

# 1989 James F. Guymon Lecture Distillation in Alambic

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Robert Léauté presented the James F. Guymon Lecture at the 40<sup>th</sup> Annual Meeting of the American Society for Enology and Viticulture in Anaheim, California, on 30 June 1989. Léauté has been with Rémy Martin since 1973 and is currently Head Cognac Master, Research and Development Manager, and RMS Vineyards Technical Advisor. The text of his presentation has been edited for publication, but not subjected to the normal review process.

## History of Distillation

Distillation is a very old technique which was used by the Chinese 3000 years BC, the East Indians 2500 years BC, the Egyptians 2000 years BC, the Greeks 1000 years BC, and the Romans 200 years BC. In the beginning, all of the above cultures produced a liquid, later called alcohol by the Arabs, which was used for medicinal purposes and to make perfumes. (Fig. 1).

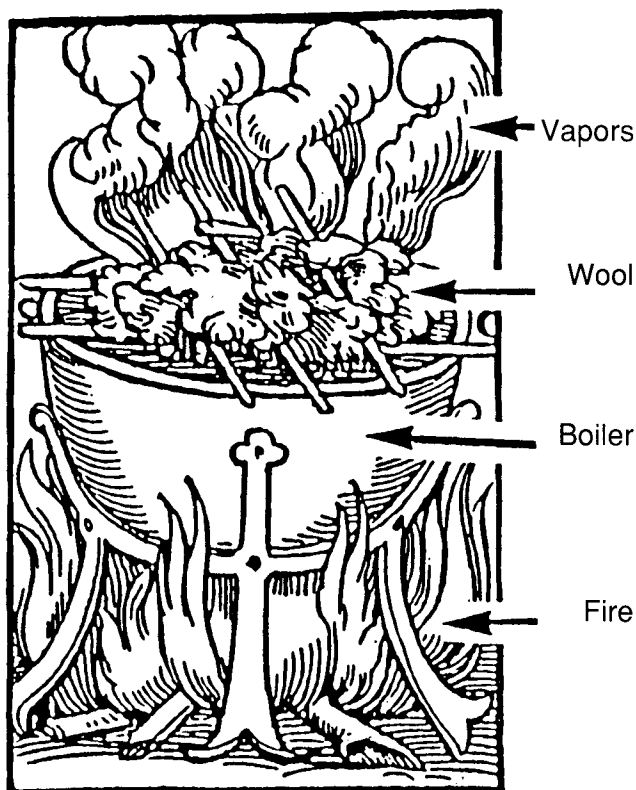


Fig. 1. Early still. Part of the vapors were condensed in the wool. The wool was changed from time to time to obtain the distillate.

By the sixth century AD, the Arabs had started to invade Europe and at the same time released the technique of distillation. Alchemists and monks progressively improved both the technique and the distillation equipment (Fig. 2). In 1250, Arnaud de Villeneuve was

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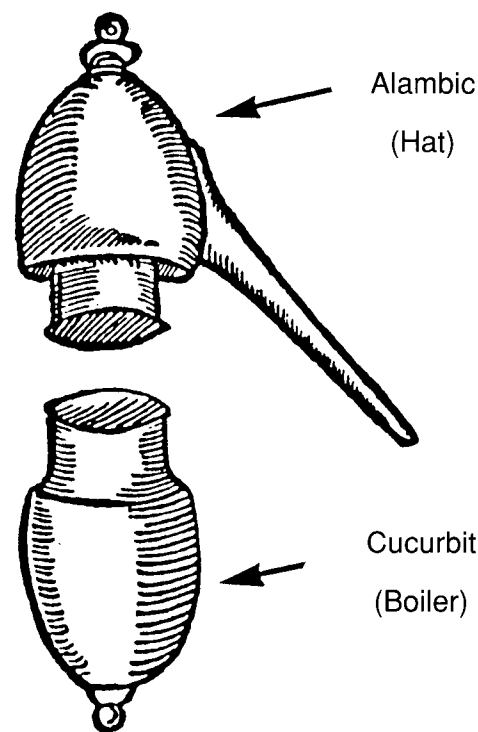


Fig. 2. Later distillation equipment.

the first to distill wines in France; he called the product which resulted from this process *eau-de-vie* or *water of life*. He attributed to it the virtue of prolonging life.

**Origin of the alambic still:** Today, the pot still used in the Cognac area is known as an alambic. "Ambix" is a Greek word defined as a vase with a small opening. This vase was part of the distillation equipment. Initially, the Arabs changed the word "Ambix" to "Ambic" and called the distillation equipment "Al Ambic." Later in Europe, the word was changed to alambic. The Dutch, French, Irish, Scottish, and others started producing distilled spirits around the 15<sup>th</sup> and the 16<sup>th</sup> century. They created gin (Holland), whiskey (Scotland and Ireland), Armagnac (France), and Cognac (France).

If the capacity of the still depended on the purpose of the distillation, then the shape was related to the country which used the distillation equipment. In the Cognac region around 1600, the Chevalier of Croix Marron perfected the *eau-de-vie* through double distillation. In France, Chaptal (1780) and Adam (1805)

dramatically improved the efficiency of distillation and gave the alambic its final design. The Cognac makers, continually seeking to obtain the best quality for their Cognac, brought both the alambic design and the double distillation methods to the peak of perfection.

In North America, bourbons and whiskies were first produced around 1750. In the booklet **America Brandy Land**, published by the California Brandy Advisory Board, the Mission San Fernando produced around 2000 barrels of brandy during the 1830s. Father Duran, the brandy maker at Mission Santa Barbara, produced brandy double distillation.

Progressively during the 1950s, most of brandy producers gave up distilling. Those who continued to

distill preferred use of the column still because of its ability to produce a brandy compatible to the consumer trend.

During the last decade, in California, one has noticed the American palate becoming more and more educated and ready for sophisticated products. At the same time, many wines and sparkling wines have reached a very high level of quality and are recognized as world class products. In the 1980s, well-established and new brandy producers decided the time had come to develop a more complex California brandy. Today, if one produces a brandy using an "alambic" and the Cognac distillation method, the brandy can be called alambic brandy.

### Cognac Type of Still - Alambic

The most famous alambic manufacturers (Binaud, Chalvignac, Mareste, R. Prulho) are based in the Cognac area.

**Raw materials to manufacture alambics:** An alambic is made of copper and bronze. Some of the alambic parts not important to the quality of the Cognac or the brandy can be made of stainless steel for practical reasons (e.g., valves, fittings, condenser tank). However, copper remains the most efficient metal to build alambics. Copper offers the following advantages: it is malleable; it is a good conductor of heat; it resists corrosion from fire and from wine; it reacts with wine components such as sulfur components and fatty acids (this property is always favorable for the Cognac or brandy quality); and it is a catalyst for favorable reactions between wine components.

*Copper boiler (A):* When the boiler is filled with 660 gallons of wine, the head space above is around 130 gallons. The boiler is the main part of the alambic, and it is specially built for to withstand continuous direct flame of approximately 1500°F and for ease of cleaning. The inside of the boiler is well polished so that the copper presents a smooth surface for easy cleaning. The boiler is in constant contact with the direct flame fueled by natural gas, propane, or butane. Boiler equipment includes the pipe to fill the boiler, the vent, the side glass, the sprinkler to clean boiler, and the valve to empty the boiler (Fig. 4).

*Hat (chapiteau, chapeau) (B):*

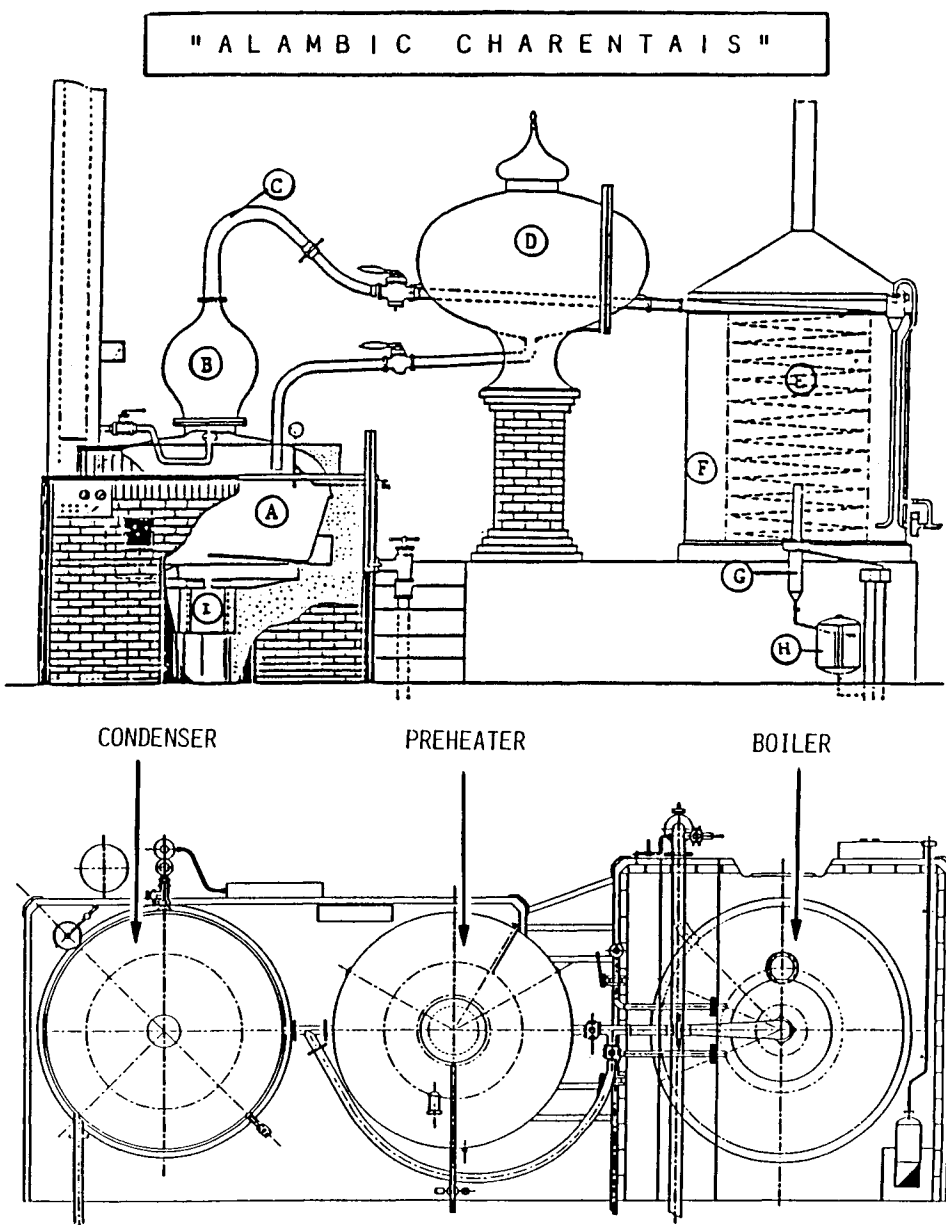


Fig. 3. Diagram of the Cognac still - alambic: A standard alambic is 2500 liters (660 gal) capacity. (A) copper boiler (chaudiere); (B) hat (chapeau, chapiteau); (C) swan's neck (col de cygne); (D) preheater (chauffe-vin); (E) coil (serpentin); (F) condenser (condenseur, pipe); (G) hydrometer port (port-alcoometre); (H) heads tank (cuvon de tetes); (I) gas burner (bruleur). (Courtesy of R. Prulho, Cognac.)

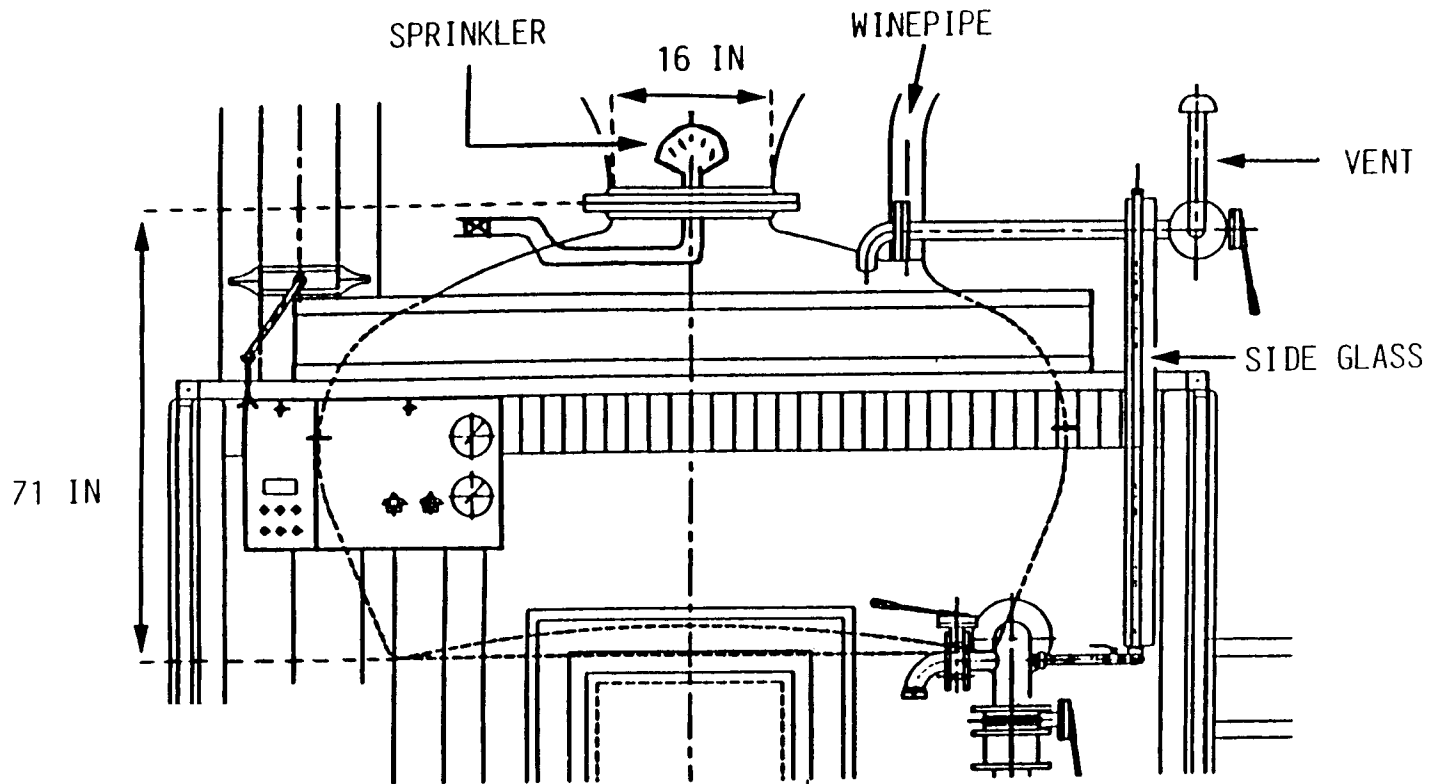


Fig. 4. (A) Copper boiler (chaudiere). (Courtesy of R. Prulho, Cognac.)

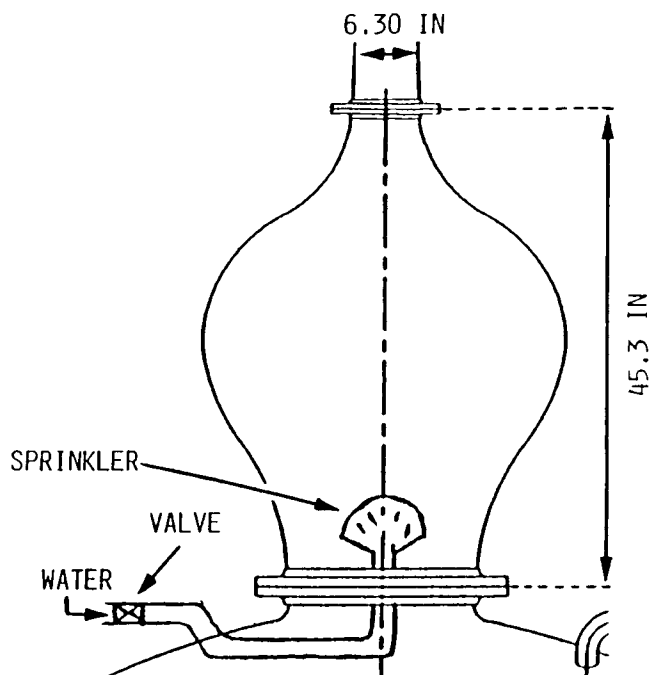


Fig. 5. (B) Hat (chapeau, chapiteau). (Courtesy of R. Prulho, Cognac.)

This part of the alambic is located directly above the boiler. The volume of the hat is approximately 10% to 12% of the capacity of the boiler, depending on the specifications required by the distiller.

The shape and the volume of the chapiteau determine the concentration, selection, and separation of the

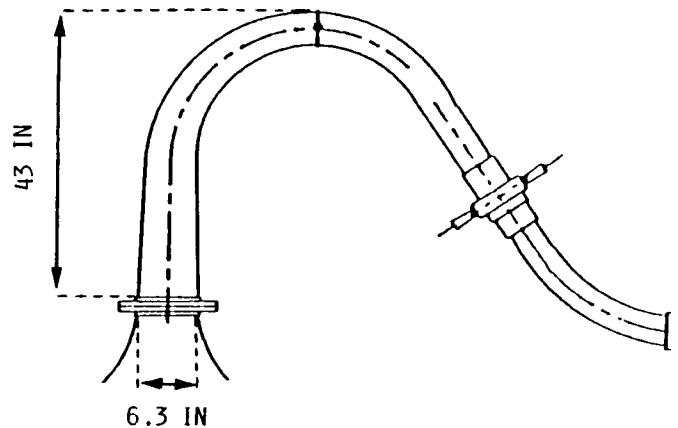


Fig. 6. (C) Swan's neck (col de cygne). (Courtesy of R. Prulho, Cognac.)

different volatile components. This selection process occurs when volatile compounds condense in the chapiteau and fall back down into the boiler, where they must be re-distilled upward. This phenomenon is called the reflux process (Fig. 5).

*Swan's neck (col de cygne) (C):* This part of the alambic is curved like the neck of a swan and directs the vapor into the coil. The height and the curve of the swan's neck are extremely important to the reflux process (Fig. 6).

*Preheater (chauffe-vin) (D):* This is a cost effective part of the alambic. The swan's neck pipe runs through the preheater and around its back. During the first hours of distillation, one refills the preheater for the next batch of distillation. By directing the hot vapors of

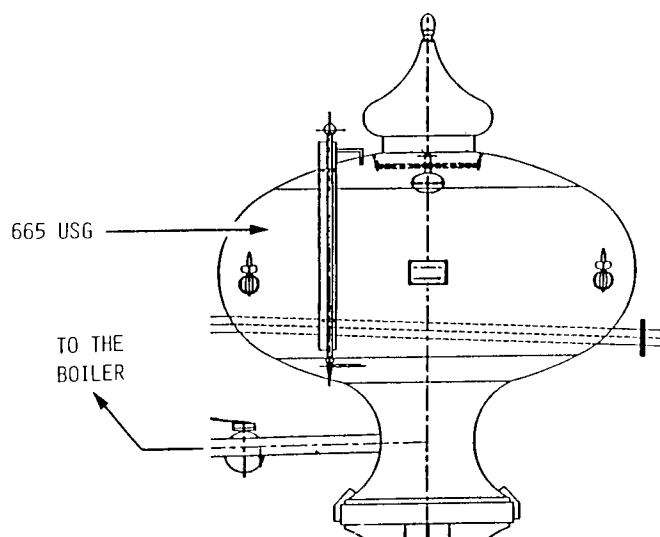


Fig. 7. (D) Preheater (chauffe-vin). (Courtesy of R. Prulho, Cognac.)

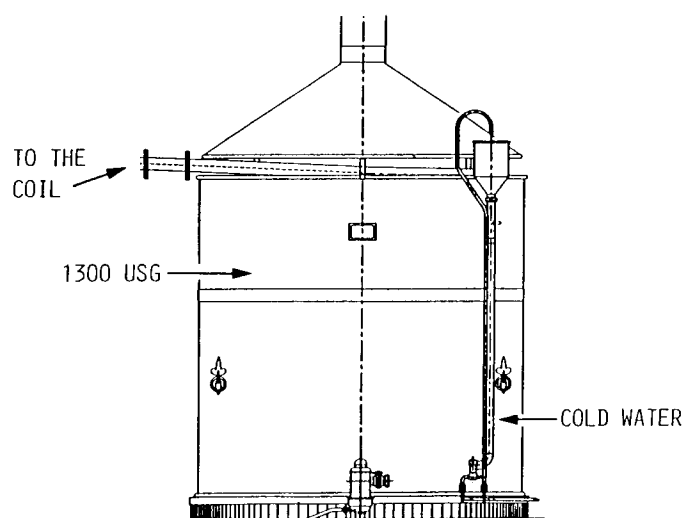


Fig. 9. (F) Condenser (condenseur). (Courtesy of R. Prulho, Cognac.)

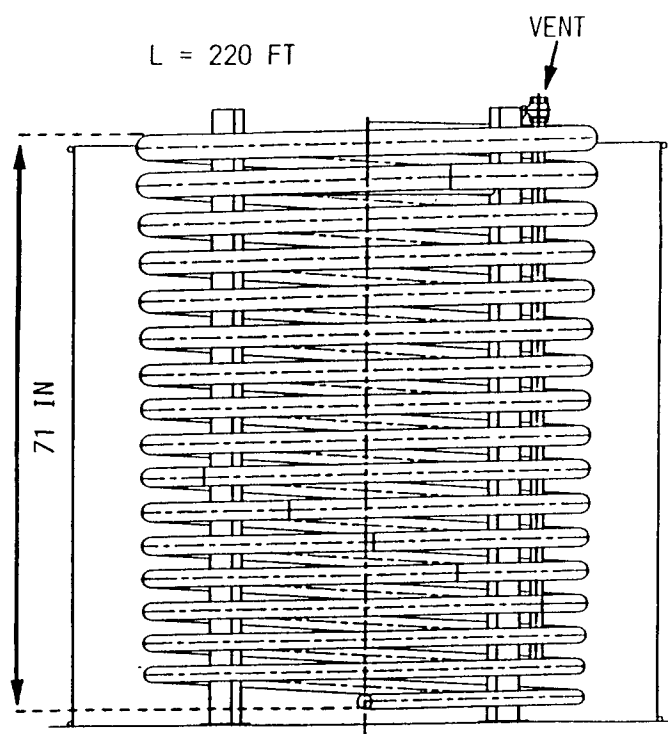


Fig. 8. (E) Coil (serpentin). (Courtesy of R. Prulho, Cognac.)

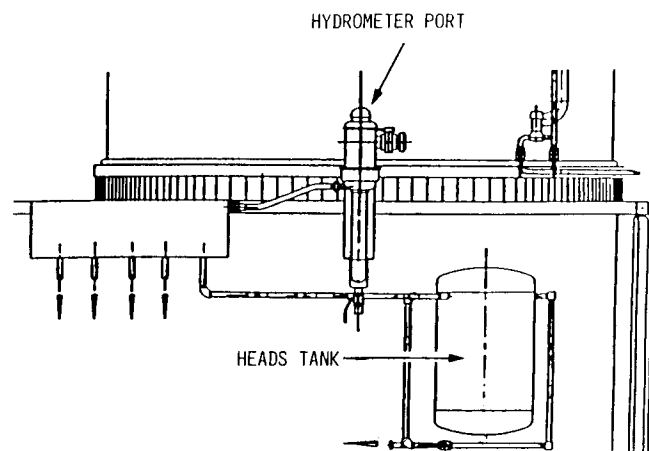


Fig. 10. (G) Hydrometer port (porte-alcoolmètre). (Courtesy of R. Prulho, Cognac.)

the currently distilling pot still through the preheater, the wine can be preheated for the next distillation. The alternative pipe running around the outside of the preheater is used when the temperature of the contents in the preheater is correct; this will avoid over-heating the contents of the preheater (Fig. 7).

**Coil (serpentin) (E):** The coil pipe is also made of copper. During the condensation, the copper reacts with components of the distillates (sulfur components and fatty acids) to give insoluble combinations. These combinations are removed from the distillate by filtration when they reach the hydrometer port. The coil has two

functions: to condense the vapors and to cool the distillate to proper temperature for filtration. At the beginning of the coil, to facilitate the condensation, the coil has a larger diameter. Progressively, the coil diameter becomes smaller until it reaches the hydrometer port (Fig. 8).

**Condenser (condenseur) (F):** This is a cylindrical tank made of copper or stainless steel which contains the copper coil pipe. Its capacity is around 1300 gallons. The condenser is filled with water during distillation. Cold water enters the condenser at the bottom, while the hot water, heated during the condensing process, exits off at the top of the condenser. (Fig. 9).

**Hydrometer port (porte-alcoolmètre) (G):** The hydrometer port is also made of copper and has several purposes: to filter the distillate, to monitor the temperature, to monitor the alcohol content of the future Cognac or brandy, to offer an access point for the distiller, and to check the progress of the distillation (Fig. 10).

**Heads tank (H):** This is a small stainless tank (15 gal capacity) used to collect the first part of the distillate,

called the heads.

**Gas burner (I):** The gas burner is equipped with a pilot light and a reliable security system. The most commonly used fuels are propane, butane, and natural gas. The gas panel to monitor the burner is located at the front of the alambic. Under the boiler, the temperature reaches 1400°F to 1600°F. This high temperature is essential to heat and cook the wine to create aromas during the distillation process. (Fuel usage: 450 pounds of liquid propane is required to produce 100 gallons pure alcohol of Cognac or brandy).

### Processing Aspects

**Theory of distillation in the case of batch distillation:** Distillation is the technique used to separate and select, by use of heat, specific volatile components from a liquid mixture (e.g., wine).

**Laboratory still:** The mixture (e.g., wine) is loaded into the boiler and heated by a gas burner for partial vaporization. The vapor is condensed and then collected into one or a series of fractions. All of these fractions are called distillate (Fig. 11).

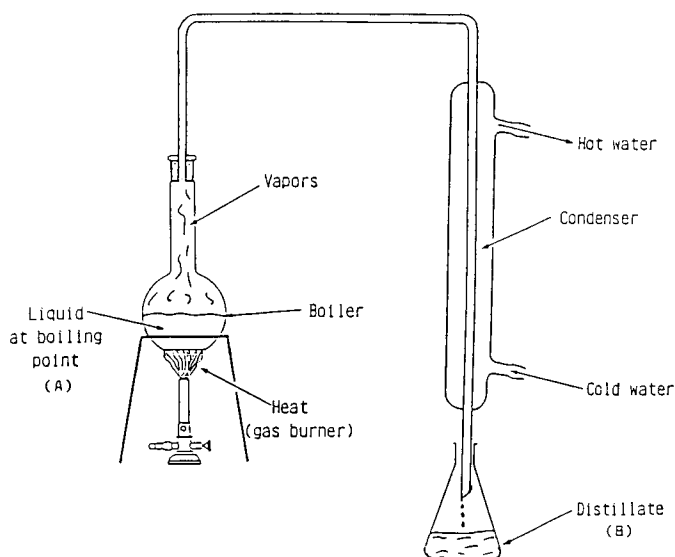


Fig. 11. Laboratory still.

**Binary distillation. Water/alcohol equilibrium:** Wines can be considered roughly as a mixture which contains mainly water and alcohol. The boiling points at atmospheric pressure (760 mm) of water and alcohol are: water, 212°F (100°C); alcohol 173.3°F (78.5°C). This mixture is homogeneous because only one liquid phase is present. In addition, it is a binary azeotrope with a minimum boiling (Fig. 12).

During the Cognac distillation, the alcohol content of the distillate always stays below 96% alcohol by volume (max. 80% (alc/vol)). The Cognac distillation only takes place in the part (B) of the diagram. In this case, the vapor-liquid equilibrium diagram is like a single-phase binary mixture.

**Double distillation technique:** The first mixture, A,

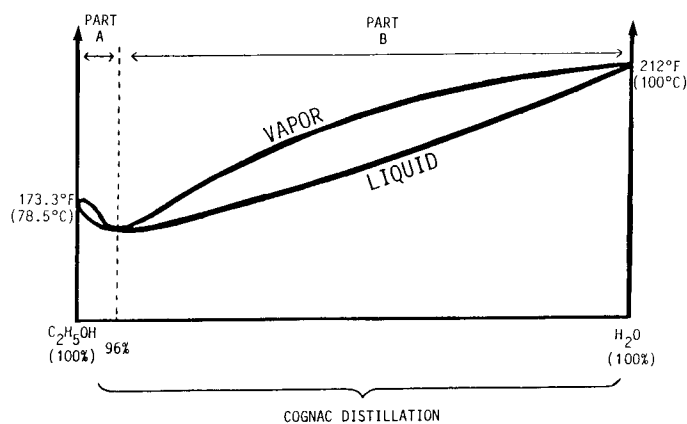


Fig. 12. Vapor-liquid equilibrium diagram of water/alcohol mixture.

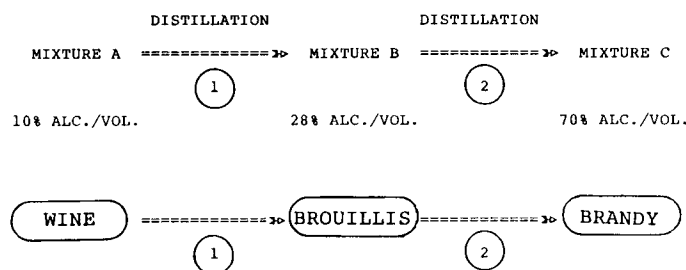


Fig. 13. Double distillation technique

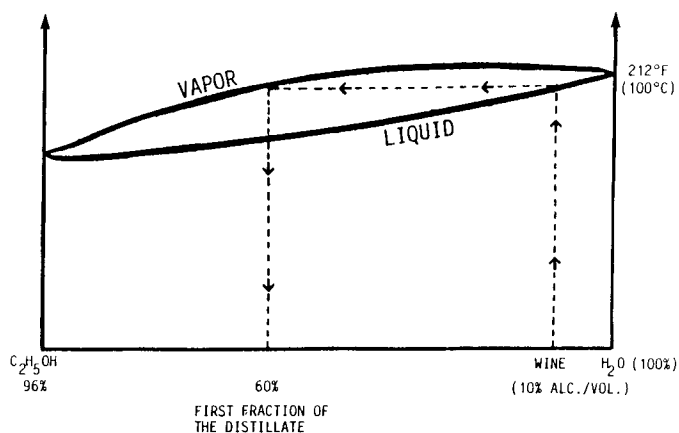


Fig. 14. First distillation diagram.

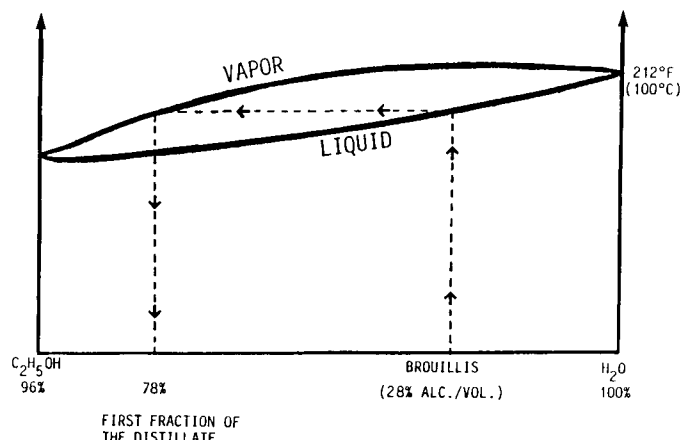


Fig. 15. Second distillation diagram.

is distilled to produce a second mixture B. When mixture B is sufficient in volume, mixture B is then distilled to produce mixture C. This is known as the double distillation technique (Fig. 13, 14, 15).

**The double distillation. Variations of the alcohol content:** *Example: wine at 10% (alc/vol).*

*First distillation:* The distillate is cut into three

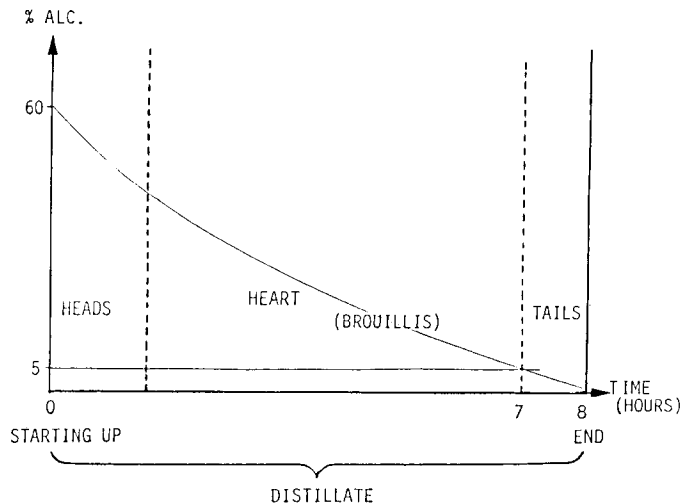


Fig. 16. First distillation (wine).

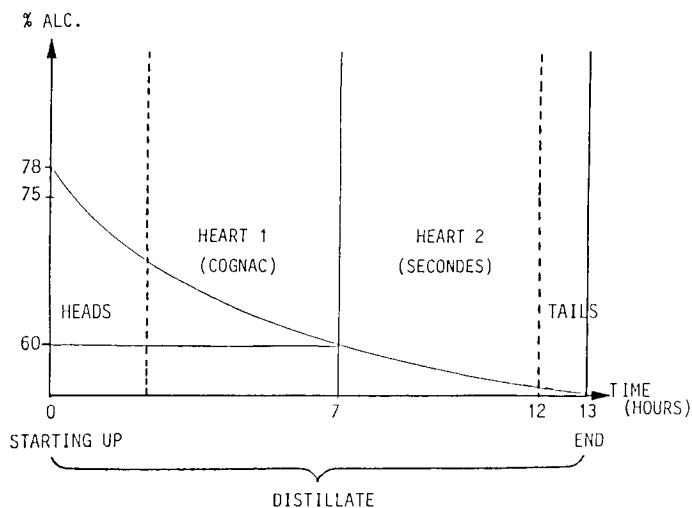


Fig. 17. Second distillation (brouillis).

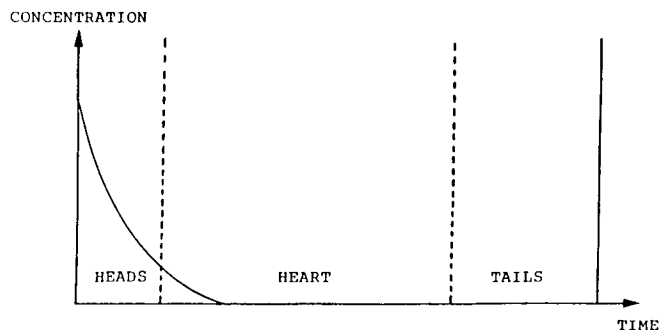


Fig. 18. Distillation curve (Type 1). Examples: acetaldehyde, ethyl acetate.

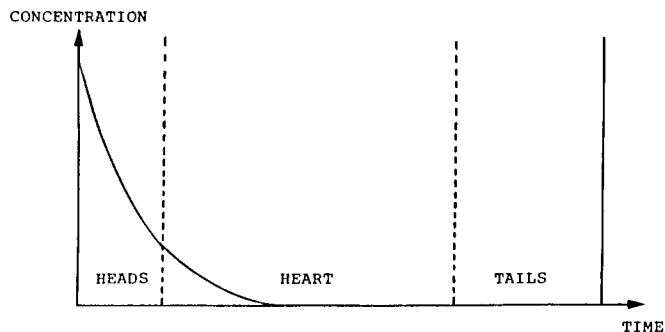


Fig. 19. Distillation curve (Type 2). Examples: ethyl caproate, isoamyl acetate, ethyl caprylate, ethyl caprate, ethyl laurate.

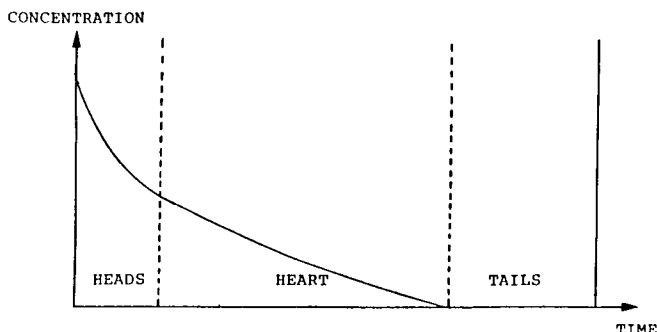


Fig. 20. Distillation curve (Type 3). Examples: methanol, isobutanol, methyl-2-butanol and methyl-3-butanol.

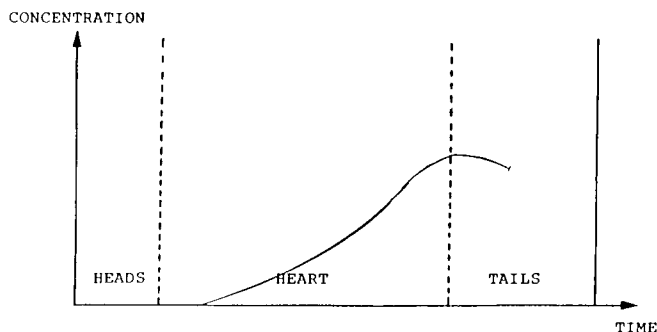


Fig. 21. Distillation curve (Type 4). Examples: acetic acid, 2-phenyl ethanol, ethyl lactate, diethyl succinate.

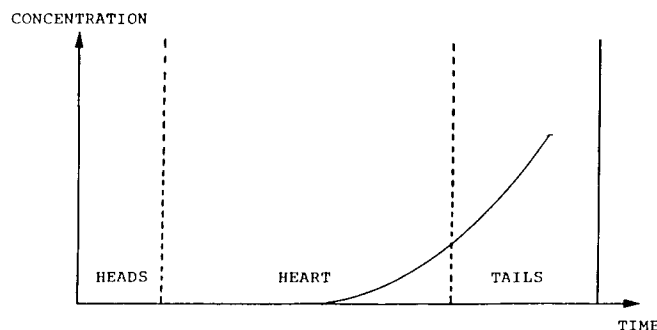


Fig. 22. Distillation curve (Type 5). Example: furfural.

fractions: heads, heart or brouillis, and tails. The alcohol content of the distillate is around 60% (alc/vol) in the first fraction and reaches 0% (alc/vol) at the end of the first distillation (Fig. 16).

*Second distillation:* The distillate is cut into four fractions: heads; heart 1, or Cognac (or brandy); heart 2 or secondes; and tails. The alcohol content of the distillate is around 80% (alc/vol) in the first fraction and reaches 0% (alc/vol) at the end of the second distillation (Fig. 17).

#### Distillation of volatile compounds of wines:

The wines contain approximately 300 volatile compounds, and except for water and alcohol, it is very complex to calculate the volatility coefficient K for each of them.

*How the volatile compounds distill:* Each volatile component will distill following three criteria: boiling point, relationship with alcohol or water, and the variation of alcohol content in the vapor during the distillation. With respect to the relationships with alcohol or water, there are several possibilities: (1) the component is completely or partly soluble in alcohol and will distill when the vapor is rich in alcohol; (2) the component is soluble in water and will distill when the vapor is low in alcohol; (3) the component is soluble in both alcohol and water and will distill throughout the entire distillation; or (4) the component is not soluble in water, but the water vapor will carry over this component (hydrodistillation).

*Classification of volatile compounds (in the case of the first distillation):* Type 1 components (which distill first) have a low boiling point and are soluble in alcohol. [Examples: acetaldehyde, BP 21°C (69.8°F); ethyl acetate, BP 77°C (170.6°F)]. The majority of such components distill at the beginning of each distillation. Their concentration is very high in the heads and at the beginning of the heart (Fig. 18).

Type 2 components (which distill at the beginning of the distillation) have the following characteristics: relatively high boiling point and complete or partial solubility in alcohol.

Fatty acids and fatty esters are in this category. [Examples: ethyl caprylate, BP 208°C (406.4°F); ethyl caprate, BP 244°C (471.1°F); ethyl laurate, 269°C (516.2°F); ethyl caproate, BP 166.5°C (331.7°F); and isoamyl acetate, BP 137.5°C (279.5°F)]. Some of these components finish distilling in the middle of the heart (Fig. 19).

Type 3 components (which are in the heads and in the heart of the distillate) have a low boiling point (not above 200°C), are soluble in alcohol, and are completely or partially soluble in water. [Examples: methanol, BP 65.5°C (150°F); higher alcohols: 1-propanol, isobutanol, methyl-2-butanol and methyl-3-butanol (Fig. 20).]

Type 4 components (which start distilling during the middle of the heart) have a boiling point above that of water and are soluble or partially soluble in water. [Examples: acetic acid, BP 110°C (230°F); 2-phenyle-

thanol, ethyl lactate, and diethyl succinate are in the same case (Fig. 21)].

Type 5 components (which appear during the distillation) have a high boiling point and are very soluble in water. They start distilling during the middle of the heart. [Example: furfural: 167°C (332.6°F).] The concentration of furfural increases in the middle of the heart to the tails (Fig. 22).

During the second distillation, the curves are slightly different because of the increased alcohol content of the brouillis. The heating program established for distillation of wine and brouillis can certainly influence the concentration of components in the distillates. Higher heat is favorable for the less volatile components, as increased heat will allow them to distill earlier and to be present in the first fractions of the distillation in higher concentration.

#### Distillation process. Three distillation processes exist in the Cognac region, the most common being:

*First distillation:* The distillation of wine gives three fractions; heads, heart (brouillis), and tails. Heads and tails are re-distilled with the succeeding batch of wine. The brouillis is used for the second distillation, also called "bonne chauffe". *Second distillation:* The distillation of brouillis gives four fractions: heads, heart 1 (Cognac), heart 2 (secondes), and tails. Heads and tails are re-distilled with the succeeding batch of wine. Secondes are re-distilled with brouillis. [Note: The mixture remaining in the boiler after distillation is known as "stillage". This dealcoholized solution must be treated to avoid pollution problems (Fig. 23).]

#### The first distillation - brouillis production:

The running time:	
To remove the stillage	
To clean the alambic	0:30 min
To fill the boiler with wine	
Duration to reach boiling point	1:30 min
Heads	0:15 min
Brouillis	6:00 h
Tails	1:00 h
Total	9:15 h

Each fraction is obtained at a temperature below 60°F. In this case, they are removed by filtration combinations between sulfury components and copper and a part of fatty acids and copper (Fig. 22).

#### The second distillation or bonne chauffe:

Running time:	
To remove the stillage	
To clean the alambic	0:30 min
To fill the boiler with brouillis	
Duration to reach boiling point	1:30 min
Heads	0:30 min
Cognac	6:00 h
Secondes	4:30 h
Tails	1:00 h
Total	14:00 h

Fig. 23. The Cognac distillation process.

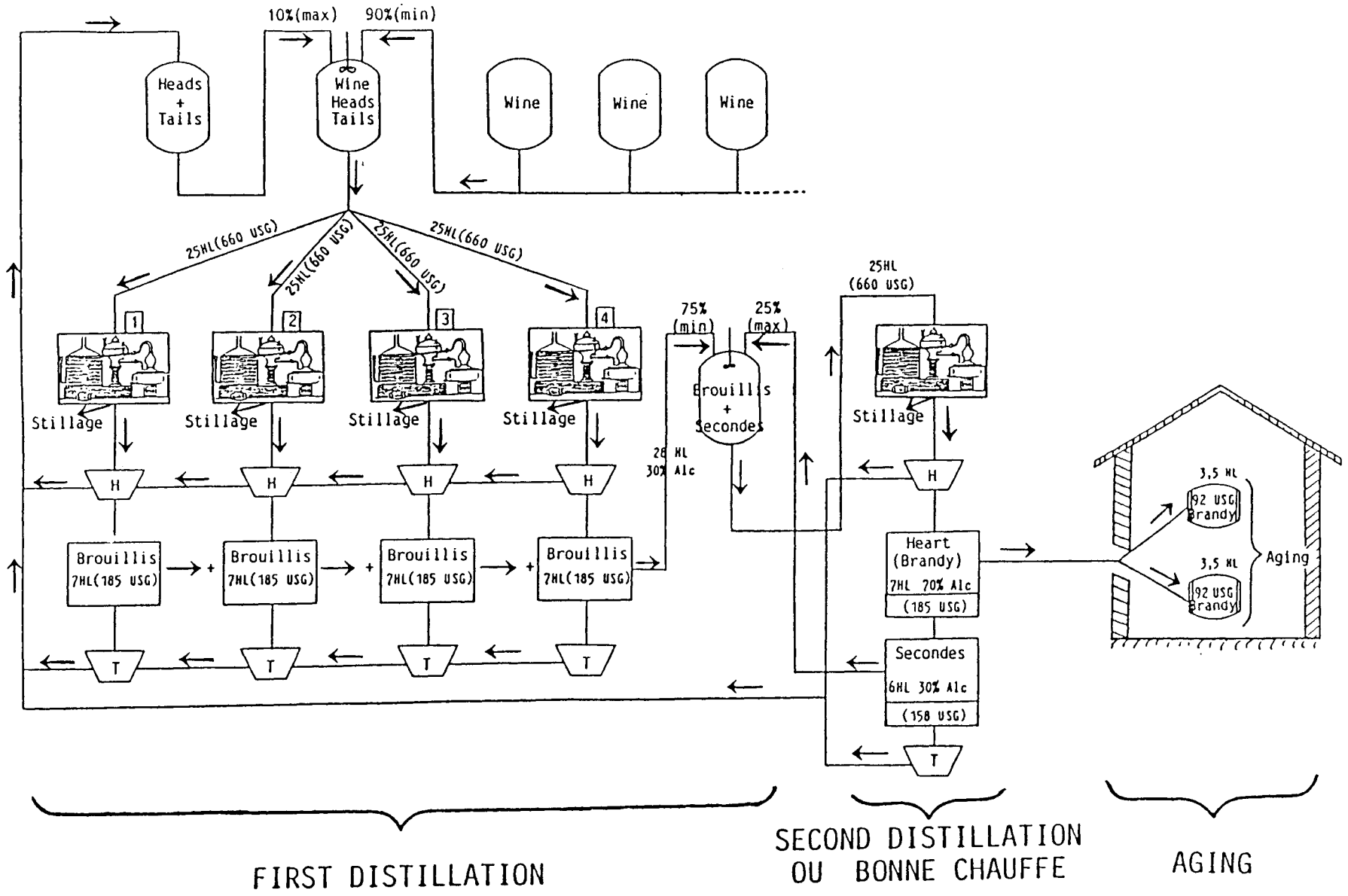




Fig. 24. First Distillation: Brouillis Production.

Running time: 9 to 10 hours

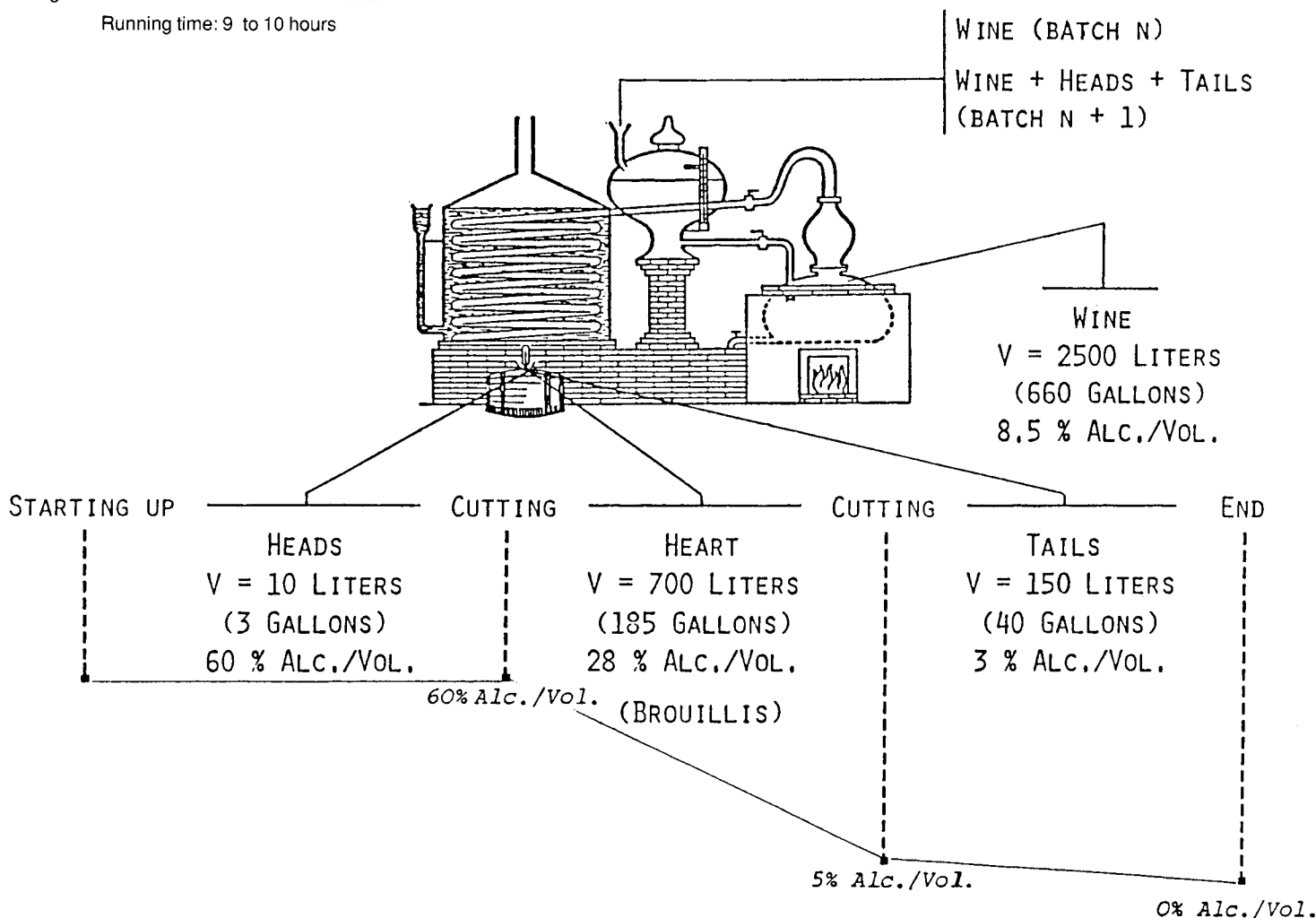


Table 1. Cutting data - first distillation.

Wine alcohol content (%alc/vol)	Cutting between brouillis and tails (% alc/vol)	Volume of brouillis (gal/L)	Volume of tails (gal/L)
7	6	180/680	47.5/180
8	5	185/700	40/150
9	3.5	190/720	16/60

Heads and Cognac are obtained between 62°F and 66°F and secondes below 60°F like the brouillis during the first distillation (Fig. 25).

**Cutting data:** Generally wine for distillation in the Cognac Region contains 7% to 9% alcohol, depending on the Harvest conditions for the year.

*First distillation:* To produce the brouillis during the first distillation at 28% (alc/vol), the distiller must cut the three fractions differently (Table 1).

*Second distillation (bonne chauffe):* If the alcohol

content of brouillis is around 28% (except for quality aspects), the cuttings remain the same. It can be noted, however, that a slightly higher alcohol content (28.5% to 29%) is obtained from distilling a mix of brouillis (75%) and secondes (25%) (Table 2).

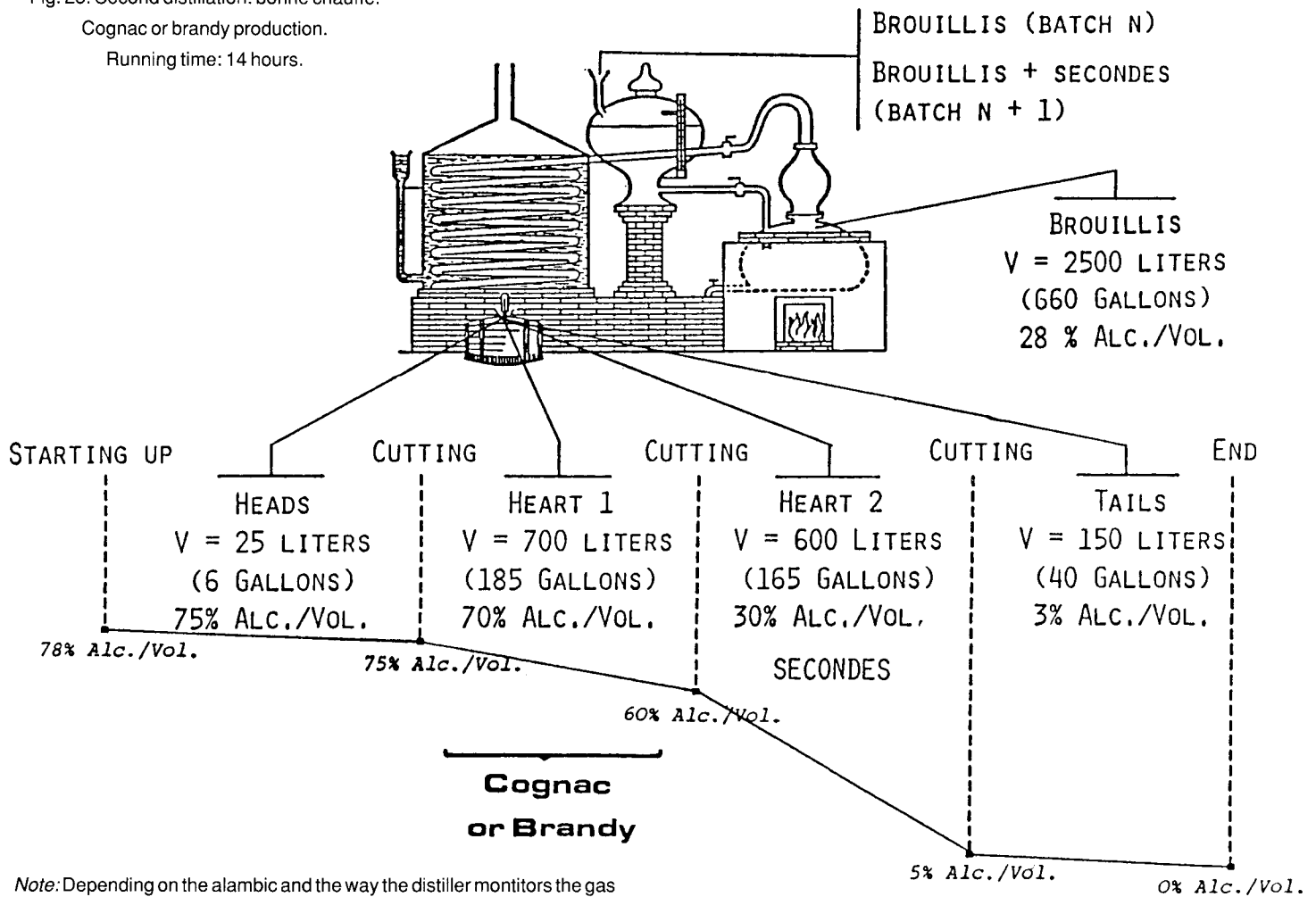
### Wines for Distillation

Wines for distillation must be specially made wines. In other words, the choice of grape varieties, the growing region, the time of grape harvest, and the technology of wine making are specifically defined to produce a wine for distillation. The purpose is not to make a table wine but to make the best possible raw material to distill and produce a quality brandy.

**Wines in the Cognac area.** *Grape varieties:* Several white grape varieties may be used to produce Cognac. However, the Ugni blanc accounts for 94% of the total vineyards planted today (Table 3).

*Characteristics of Cognac wines:* The Ugni blanc is the predominant grape variety. Originally, it was an

Fig. 25. Second distillation: bonne chauffe.  
Cognac or brandy production.  
Running time: 14 hours.



Note: Depending on the alambic and the way the distiller monitors the gas flow, the fraction volumes for the first and the second distillation may differ slightly.

Table 2. Cutting data - second distillation

Alcohol content of brouillis (%alc/vol)	Cutting between Cognac & secondes (% alc/vol)	Volume of Cognac produced (gal/L)	Volume of secondes produced (gal/L)
28	60	185/700	158.5/600
29	59	193/720	169/640

Table 3. Grape varieties for Cognac production.

Grape variety	Percentage of the total area
Ugni blanc	94%
Colombard	4%
Folle Blanche	1%
	<b>99%</b>
Miscellaneous <sup>1</sup>	1%

<sup>1</sup>Secondary grape varieties such as Jurancon, Semillon, Montils, Blanc Rame, Select 100 T, represent 1%.

Table 4. Characteristics of Cognac wines.

	Tasting (ideal comments)
Appearance	pale green yellow
Nose	little nose and never powerful delicate fruity and flowery aroma slightly lemony (sometimes)
Mouth	notably big acid very fresh no sugar, very dry no bitterness clean in the finish

Italian variety known as Trebiano. Because of the climate and the latitude of Cognac area, the Ugni blanc does not reach maturity, and this is a quality factor (Table 4).

Analysis: See Table 5.

Other components of Cognac wines: See Table 6.

Table 5. Characteristics of Cognac wines.

Classic analysis			
Percent alcohol by volume	7	to	9
Dry extract (g/100 mL)	2	to	2.5
Total acidity (tartaric acid g/100 mL)			
before malolactic fermentation	0.7	to	1.0
after malolactic fermentation	0.5	to	0.7
Volatile acidity (mg gallic acid/L)			
before malolactic fermentation	0.01	to	0.02
after malolactic fermentation	0.02	to	0.03
Reducing sugar (mg/L)	below 1000		
Total phenols	below 200		
Total SO <sub>2</sub> (mg/L)	0 or trace		

Table 6. Cognac wine (harvest 88) gas chromatography analysis.

	(mg/L)
<b>Alcohols</b>	
Methanol	18.30
Propanol	34.80
Isobutanol	88.30
Methyl-2-butanol-1	
Methyl-3-butanol-1	175.10
2-phenylethanol	20.10
Hexanol	1.60
Hexenol	0.40
<b>Polypols</b>	
2-3-Butanediol	390
Glycerol	5650
<b>Aldehydes</b>	
Acetaldehyde	9.60
Benzaldehyde	0.03
<b>Esters</b>	
Ethyl acetate	33.40
Isoamyl acetate	3.00
Ethyl hexanoate	0.50
Ethyl caprylate	0.80
Ethyl caprate	0.20
Ethyl laurate	36.10
Ethyl lactate	0.20
Diethyl succinate	
<b>Miscellaneous</b>	
Damascenone	0.01
α-Terpineol	0.004

\*Rémy Martin Research and Development Laboratory.

### Winemaking for Cognac:

Harvesting	by hand or by picking machine
Crushing	unnecessary if utilizing a picking machine
Pressing	with the stems in horizontal press
No SO <sub>2</sub>	no clarification
Fermentation	with natural yeasts above 68°F
Racking	no racking after fermentation
Storage	the wine is kept at temperature below 50°F in tanks and protected against oxidization

**California wines for distillation:** In California, both pot and column stills are used to produce brandy. Regarding the Cognac wine characteristics, the distillers tried to use wines for distillation which have a few similarities.

In 1973, Professor James F. Guymon, after studying several grape varieties, came to the conclusion that the early-harvested French Colombard wines produces a better brandy than Thompson Seedless.

In 1978, Onishi *et al.* distilled in a pot still following the Cognac method wines of Thompson Seedless, Sauvignon blanc, Peverella, and French Colombard. He confirmed Professor Guymon's conclusion that the French Colombard produces a better brandy. Later in 1983, in his Guymon Memorial Lecture, Elie Skofis was more specific about the technology of wine making and the distillation wine characteristics. He gave the following recommendations. Distillation wine characteristics should include: (1) proper grape maturity - high acid and low pH; (2) preference for white or lightly-colored varieties (such as Tokay, Mission, and Emperor) over red or black varieties; (3) separation of juice from skins or pomace prior to fermentation and handling them as dry white table wine; (4) low SO<sub>2</sub> (not over 75 ppm in the brandy wine fermentation); (5) fermentation temperature lower than 75°F; (6) distillation of the fermented wine immediately after fermentation with a partial racking from heavy fermentation lees; and (7) if a fortified wine, it must be one where only high quality wine spirits were used.

These recommendations are applicable for both pot still and column still. In fact, the characteristics required for wines to distill in the column still are less strict than those to select wines to distill in alambic. In this case, their characteristics must be similar to the Cognac wine characteristics.

Regarding Skofis' recommendations, slight changes can be made: recommendation (4), no SO<sub>2</sub> or no more than 20 ppm to avoid having high quantities of acetaldehyde in brandy and recommendation (5), fermentation temperature between 68°F to 77°F. This is mainly done to reduce acetaldehyde and ethyl acetate by evaporation.

**Quality aspects:** The distillation is a selection and a concentration of volatile compounds which give the specific character to Cognac. In addition, during distillation in alambic, the wine and the brouillis are cooked; many reactions occur between the compounds, and this phase generates delicate aromas.

**Wines:** For distilling, Cognac wines must be perfect. A slight defect which is hardly detectable in wine may be detectable in Cognac because of the concentration during distillation.

**Quality controls on wines:** Today, the distiller has three means to check the quality of wines for distillation in an alambic: tasting, analysis, and microdistillation. The microdistillation is conducted in a laboratory still with copper shavings placed in the boiler. This technique is very useful to detect the following by tasting:

Table 7. Example A: Use of SO<sub>2</sub>.

Wine: 8% alc/vol Total acetaldehyde: 30 mg/L	→	Not detectable by tasting
↓		
First distillation 28% alc/vol		
↓	→	Concentration 70 : 8 = 8.75
Second distillation 70% alc/vol		
↓		
Estimated loss in heads and by evaporation: 50%		
↓		
Concentration in Cognac $30 \times 8.75 \times 0.5 = 131.25$ mg/L	→	Detectable

Acetaldehyde threshold of detection in Cognac: 60 to 80 mg/L.

high acetaldehyde; too much ethyl acetate; acrolein; butyric smell; oxidization characters; high level of volatile phenolic compounds; and pollution by sulfury compounds, hydrocarbons, etc.

*Examples of defects not detectable in distillation wine. Example A - use of SO<sub>2</sub>*: Acetaldehyde is formed at the beginning of fermentation. There is free acetaldehyde in wine. In addition, the use of SO<sub>2</sub> in musts produces fixed acetaldehyde in the wine. During distillation, the combination with SO<sub>2</sub> can generate free acetaldehyde.

In Cognac, the acetaldehyde threshold of detection is ca 60 to 80 mg/L. With more than 80 mg/L, a recently distilled Cognac is too rich in acetaldehyde (Table 7).

*Example B: Fermentation at low temperature, 60°F*: During the fermentation, the loss of ethyl acetate is negligible (Table 8).

**Distillation. Distillation technique:** Variations related to cuttings, mixture (wine, heads, tails, brouillis, secondes), and running time of distillation change the characteristics of Cognacs (Table 9).

*Mixture:* See Table 10.

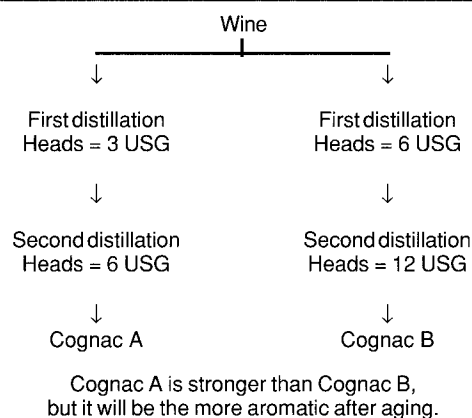
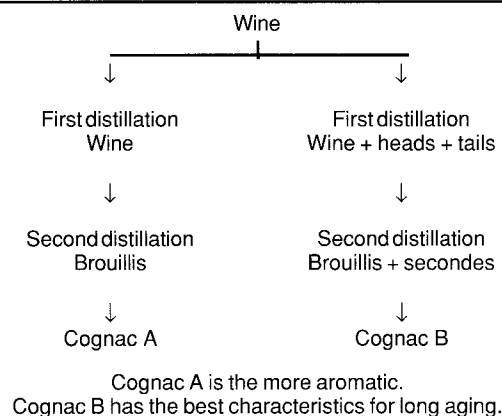
**Reaction between compounds during distillation:** The first distillation lasts around 10 hours and the second distillation approximately 14 hours. When it is operating, many types of reactions occur between the compounds of mixtures which are boiling. The boiler can be compared to a reactor.

Regarding the future characteristics of the Cognac (or brandy), the reactions which occur during the first distillation are the most important. These reactions are functions of: the characteristics of the wine; the use of lees; pH and acidity; the size of the alambic; the temperature generated by the gas burner under the boiler; the duration of the distillation; and the cleaning of the

Table 8. Example B: Fermentation at low temperature (60°F).

Wine: 7% alc/vol Ethyl acetate: 70 mg/L	→	Not detectable by tasting
↓		
First distillation 28% alc/vol		
↓	→	Concentration 70 : 7 = 10
Second distillation 70% alc/vol		
↓		
Estimated loss in heads and by evaporation: 30%		
↓		
Concentration in Cognac $70 \times 10 \times 0.7 = 490$ mg/L	→	Detectable

Ethyl acetate threshold of detection in Cognac: 450 to 500 mg/L.

Table 9. Distillation technique.  
Cutting variations.Table 10. Distillation technique.  
Cutting variations.

alambic. (*Note:* In addition, the wine extracts components from lees because of the heat. These components also can react with others during distillation.)

The yeasts represent around 60% to 70% of the lees. Their use in distillation wines give more fatty esters (like ethyl caprylate, ethyl caprate, ethyl laurate, esters C<sub>14</sub> to C<sub>18</sub>), more fatty acids, and nitrogen compounds (like amino acids). The fatty esters give fruitiness to the Cognac; the fatty acids give body and are like fixatives for many other aromatic components; amino-acids are involved in thermic break down reactions.

*Types of reactions:* The reactions are numerous; that is the reason that the double distillation technique in alambic is unique. Volatile components already in wine, may decrease or increase in concentration, depending on the types of reactions they are involved in. New volatile components can appear and generally are important for the aromas of Cognac.

*Examples of reactions:* Some reactions have been known for years, such as hydrolysis, esterification, acetalization, reactions with copper, and furfural production. Generally, the above produce, in relatively large quantities (more than 2 mg/L), constituents which are easily detected by gas chromatography. Others reactions produce, in a very small quantities (less than 1 mg/L), constituents which are detected by glass capillary gas chromatography. During the last decade, many authors published articles about these reactions and the components they produce in spirits (C.R. Strauss, P.J. Williams, L. Nykänen, H. Soumalainen, C. S. Ough, J. Almy, Y. Z. Gunata, C. L. Bayonove, R. L. Baumes, R. E. Cordonnier, and others).

For instance, by hydrolysis, thermal break down and rearrangement may be generated: monoterpenes (linalool and alpha terpineol, < 1 mg/L); ketones ( $\alpha$ -ionone and  $\beta$ -ionone, < 0.01 mg/L); and others (vitispirane and T.D.N., < 0.1 mg/L).

Maillard reactions (reactions between a sugar and amino compounds) can also take place. The Maillard reaction is the main source of heterocyclic compounds such as furans, pyridines, and pyrazines as has been quoted in Cognacs by M. Marche, De Smedt, Lehtonen, and others.

**Alambic equipment:** Today, for better distillation conditions, the alambic manufacturers propose several equipment features to the distillers. This equipment is used to monitor the gas flow, to clean the boiler, to maintain the proper temperature for the distillate, and to make the correct cuts. These features make the distillation process easier and give the distiller more time to spend on the quality aspects.

### California Alambic Brandy

Cognac is a brandy which can be produced only in the Cognac region; however in California, the use of the Cognac-making technology, with adaptations, makes possible the production of a brandy called "alambic brandy."

**Example of California alambic brandy.** *Concept:* Several choices may be made: for example, to develop varietal grape characters; to reach a high complexity; to stay light and elegant in aroma and taste; and to be different in taste compared to other brandies.

*Choice of grape variety:* Many grape varieties may be used to produce alambic brandies. Approximately twenty varieties have been tested and include the following: Chardonnay, Chenin blanc, Emerald Riesling, Folle Blanche, French Colombard, Gamay, Muscat of Alexandria, Palomino, Pinot blanc, Pinot noir (white wine), Sauvignon blanc, Semillon, Symphony, Ugni blanc, Zinfandel (white wine), etc. In addition, studies regarding production areas have also been researched.

All wines are first distilled in a "baby" alambic (6.5 gal). After successful "baby" alambic distillations, the selected wines were distilled in a standard size alambic to make final production decisions. Six grape varieties were definitely selected: Chenin blanc, Folle Blanche, French Colombard (main grape variety), Palomino, Pinot noir, and Muscat (less than 10% in the final blend).

*Technology of wine making:* The grapes are harvested early to obtain an alcohol content below 10% (alc/vol). Winemakers who produce the wines must meet special requirements in order to produce wines with similar characteristics to the Cognac wines. In addition, the wines are cooled after the fermentation to avoid malolactic fermentation. In this case, the double distillation technique captures the varietal aromas.

*Distillation:* Each wine is distilled separately, following different techniques to develop the varietal aroma. For instance, to enhance the Pinot noir aroma, the distillers remove from the distillate very small quantities of heads. (*Note:* The double distillation technique even on a small scale produces distillates which are ideal to describe by tasting varietal aromas.)

*Relationship between analysis and distillation technique:* Six California brandies were analyzed by gas chromatography and compared with an average analysis profile of VS Cognac. The constituents selected may give information about the distillation technique. The codification is presented in Table 11.

Volatile constituents analyses of finished brandies are not always reflected in analyses of recently distilled brandies for the following reasons: (1) selective evaporation during aging - the less volatile constituents are more and more concentrated; (2) oxidization mechanism - production of acetaldehyde, 1-1-diethoxyethane, ethyl acetate; (3) blending technique - column still brandy and pot still brandy may be blended together; (4) blending material - 2.5% by volume of the finished products (ca 20 g/L may be added before bottling); and (5) treatment - charcoal treatment and ion exchanger treatment can remove constituents from the brandy.

**Alcohols:** C11, C12, and C13 are column still brandies. C14 may be a blend with column still brandies and pot still brandies. A11 and A12 have more alcohols than the column still brandy. A11 may be produced from high

Table 11. Gas chromatography analysis of six California brandies compared with an average analysis profile of VS Cognac.  
(Column still brandies: C11, C12, C13, C14. Alambic brandies: A11, A12, VS Cognac).\*

	Constituents - alcohols (mg/L at 40% alc/vol)						
	C11	C12	C13	C14	A11	A12	VS Cognac
Methanol	55	95	78	196	149	217	204
Propanol	114	150	196	150	163	198	149
Isobutanol	126	99	121	141	154	256	437
Meth. 2 butanol 1							
Meth. 3 butanol 1	488	429	394	537	697	809	1164
<b>Higher alcohol total</b>	<b>728</b>	<b>678</b>	<b>711</b>	<b>828</b>	<b>1014</b>	<b>1263</b>	<b>1750</b>
2-Phenylethanol	1.9	5.1	3.7	1.0	3.9	6.8	18.4
Hexanol	5.1	5.1	3.0	2.8	36.2	24.9	9.5
Hexenol	0.01	0.01	0.01	0.01	4.50	1.40	1.40

\*Rémy Martin Research and Development Laboratory

Table 12. Constituents: acetaldehyde; 1-1 diethoxyethane; furfural; esters  
(mg/L at 40% alc/vol).\*

Acetaldehyde	22.80	35.00	29.00	40.50	41.30	81.00	56.20
1-1 Diethoxyethane	8.50	10.00	40.00	17.50	23.00	41.10	23.20
Furfural	1.20	1.10	0.60	1.60	1.3.10	13.80	11.75
Ethyl acetate	59.00	90.00	68.00	71.50	156.00	214.00	176.00
Isoamyl acetate	9.70	3.90	1.40	4.40	9.05	2.15	2.80
Ethyl hexanoate	2.86	1.60	1.60	0.90	2.60	4.00	3.60
2-Phenyl ethyl acetate	1.40	0.90	0.30	0.60	0.53	1.44	0.94
Ethyl caprylate	5.10	3.70	4.00	3.20	9.65	12.80	12.80
Ethyl caprate	9.60	5.50	6.30	4.90	12.50	20.10	17.40
Ethyl laurate	1.20	2.30	4.40	1.20	5.35	8.50	6.60
<b>C<sub>8</sub> - C<sub>12</sub> ester total</b>	<b>15.90</b>	<b>11.50</b>	<b>14.70</b>	<b>9.30</b>	<b>27.50</b>	<b>41.40</b>	<b>36.80</b>
Ethyl lactate	10.80	11.90	28.90	1.90	27.70	22.10	73.60

\*Rémy Martin Research and Development Laboratory

alcohol content wines or slightly fortified wines. A11 and A12 are rich in hexanol and hexenol; it may come from the crushing and stemming at a too-high temperature.

**Aldehydes and acetal:** The maturation increases the amounts of acetaldehyde and acetal. C14 is older than C11, C12, and C13. A12 seems to be more matured than a VS Cognac.

A11, A12, and VS Cognac are richer in furfural than the column still brandies. It comes from the double distillation technique in alambic.

**Esters.** *Ethyl acetate:* A11, A12, and VS Cognac have a higher amount of ethyl acetate. It is below the threshold of detection and in such products it enhances the

aromas.

*Isoamyl acetate and ethyl hexanoate:* C11 is quite different compared to C12, C13, and C14. This brandy has a banana smell and a candy-like aroma. A11 is also rich in isoamyl acetate.

*Ethyl caprylate, ethyl caprate, and ethyl laurate:* There are higher amounts of these constituents in A11, A12, and VS Cognac. It gives fruitiness and structure to the products.

*Ethyl lactate:* There is the highest amount in VS Cognac. It comes from both the double distillation technique and the malolactic fermentation.

## Conclusions

The double distillation technique in alambic, starting from wines specially made for distillation, gives distinctive brandies.

In California, the alambic brandies are delicate and subtle, complex in aroma, rich in potential for long aging, typical and different than column still brandies and Cognacs - proof that California is a right place to produce both world class wines and world class brandies.

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