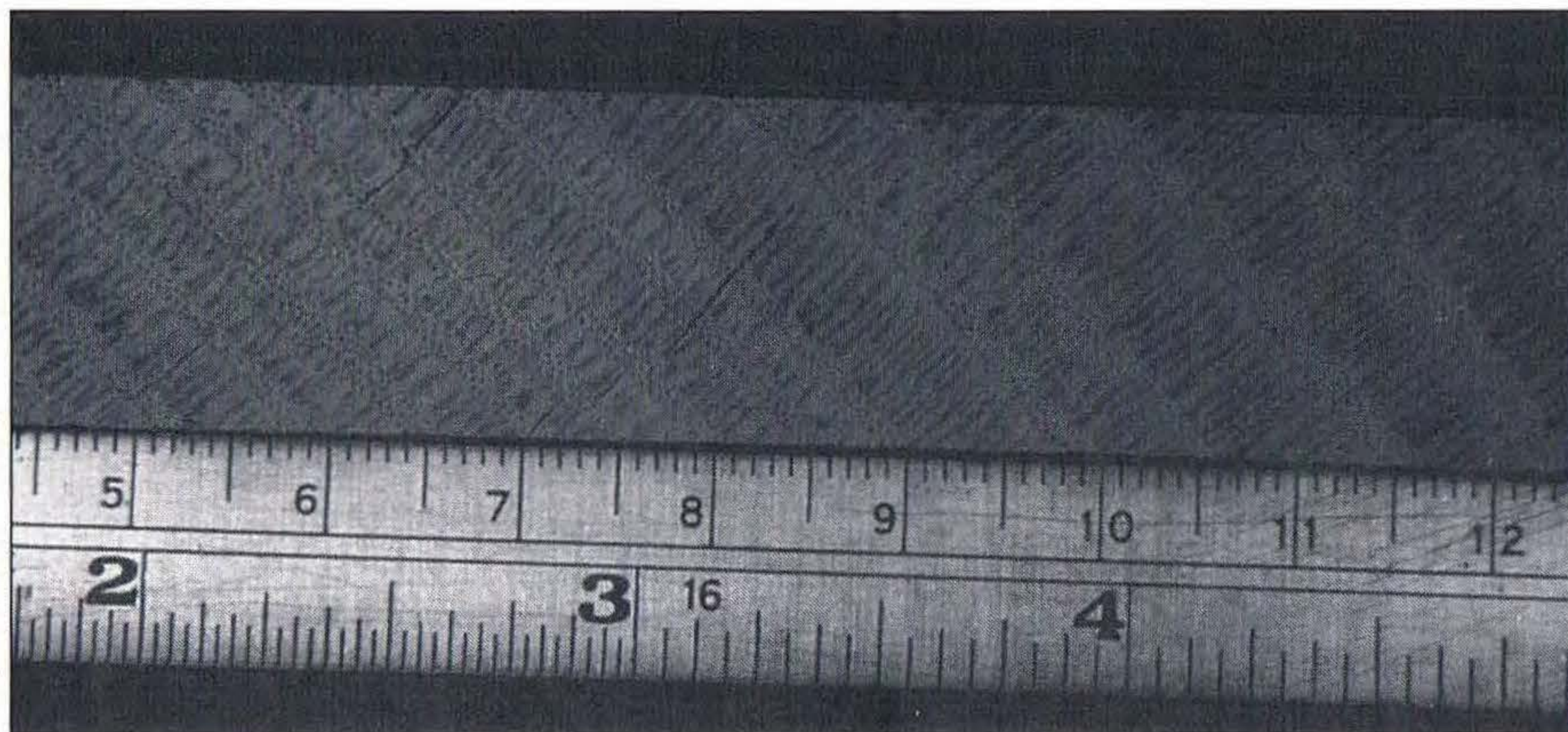
Q. robur, known as English or French oak, also grows to over 25 m in height and can live over 300 years. Its branches spread out to provide more shade than sessile oak and it tends to produce wide-grained wood. It prefers fertile soils where there is plenty of water. As *Q. robur* tolerates a wider range of growing conditions, it is more widespread in Europe than sessile oak. It extends further north into the Scandinavian countries, further south into Turkey, Georgia and Portugal, and east as far as the Urals. Wood from this species tends to have wider grains than sessile oak, although the two species can be positively

distinguished only by examination of leaves and acorns. The acorn of *Q. robur* is attached via a long peduncle whereas that of sessile oak is attached directly to the twig. However, there is much cross-fertilization between these two species so hybrids are common.

Coopers do not usually distinguish the two species in their workshops. Like wine-makers, they tend to pay more attention to forest location and grain size than to oak species.

Eastern European and Soviet Oaks - Historically, the forests of eastern Europe were important sources of oak, mainly *Q. robur* and *Q. petraea*. Before the second world war Polish, Russian and Baltic oaks were important in both the beer and wine industries and coopers have been scouting east keenly in search of good quality wood that can be bought more cheaply than French oak. Political changes in Eastern Europe in the late 1980s immediately resulted in Hungarian and Moravian oak being offered to wine-makers in the west.

There is plenty of oak in Eastern Europe, but many questions remain, such as how much of this wood is suitable for barrels? And how do the newly freed countries of Eastern Europe want to manage their forests? According to research done by Backman and Waggener of the University of Washington (USA) in 1988, the erstwhile



Quercus alba wood section, showing vigorous annual growth rings (growth direction is from left to right in this photograph). Darker wood is porous spring wood; lighter wood is denser, summer wood.

Soviet Union had approximately 9.7 million hectares of oak, of which around 3.1 million are located in the far eastern region, close to the Pacific Ocean. This is *Quercus mongolica*, not a species used for cooperage. About 1.7 million hectares are in the Ukraine and is said to add up to around 233 million cubic meters. Most of the balance, i.e. close to 4.7 million hectares with 763 million cubic meters of oak, is in European Russia.

Although in the 19th century Baltic oaks were prized by the French and British, it seems likely that very little oak suitable for cooperage is left in Lithuania, Latvia and Estonia. In the 1980s the then Soviet Union exchanged trade credits for thousands of oak barrels from cooperages in Cognac for use in its brandy industry.

This suggests that throughout much of the 20th century Soviet forestry management may have been less than perfect. It is possible that much of the million hectares of 'mature and fully mature'

oak growing in Russia — according to Soviet statistics — is copse-wood fit only for making fires.

French Oaks and Oak Growing Regions - Although Baltic and Slovenian oak was important in the 19th century, today French oak has become the standard by which all other oaks are judged. Thanks to sound forestry management, French oak is available in viable commercial quantities and can add to wine flavors that appeal to modern consumers. Almost a quarter of France, or nearly 14 million hectares, is forest, constituting more than 40 per cent of all forest in the European Community. About one third of this forestland supports oak.

There are 2,600,000 hectares of *Q. petraea* and *Q. robur*, the two species of oak of interest to the cooper, of which at least 2,000,000 hectares are located in the

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regions discussed below. It was estimated in 1986 that there were 430 million cubic meters of European oak growing in France. In 1987, for example, 1.76 million cubic meters of oak were harvested, of which between seven and ten per cent was used by the cooperage business.

Since 1947 around two million hectares of land in France have been re-forested. Unlike some other countries, where ancient stands of hemlock, spruce and fir have been cut down to make toilet paper and diapers, France has done a good job of managing its forests since World War II. Supplies of French oak — barring unusual circumstances such as dramatic climate change — should remain abundant. Silviculture is actively practiced in France so that trees in government-owned forests are not allowed to grow wild, but are carefully managed to yield suitable wood, just like any other crop, albeit one that can take two centuries or more to mature. In France, for every cubic meter of oak harvested in a year, three grow. Can we say the same thing in America?

Concern about the condition of the French forests dates back to at least 1291, when scholars note the mention of 'maistre des forets' in the Royal Ordinances. The most famous of these Ordinances was written during the regime of Colbert in 1669. Colbert is commemorated in the Tronçais

forest where he ordered oak trees to be re-planted for use in shipbuilding.

The French L'Office Nationale des Forets (ONF) stages auctions during the fall. As the ONF controls most of the oak forests with the kind of trees capable of providing stave quality wood, this governmental body can control prices and usually does so by limiting the amount of wood put on the market.

Oak logs from many different forests in France are used to make barrels. As there is no control over the use of regional names, the outsider can get confused quite easily. Limousin usually refers to forests east of Bordeaux and Cognac where *Q. robur* dominates. Wide grained wood — primarily used for brandy— is found here. Vosges wood is found in the mountain range of the same name in northeastern France. Wood character varies according to soil and climate. Allier, Nevers, Burgundy, and Center refers to trees found (and I am simplifying here) near Orleans, Moulins, Dijon, etc. Below are descriptions of each of the primary oak-growing regions in France and the wood grown there.

Western Loire and Sarthe - Woods from forests in the western Loire, from the Departements Indre, Cher and Indre-et-Loire, and in the Sarthe near Le Mans, have tight grains and are highly prized.

Limousin - Woods from the following regions in France are usually called Limousin: the eastern part of the Departement Deux-Sevres, Vienne, Hautes de Vienne, the northern part of the Correze, the Creuze, the eastern part of the Charente, the southern part of the Indre, and the northern part of the Dordogne. Soils here tend to be clay/limestone or granite. These woods are more tannic than the tight-grained woods.

Nievre and Allier - Woods from these two central departements just south of Sancerre go by many names. Sometimes this wood is sold under the name of the specific forest. Troncais, for example, is a government-owned forest north of Moulins, while Bertranges is a forest near Nevers. This oak may also be sold under the name of the region, such as Allier and Nevers. To many French wine-makers, however, all of this wood is regarded simply as "bois de centre," wood from the center of France. However these forests are named, the wood is usually tight-grained and is popular for both brandy and wine. Soil here tends to silica and clay. As stands are planted with close spacing, the trees are said to grow up, rather than out; hence the tighter grains.

Vosges - Wood from the Vosges forests west of Alsace became popular with wine-makers in the early 1980s. This wood is usually tight-grained and resembles the oak from Nievre and Allier. Oak experts say they can identify this wood by its "clear"

or "white" color. However, the character of Vosges woods varies according to the altitude of the stand.

Jura and Bourgogne - Just to the east of Burgundy are forests that traditionally supplied Burgundy with oak. These forests are still important and supply oak to Burgundian cooperages.

Argonne - Located near Champagne, this forest provides a small amount of oak for the cooperage business, principally for those few champagne producers who still ferment in barrels. Sometimes the wood is sold as Vosges.

Nomenclature and Chemical Properties of Wood

There is much confusion about nomenclature in the world of oaks. This means not only that wine-makers are suspicious about proclaimed wood origins, but that people use different definitions for the same name. Some would include wood from the western Loire in the category of 'bois de centre' while others would exclude anything but Nevers and Allier. Others will classify wood around Nevers with wood from the Yonne and Cote d'Or as "Bourgogne."

According to the L'Office Nationale des Forets, the five most important regions for oak were, as of 1987, Bourgogne (Cote d'Or, Nievre, Saone-et-Loire, and Yonne); Lorraine (Meurthe-et-Moselle, Meuse, Moselle, Vosges); Centre (Eure-et-Loire,

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Loiret, Loire-et-Cher, Indre, Cher, Indre-et-Loire); Champagne (Ardennes-Marne-Aube-Haute-Marne) and Franche-Comte (Doubs, Jura, Haute-Saone, Territoire de Belfort). The departements producing the most oak were, in order of importance, Haute-Saone, Nièvre, Yonne, Cote d'Or, Haute-Marne, Dordogne, Cher, Allier, Moselle, Saone-et-Loire, Loire-et-Cher, l'Orne, l'Eure, and la Sarthe.

The chemistry of wine maturation in wood is still not fully understood. Experience shows that wood (unlike amphorae and sealed vats made of inert materials) inevitably exposes the wine to a certain amount of oxygen and actively helps to clarify and stabilize the wine matured in it; quite apart from the wide range of flavors and characteristics added and transformed as a result of exposure to that particular wood. The wood in which a wine is fermented and/or aged has a profound and often complex effect on its flavor. Certain substances present in wood may be directly extracted and absorbed, without change, into the wine however. Those extractable substances identified in the most commonly used wood, are listed below.

Lactones –not a singing group - These compounds are responsible for what is generally called the aroma of oak, or

“oakiness,” described as coconut-like. Toasting of the wood increases this flavor, to a point. Open-air seasoning of the staves prior to manufacture generally decreases the lactones. These compounds can easily overpower a wine's inherent aroma.

Phenolic aldehydes - Vanillin is the best known member of this group. Toasting increases the level of these, as does seasoning in the open air. Barrel fermentation reduces their level.

Volatile phenols - These impart a spice-like character that is often described as clove or carnation. These decrease with seasoning of the oak.

Terpenes - These essential oils important in fruit, tea and perfume are found in American oak and, to a lesser degree, in some French oak. It is likely, but as yet unproven, that they have flavor effects. This was a particularly active area of wine research in the early 1990s.

Carbohydrate degradation products - This is a large and complex group that includes furfurals, which are produced from toasting wood sugars, and have a bitter almond flavor. Maltol and cyclotene also are produced from the toasting process and have not only caramel-like

flavors of their own, but also act as flavor potentiators. Like monosodium glutamate with food, these potentiators increase the perception of other flavors.

Tannins and other phenolics - These give color and astringency but, more importantly, act as a reservoir to balance the oxidative/reductive reactions of the wine, protecting it from oxidation and lessening the chance of unpleasant reductive aromas.

Barrel Manufacturing

Barrel manufacture involves far more than mere mechanics and the ability to fashion a watertight container out of nothing but bent wood. Every stage of barrel manufacture has an impact on wine matured in that barrel. First the tree is cut down, usually during the autumn or winter when the sap is down.

Cutting wood: Sawing vs. Splitting - Logs of appropriate lengths are cut and then split into four quarters lengthwise. The bark and sapwood are cut off so that staves may be cut from transversal (rather than tangential) sections of wood.

Because American oak is so much less porous than European, the logs can be quartered and then staves of American oak can simply be sawed from each quarter. In other words, the quartered bolts are placed on a conveyor belt and a saw parallel to the conveyor trims off a potential stave. Then the remainder of the bolt is flipped over and another cut is made. The worker does not have to concentrate on anything

but working quickly.

European oak could well leak if thus sawed, however, and staves have to be split much more carefully — following the grain — to minimize the risk of leakage. European oak was therefore traditionally split by hand so that the ax blade could follow the grain. Nowadays mechanically operated axes are guided through the wood sections and the resulting staves trimmed.

Drying Wood: Air vs. Kiln - After the wood has been split or sawed, it must be dried. Otherwise the wood continues to dry and wine may leak out of the barrel as it shrinks. The drying process can be achieved either naturally in the open air or artificially using kilns. French oak has traditionally been air-dried one year for every 10 mm in width, so that it takes between 18 and 36 months to “season” wood. It is dried in stacks of potential staves in the open, preferably on a site far from any industrial activity or any other source of pollution. This ties up so much capital for so long, however, that many cooperages have been forced to substitute artificial drying techniques, which generally take no more than 12 months.

Many quality-conscious wine-makers will pay a premium for wood dried in the open air, however. First, it is felt that kiln-dried wood does not dry properly and that the barrel made from these staves will leak more than those made from naturally seasoned staves. Second, natural drying

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tends to reduce the stable extractable compounds of the wood while heightening its aromatic potential. Traditional lore holds that as wood is seasoned outdoors and turns gray, darkening the ground beneath it, harsh tannins are being leached out of the wood. Wine matured in air-dried wood tends to taste less aggressively tannic than the same wine matured in kiln-dried wood. Recent research indicates that tannin levels do not change significantly in air-dried wood, although the threshold of sensitivity to tannin does rise, according to Australian research. French research indicates that molds and enzymes form on and in the wood. Bitter phenolics are neutralized and polysaccharides are liberated. Some cooperages maintain that it is not the duration of the air-drying process that is important, but the wood's exposure to rain and the temperature at which the wood is dried. Their wood may therefore be watered to simulate rain, but there has been little scientific analysis of results of this practice.

Assembling

After the staves have been deemed dry enough, they can be assembled into barrels. Barrel-making is made possible by the fact that wood can be bent when it has been heated. If the staves are shaped

properly, the result will be a barrel. All edges will meet properly and the barrel will hold liquid without any agent other than the hoops which hold the staves together.

First, the staves are sized and trimmed into oblong lengths that might be called a double taper. Traditionally this work, known as 'dressing' the staves, was done by hand. The stave was 'listed.' Listing means to give the double taper shape with a cooper's ax, known as a *doloire* in French. Then, the inside of the stave was 'scaloped' with a two handled hollowing knife to allow for easier bending. Finally the staves were joined on a jointer, known as a *colombe*. Here the staves were given their final shape — rounded at the bilge (the middle) and narrowed at the heads (the ends) — giving the barrel its proper shape. Nowadays most of this work is done with machines, even in France, at great savings of time and energy.

Finally, the cooper fits the staves in a frame so that each barrel will have the same circumference. An especially strong and wide stave is chosen for the stave into which the bunghole will eventually be drilled. Then he arranges these staves around an iron 'raising up' hoop, the result looking like a skirt or a teepee splayed out from the hoop at the top. This job calls for great manual dexterity. In many American cooperages machines can do much of this work.

Shaping and Toast

Research has shown that the heating process is one of the most important in barrel manufacture, modifying the wood's physical and chemical composition and profoundly influencing any wine stored in the barrel. Various sources of heat can be used to shape the barrel: natural gas, steam and boiling water, or the fire of wood chips. Some cooperages combine techniques and shape the barrel with the aid of boiling water or steam, then finish the barrel with a fire toasting.

The spectacle of the fire and the coopers knocking down the hoops and bending the barrels is exciting. A high degree of coordination is required. The would-be barrel is rolled over a cylindrical vented metal firepot, known as a *chaufferette* in which small oak chips are burned. The coopers walk round the barrel knocking down the temporary iron hoops.

Each cooper pounds his hammer on a hoop driver — a short block of wood with a flat metal end — while slapping a wet rag on the wood to keep it from getting too toasted too quickly. After the top of the barrel has been shaped, the coopers wrap cables around the base of the barrel and use a capstan to cinch up the base. Natural gas, boiling water and steam will heat the wood effectively and allow the cooper to bend the staves without creating blisters on their insides. Many wine-makers prefer this technique as the barrel is easier to clean. Other wine-makers prefer barrels shaped over a fire of wood chips, as the 'toast' on the inside of the barrel provides an interesting 'toasty' flavor to the wine.

These wine-makers feel that any extra effort in barrel maintenance is justified by the special flavor provided by this technique. The amount of time the barrel sits on the fire and the heat of the fire both have dramatic impacts on the appearance of the barrel's interior and on the resultant wine flavor. Nowadays wine-makers can order barrels 'toasted' to order. Some cooperages will use an electric ambient heater or a wood fire to 'toast' the heads too, although these are usually left untoasted.

The Heads

After the body of the barrel has been formed, then the heads, or barrel-ends, must be made and fitted. Five or six head staves are fitted together with wooden dowels or stainless steel *gudgeons* (headless nails). Reeds are placed between the head staves to prevent leaking. Then the head is cut to size, usually slightly oval in shape. Near each end of the body of the barrel, a groove, called the *croze*, is cut into the inside of the barrel. The head is cut at the edges so that it will fit into the *croze*.

Formerly, all of this work was done by hand, but now virtually all of it is done on machines which have replaced an array of traditional cooper's tools with names (adze, chiv, etc.) to delight the dedicated Scrabble player. Finally the head is fit into the barrel. To do this, the hoops are loosened and the head is inserted into the *croze*. Usually a flour paste is used to help prevent leaks between the head and the *croze*. Now it is ready to be filled with precious liquids.