WINE-MAKING

IN

HOT CLIMATES.

—

ROOS.

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F. Flossfeder

DEPARTMENT OF AGRICULTURE.

VITICULTURAL STATION, RUTHERGLEN, VICTORIA.

WINE-MAKING IN HOT CLIMATES,

BY

L. ROOS,

Director of the Œnological Station of the Hérault.

Translated by

RAYMOND DUBOIS, B.Sc. (Paris),

Diplomé de l'Ecole d'Agriculture de Montpellier, Director of the Viticultural Station, Victoria;

AND

W. PERCY WILKINSON,

Private Assistant to the Government Analyst, Consulting Analyst to the M. and M. Board of Works.

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TRANSLATORS' PREFACE.

In presenting this translation of *L'Industrie Vinicole Méridionale*,* by Professor L. Roos, to Australian wine-makers, the sole aim of the translators has been to render a thoroughly modern work on wine-making available, of a type of which the necessity has been obvious, and frequently commented on for some years.

The selection of the present work for translation was guided principally by the fact † that the climate, and conditions of wine-making, in the South of France, for which the book was expressly written, are practically identical with those of Australia. The new methods and innovations in vinification adopted there (as also in California) should be applied here without hesitation, if we are to keep abreast of recent advances, or rather, of our competitors in the export wine trade with Great Britain, on which the future expansion and success of our viticultural industry largely depends.

We feel convinced, from an intimate knowledge of the actual local conditions of wine-making, that the general and immediate adoption throughout Victoria of the improved methods of vinification so ably advocated by Professor Roos, and already extensively applied in practice in the South of France, Algiers, and California, will prove of the utmost advantage to our wine industry;

* Roos, L., *L'Industrie Vinicole Méridionale*, pp. vi. 326. 8vo. Montpellier and Paris. 1898.

† One of us (R. Dubois) studied for several years under Professor Roos at Montpellier.

and should result in greatly diminishing the quantity of wine annually passed through the still, and in increasing the production of sound dry wine of good keeping qualities, which will be of higher average market value than hitherto.

Our earnest hope is that Australian wine-makers will accord Professor Roos' book the serious attention and consideration it merits, as recording the latest definite advances in wine-making in hot climates.

RAYMOND DUBOIS.
W. PERCY WILKINSON.

Viticultural Station,
Rutherglen, 15th February, 1900.

WINE-MAKING IN HOT CLIMATES.

CHAPTER I.

FERMENTATION.

Etymologically, the word *fermentation* (derived from the Latin *fervere*, to boil) marks the phenomenon by which the transformation of a part of the substances constituting a given liquid takes place, the phenomenon being accompanied by movements similar to those produced by the boiling of a liquid.

The term *fermentation* seems therefore only applicable to cases where chemical transformations are accompanied by a kind of boiling.

As long as the causes of these chemical transformations, of which the bubbling is only the corollary, were not known, the above definition sufficed ; but since the cause is known, since we know that many other chemical transformations although not accompanied by bubbling are similar to those which gave rise to the word *fermentation*, it became necessary to designate phenomena of the same order by different words, or, as has been done, apply to all, despite its etymological inexactitude, a word which would have a conventional signification.

It is scarcely necessary to speak of Pasteur, as his numerous works on this question are universally known. It was he who demonstrated, after the unfruitful researches of most eminent scientists, that fermentations were the work of infinitely small organisms called *microbes*.

All fermentations have a point in common, which is that a very small weight of organized matter is sufficient to transform relatively considerable quantities of material.

Thus, a few pounds of beer yeast may produce thousands of gallons of that liquid, and a few grains of acetic ferment are sufficient to transform a cask of excellent wine into vinegar.

Non-organized, often very soluble bodies, are known, acting in the same way. For instance, *pepsine* may transform a considerable weight of insoluble fibrin into soluble peptone.

Fermentations and transformations of this class are somewhat similar, and, therefore, the general term of fermentation has also been applied to transformations brought about by *soluble ferments*. However, to distinguish the two phenomena, the fermentation brought about by organised ferments has been called *true fermentation*, while that brought about by the soluble ferments or diastases has been named *pseudo-fermentation* or *diastasic-fermentation*.

The microbes or agents of true fermentations exist in infinite variety, they are subdivided into several species, the principal being *moulds*, *yeasts*, *mycoderma*, *micrococci*, *bacteria*, *bacilli*, and *vibrios*. With regard to the diastases they are also in great variety, and bear different names indicating either their origin or behaviour. That known as *pancreatine* (a mixture of soluble ferments) normally existing in the pancreas, plays a very important part in digestion; that called *amylase* renders the starches soluble.

As a general principle, all fermentation induces in the liquid the disappearance of one or several substances, and *vice versâ*, the appearance of one or several new products.

The most important of all is the *alcoholic fermentation*.

ALCOHOLIC FERMENTATION.

This is a true fermentation, and is, in the great majority of cases the work of organised microscopical plants, known as *yeasts* (levures).

It is the transformation of several substances of an analogous chemical constitution (glucose and other sugars) into alcohol as the principal product, carbonic acid, glycerine, succinic acid, and a few other substances, some of which are not yet completely known.

We say intentionally glucose and other sugars, although it is well known that alcohol may be obtained from many other substances, starch for example, but these substances are not capable of being directly transformed into alcohol and secondary products. They must first be transformed into glucose or fermentable sugar.

There are, it is true, a few rare exceptions to this rule, and though of very great scientific interest, they remain unimportant in practice.

The transformation into glucose, of substances forming alcohol, may be brought about by chemical means, or more often by diastasic fermentations preceding the alcoholic fermentation.

Sometimes, as happens in the case of a large number of yeasts, the alcoholic ferment secretes a diastase, bringing about the transformation into fermentable sugar. Cane sugar, for instance, only gives alcohol after having been submitted to a diastasic fermentation, which is indirectly the work of the yeast itself, for it is by the aid of a soluble ferment, *invertine*, secreted by it, that the preliminary preparation is accomplished.

Starting from glucose, the production of alcohol is the result of true fermentation ; starting from cane sugar, it is the result of a double fermentation, one diastasic, the other true.

The most searching analyses, made on many different *cépages*, have not revealed in grapes, at maturity, the presence of cane sugar in noticeable quantities.

Grape must only contains glucoses, as directly fermentable constituents, the two most important being *dextrose* and *levulose*, existing in about equal proportions at maturity. Therefore, the vinous fermentation can only be regarded as a true fermentation.

Alcoholic fermentations are numerous ; the best known in our regions are those furnishing wine, ale, or beer, cider, and perry. But the alcoholic beverages used in different countries, and prepared from very dissimilar substances—milk, juice of certain roots—are also the result of fermentations analogous to those already mentioned.

They are all produced by related organisms, but yet not identical. The characteristic of their common work is the production of alcohol, but they differ individually with respect to the weight of alcohol produced in relation to the weight of sugar consumed, and by the nature and quantity of secondary products formed.

These secondary products are of two kinds : first, those depending on the variety of the ferment effecting the transformation.

The products of fermentation, principal and secondary, are eliminated by the organisms as the result of their work.

The researches of Pasteur, justly considered unattackable from a scientific stand-point, brought about the conceptions we have just briefly described.

The alcoholic ferment is a plant cell, nourishing and reproducing itself in a suitable liquid, and, as a result of its nutrition, producing new substances utilized by it in turn.

The agents of alcoholic fermentations are called *yeasts*, and belong to the order *Saccharomyces*.

The first studied and best known is the *Saccharomyces Cerevisiæ*, or beer yeast.

The *Saccharomyces Cerevisiæ* is composed of cells, which appear under the microscope in a lenticular more or less globular shape, often elliptic, and sometimes circular. They measure, on the average, five or six thousandths of a millimetre in diameter, and are surrounded by a thin membrane, the composition of which is approximately that of cellulose.

The yeast cells, according to their age, have varied aspects; when young they appear turgid, full of non-granular highly refractive protoplasm ; when old they seem almost empty, shrivelled, wrinkled, with the protoplasm full of pigment, and more or less opaque.

The reproduction of these micro-organisms occurs in two different ways, but only one is of interest to the fermentation industry, the reproduction by budding.

It consists in the cell swelling at one point of its surface. The swelling is full of protoplasm, and, at the beginning, is not differentiated from the protoplasm of the mother cell. The swelling is at first very wide at the base, but contracts gradually until it forms a true ramification on the mother cell. Under ordinary circumstances these ramifications very soon become detached. The cells, in groups of two or three, become separated, and, isolated or not, become new mother cells, ready to reproduce by the same process.

It goes without saying that to vegetate and reproduce normally, the yeasts must find in the liquid they live in, besides special physical and chemical conditions, elements which are necessary to the constitution of their tissues.

These elements are of two classes, organic and inorganic, as has been proved by numerous analyses of yeasts.

The thin membranous envelope covering the protoplasm seems to consist of a substance analogous, if not identical, with cellulose. The following analysis, due to Schlossberger, shows this striking analogy :—

		Envelope of the Yeast.		Cellulose.
Carbon	...	45·50	...	44·50
Hydrogen	...	6·90	...	6·20
Oxygen	...	47·60	...	49·30
		100·00		100·00

The envelope represents one-fifth to one-sixth of the total weight of the yeast in a dry state. The protoplasm has a much more complex organic and inorganic composition. The greater part is formed of nitrogenous matter, similar to albumen ; but contains also fatty substances.

The inorganic matters represent about 6 per cent. of the total weight of the dry yeast, they number about one dozen, their respective importance is rather varied.

Phosphoric acid and potash predominate, the phosphoric acid represents over 50 per cent. of the weight of the ash, the potash about 40 per cent.

To conclude, the liquid must offer to the yeast, carbon, nitrogen, oxygen, hydrogen, phosphoric acid, potash, and traces of other mineral matters, to insure its development.

In the must or juices used by different fermentation industries, the sugars furnish carbon, hydrogen, and oxygen. As for the other matters, they exist in various more or less complex forms in the liquid itself. The nitrogen in the form of albumenoid or even ammoniacal compounds. The inorganic matters are constituents of the parts of the plants which furnish the must.

The characteristic of the yeast is that it consumes considerable quantities of carbohydrates (sugars), retaining only a very small proportion ($\frac{1}{75}$th) for the constitution of its own substance. All the rest is transformed into alcohol and other secondary products already mentioned.

The work of the yeast is too complex to be expressed by a chemical equation.

The following simple table will show what becomes of 100 grammes of glucose under the action of beer yeast, in a liquid suitably constituted:—

Alcohol	46·56
Carbonic acid	48·36
Glycerine	3·25
Succinic acid	0·61
Glucose used by the yeast for its constitution, and in the formation of not clearly defined products ...	1·26
	100·00

VINOUS FERMENTATION.

The vinous fermentation is that by which *the must of fresh grapes* is transformed into wine.

Under ordinary conditions, it is a spontaneous fermentation. The must does not require to be sown with yeast, as is often done in the manufacture of other fermented drinks.

At maturity, the grape is covered with micro-organisms, which induce the fermentation of the must.

This fact was clearly established by Pasteur ; and it is only at the time of maturity that the exterior of the grape is covered with yeast-spores.*

Grapes protected against outside dust by proper devices, furnish musts incapable of spontaneous fermentation, if they are prepared with the precautions necessary to preserve them from contamination.

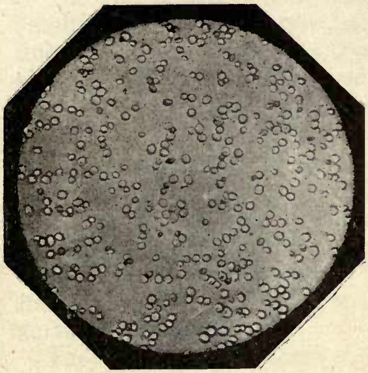
The particles of dust are fixed on the grapes and stalks, and even on any other of the vine organs, by a kind of waxy matter. This forms the *grape-bloom.*

Most diverse matters are found side by side, mineral particles, spores of common mildew, germs of *wine yeasts*, and in still greater number, the germs of a yeast, common to all sweet fruits, but, as we shall see, of no great importance in vinification, this is the *apiculate yeast.*

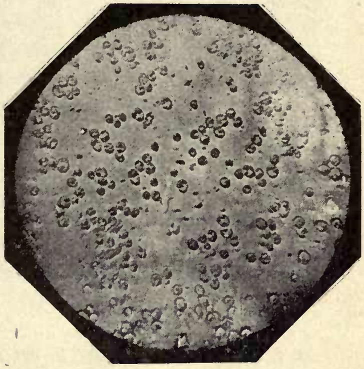
The principal factor in vinous fermentation is the elliptic yeast (*Saccharomyces ellipsoideus*).

* It was believed for a long time that the ferment or yeast existed in the pulp of the grape. This erroneous opinion is even now quoted by certain authors.

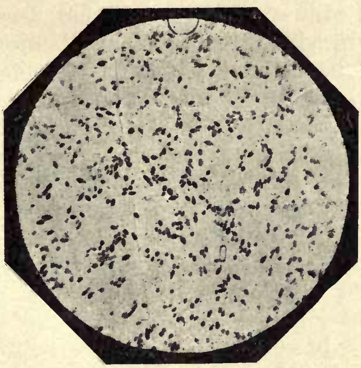
PLATE I.



Wine Yeast (Young).



Wine Yeast (Old).



Apiculatus Yeast.

In spite of its name it is almost circular, of lenticular shape, transparent, like the yeast of beer, and full of refractive liquid when young and active; more or less full of pigment, opaque, and shrivelled when old or living in an unfavorable liquid.

The dimensions of the elliptic yeast are about five thousandths of a millimetre each way. Its mode of reproduction is the same as that of the beer yeast, but the ramified form is less frequent in the *Saccharomyces ellipsoideus* than in the *Saccharomyces cerevisiæ.*

However, if in reality the elliptic yeast is the principal agent of vinous fermentation, it is not so exclusively. The apiculate yeast (*Saccharomyces apiculatus*) is one of the most widely distributed in nature. Pasteur was the first to indicate its existence on acid and sweet fruits generally, and grapes in particular. Reitsch and Martinand * also indicated the predominance of apiculate yeast on the surface of ripe grapes.

They have shown, further, that it exists in abundance at the beginning of any spontaneous vinous fermentation.

Its action, however, is only partial, for it cannot live in must containing more than 3 to 4 per cent. of alcohol.

Reitsch and Herselin established this fact by a series of conclusive laboratory experiments.†

The elliptic yeast, on the contrary, is able to work in a much more alcoholic liquid. It commonly gives up to 16 per cent. (by volume) of alcohol,‡ but it really starts working in ordinary cases, that is, in unsterilized musts, only when the fermentation has been commenced by the apiculate yeasts.

For vinous fermentation to take place under good conditions, and for a must to give not only the maximum yield in alcohol, but also that harmony of qualities which assures its value, the fermentable liquid should realize certain chemical and physical conditions, some of which are still obscure, but others very distinctly established.

Later on, when discussing the vintage, and vinification, we will study the influence of the chemical and physical conditions of the must, on the quality of the wine. We desire

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* Comptes Rendus de l'Acad. des Sciences, 6 April, 1891. Des microorganismes des raisins mûrs.

† Reitsch and Herselin. *Progrès agricole et viticole*, 1895.

‡ 28 per cent. of proof spirit.

to draw attention here to the relative inferiority in practice, now long known, of the wine-making industry as compared with other fermentation industries.

Defects in qualities of wines are of two kinds. Those known as organic, depending on the grape, the *cépage*, its state of maturity, the atmospheric influences which it was submitted to, alterations caused by diseases it may have been subject to, &c.

Against some of these defects nothing very effective can be done; against others, resulting from vine diseases, for instance, continual care and efficacious treatment are generally sufficient to annihilate them.

The other qualities or defects, which may be termed accidental, are the result of different manipulations to which the grapes were submitted during their transformation into wine, and of the conditions under which the transformation was effected. Theoretically, the transformation ought to take place under the exclusive influence of the yeasts we have just mentioned, but practically it is not so.

The vinous fermentation generally remains the principal result, but side by side there are effected a number of other fermentations, which are known as secondary fermentations, because they usually have less influence on the nature of the product. Their action, however, is never nil in practice, and the further the must is from its normal state, the greater their importance becomes.

In all the industries of fermentation of sweet musts, whatever the origin of that must is (brewing, distillation, for example), manufacturers do not go groping like blind people; the conditions of these fermentations, on the contrary, are carefully studied, and care is always taken to realize the most favorable conditions.

In the wine-making industry this is not done, perhaps because it is the most important of all. This seems to everybody, however, to be a very poor reason. We are more inclined to think that it is because the wine-grower does not know, and will not take the trouble to frankly regard himself as a manufacturer during the vintage time.

We know what objections will be raised against this argument. The grape harvest is only made once a year, whereas, the operations of other industries are repeated every day. We agree that this is a difficulty, but also think that it does not justify either a complete lack of observation or disregard; it seems, on the contrary, that the necessity of observing the conditions is so much more necessary as the occasions are more rare.

Are there many vignerons who are able to recall the behaviour of particular vatfuls of the preceding year, the diverse phases of their fermentation, or who possess such a stock of observations as to enable them to deduce the best conditions for the vinous fermentations? They are *raræ aves.*

The characteristic failing of vine-growers is to act without method, and the result is an exceedingly great diversity of processes used in working the raw material, which, after all, does not vary much in composition.

CHAPTER II.

STUDY OF THE GRAPES.

MATURATION.

The phenomenon of the maturation of fruits has been the object of numerous studies. Many eminent scientists have tried to solve this captivating problem, but we cannot yet state that complete light has been thrown on the subject.

We shall refer here to a study, dating from the last few years only, which is interesting from two points of view—first, because it summarizes the principal works on the subject ; secondly, because it is applied to a very important *cépage* of the southern region of France.

That *cépage* is the Aramon, and the Aramon grafted on American vines in extensive culture.

The researches mentioned date from 1891. In that year the vine which furnished the samples was not submitted to any particular care. In the preceding year it had received an ordinary fertilizing with farm manure composed of arachide shells litter.

The plot of ground, situated in the commune of Villeveyrac (Hérault), is flat, constituted of clay-limestone soil, limited to the west by a departmental road and by private roads on the other sides.

The vineyard, planted with Jacquez in 1884, was grafted with Aramon in 1886.

The samples were taken every fortnight, from the 1st of May to the 21st of September, 1891. The vintage took place on the 28th September.

The first sample taken on the 1st May represents the whole of the buds ; but, from the 15th of May, it was possible to separate the three principal aerial organs—the grape, leaf, and branch—and to analyze each separately.

In this study we will consider more particularly the formation of sugar in the grape.

FORMATION OF SUGARS IN THE GRAPE.*

" Although these experiments were not carried out with the exclusive object of throwing light on the controversy as to the origin of sugars, we shall see that the results may be valued, in presence of the principal hypothesis actually existing on the genesis of the sugars in grapes. As happened with Portes and Ruyssen, we found ourselves confronted with three theories to explain the essential phenomena of maturation—diminution of acids and augmentation of saccharine matters—for, as we have seen, these two phenomena occur at the same time.

" 1st. The theory which regards tannin as the generator of sugar.

" 2nd. The theory which considers starch as the principal source of almost all the organic principles.

" 3rd. The theory which accords to the acids the part played by starch in the above theory.

" We have not followed the tannin in the various phases of vegetation, and cannot therefore express an opinion on the first of these theories. It has been, however, almost completely abandoned,

" With regard to the second, we searched for starch in the different organs and succeeded in detecting it under the microscope, in small spherical granules, greenish, but not coloured blue by iodine, and not luminous in polarized light with the Nicols crossed. Only a few granules of an irregular shape were coloured blue by iodine.

" The starch with these two characteristics was only found in the seeds of the grape. The granules, however, were smaller than those of ordinary starch—comparable in dimensions to those of rice starch.

" We cannot conclude from these succinct results that starch only exists in small quantity, or not at all, in the different organs of the vine. Sachs, Cuboni, Schimper, with less rudimentary methods, consisting of eliminating the chlorophyll by a preliminary treatment, have detected and even estimated the starch in vine leaves ; we have no wish to depreciate the results obtained by these observers, without previously obtaining the support of more convincing experiments.

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* L. Roos & E. Thomas. Contribution à l'étude de la végétation de la vigne. (*Ann. Agronomiques.*)

"Starch seems, therefore, to exist in the leaves, and, in a general way, in all the green parts of the plant; it may therefore be considered as the source of the more or less numerous organic products, particularly the saccharine matters.

"But this hypothesis has been contradicted by Buignet, who, to begin with, contests the presence of starch in acid fruit.

"In admitting its presence in the plant, he adds that its transformation could not in any case furnish the sugar of the fruits, as this sugar is lævogyre, while the glucose derived from starch is *dextrose*, with a rotation of + 53°. This is an argument which seems to dispose of the opinion of Alessandri and Pollacci,* who assert that the sugar is the result of the saccharification of the starch in the pips or seeds; and that of Léon Brasse,† who studied the transformation of starch in a great number of different leaves, amongst which, it is true, the vine leaf does not figure, and demonstrated that a soluble ferment, *amylase*, existed in all leaves, capable of saccharifying not only the soluble starch, but also crude starch.

"This appears convincing, but to be really so it would be necessary to know if the vine starch exists only in one modification, and if that modification is that furnishing dextrose by saccharification.

"We know that the sugar resulting from saccharification of inuline is lævogyre, and it is not proved that inuline does not exist in the vine.

"Previous observations due to Dehérain established that the rotation of fruit sugars, though at first decidedly positive, diminishes progressively and passes to minus. Later on, Prof. Bouffard, of the School of Agriculture, Montpellier, arrived at similar results while studying Aramon must. Our results entirely confirm those of the two above authors, and allow us to affirm that grape-sugar is composed of an admixture of glucoses in which dextrose predominates before maturity.

"Buignet asserts that the sugar of fruits is at first in the state of cane sugar, which, later on, by inversion yields glucoses. But the argument he advances against the

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* *Botanische Zeitung*, 1883.
† Dissolution de l'amidon dans les feuilles. *Ann. Agronom.*, t. xii.

amylaceous origin may be turned against him, for if it is true that grape-sugar has about the same composition as inverted sugar in the fruit at maturity, this is not true if it is considered before that epoch, and the inversion giving a mixture in equal parts, lævogyre, of dextrose and levulose, could not at any moment produce a sugar of positive rotation.

"To conclude this matter, Boehm has proved that the leaves form starch with the aid of sugar, and that, by submitting plants normally exempt from starch to the action of a saccharine solution, one can, after a while, distinctly detect the formation of starch.

"Schimper, arguing from his own experiments and those of Boehm, concludes that the appearance of starch in the leaves being always posterior to that of glucose, this cannot have an amylaceous origin, at least in the leaves; its accumulation in the fruit would therefore be the result of a direct migration in the shape of glucose, or an indirect migration of the glucose transformed previously into ordinary starch, and further into soluble starch, which would pass into the berry to become saccharified.

"Amylase operates, no doubt, in rendering the starch soluble, and subsequently in saccharifying it.

"It is also to that ferment that the disappearance of cane sugar should be attributed.

"However, it is possible to admit that the inversion of the crystallizable sugar furnishes a part of the glucoses detected in the fruit, that a part of those glucoses emanates from the starch, the dextrose being furnished by the ordinary starch, the levulose by a kind of inuline, or, as we will see later on, might have a different origin.

"Let us now examine our results, in comparison with the theory which sees in the transformation of the acids the genesis of the sugars.

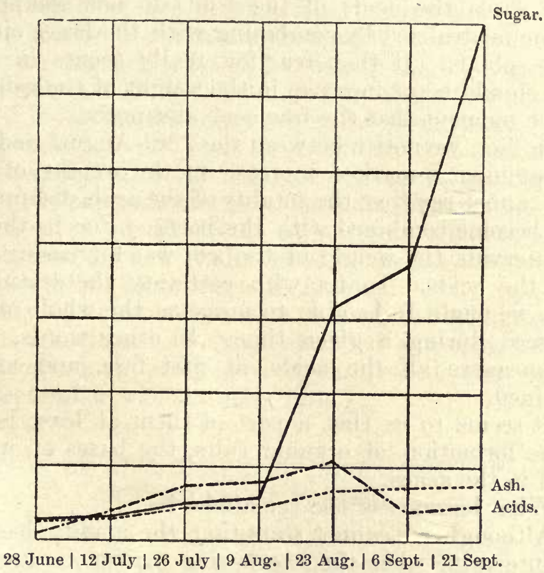
"From the weights of the grapes, leaves, branches, and the number of branches gathered for each experiment, we intend to establish the composition of an average branch, starting from the 28th June, the date at which the blooming is completely achieved; and place in juxtaposition the absolute quantities of acids expressed as sulphuric acid, of saccharine matter as glucose, and of the ashes contained in the different organs.

COMPOSITION OF AN AVERAGE BRANCH, WITH THE ABSOLUTE QUANTITIES OF SACCHARINE MATTER AS GLUCOSE, THE ACIDITY AS SULPHURIC ACID, AND OF THE ASH.

Dates.		Total Weight.	Length in Metres.	Weight of Grapes.	Weight of Leaves.	Weight of Canes.	Sugar (expressed as Glucose). Grapes.	Leaves.	Canes.	Total.	Acidity (expressed as Sulphuric Acid). Grapes.	Leaves.	Canes.	Total.	Ash. Grapes.	Leaves.	Canes.	Total.
		grammes	metres	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.
June	28	143·6	0·96	23·6	71·0	47·6	0·148	1·181	0·643	2·606	0·281	0·717	0·167	1·165	0·223	1·704	0·609	2·536
July	12	261·2	0·97	16·70	68·6	45·3	1·435	0·926	0·611	2·972	3·073	0·432	0·077	3·582	0·635	1·722	0·607	2·964
"	26	414·6	1·05	309·6	65·0	45·0	2·229	1·092	0·675	3·996	6·192	0·494	0·090	6·776	1·426	1·735	0·661	3·822
Aug.	9	481·0	1·01	343·6	80·6	56·6	3·470	1·023	0·622	5·115	6·837	0·314	0·090	7·241	1·271	1·780	0·877	3·928
"	23	733·0	1·00	611·5	76·3	46·3	29·168	1·243	0·528	30·939	9·600	0·374	0·069	10·043	2·446	2·792	0·708	5·946
Sept.	6	637·0	1·11	484·3	106·0	48·3	35·209	2·131	0·290	37·630	3·390	0·424	0·048	3·862	2·276	3·900	0·836	7·012
"	20	881·6	1·11	753·3	76·6	55·0	68·926	1·378	0·220	70·524	4·218	0·444	0·066	4·730	2·862	3·508	1·001	7·371

"To enable these results to be readily grasped, we have expressed them by a graphic curve indicating the elements in absolute value at different epochs.

ABSOLUTE QUANTITIES OF SACCHARINE MATTER (AS GLUCOSE), OF ACIDITY (AS SULPHURIC ACID), AND ASH CONTAINED IN AN AVERAGE CANE.



" We have seen previously that the percentage strength of the sugar in grapes increases at the precise moment that the production of acidity diminishes. If we consider the absolute value of the grape, and the average branch, it is not so any more ; the acidity constantly increases in absolute value up to the 23rd August, and the formation of sugar is observed at the same time.

" The augmentation of the sugar is even enormous, from the 9th to the 23rd August, for it is during that period 25 times greater than that observed previously for equal intervals.

" The variations of the acidity and saccharine matter therefore seem independent of each other—at least up to the 23rd August. From that date the saccharine matter increases considerably up to maturity, but we observe at the same time, a great diminution in the quantity of the acid.

It seems impossible to admit that the total sugar is derived from the acids, for we notice that the absolute quantity of each increases simultaneously. At the same time, we cannot say that the acids do not furnish their contingent of saccharine matter.

"Fremy noticed that the acid reaction of fruits diminishes with ripening, but he also notes that in a great many cases the acids of the fruit do not disappear, but become neutralized by combining with the bases circulating in the plant. If that reaction really occurs in the vine there should be an increase in the weight of the ashes at the precise moment that the free acids disappear.

"In fact, we notice between the 23rd August and the 6th of September a marked increase in the weight of the ash —we cannot say that the totality of the acids disappeared, or have become combined with the bases. For in the preceding intervals the weight of the ash was increasing together with the acids. To fix with certainty the destiny of the acids, we ought to be able to measure the whole of the acid produced during a given time. In other words, to know and measure all the acids, at first free, and afterwards combined.

"It seems to us that a part of them at least is utilized in the formation of organic salts, the bases of which are found in the ashes.

"What becomes of the remainder?

"Although we cannot state that the acidity decreases in absolute value when the saccharine matter is augmenting, we may at least notice that when the acidity decreases, the sugar, composed in greater part of dextrose, changes its composition.

"This change is very distinctly shown by the polarimetric deviation, which from slightly plus or nil passes to minus, and increases in that direction up to maturity.

"It will be easily conceived that the necessity for perfect washing, and of diluting the matter in a large volume of water, prevented us from making precise polarimetric observations. We noticed slight plus deviations up to the 23rd of August, and at that date the must, which contained 5·3 per cent. of glucose, showed no deviation whatever; on the 6th September the must contained 9 per cent. of glucose, and the observed deviation in a 20-centimetre tube was −·12°.

"The augmentation of sugar may, therefore, be attributed for the greater part, to the formation of levulose during that period.

"Prof. Bouffard, already mentioned, concludes in the same way, according to experiments made by him on Aramon *cépage*, that the dextrose is first formed, and that the levulose appears later on.

"As the result of our observations, it appears that the diminution in absolute value for the acidity, is always accompanied by an augmentation of levulose in the fruit, and one is led to think, that if the acids contribute to the fermentation of sugar, it is the levulose that originates from them.

"We certainly do not want to generalize this hypothesis, or even to apply it to the Aramon *cépage* in an absolute manner. Our experiments, only conducted during one year, and under given conditions as to soil and climate, ought to be confirmed by new studies or experiments made under different conditions as to soil and climate.

"We may add that on the 10th August, the acidity of the grapes was constituted by more than 50 per cent. of free tartaric acid, which progressively diminished, and on the 21st of September was not detectable."

COMPOSITION OF RIPE GRAPES OF DIFFERENT CÉPAGES IN THE SOUTH OF FRANCE.

The succinct study of the phenomena of ripening which we have just considered, is only of theoretical interest to the wine-making industry.

The knowledge of the immediate composition of grapes at vintage time is of much more direct interest.

Until recently no complete study of the subject had been made. Girard and Lindet have filled this gap, and we will borrow from their very conscientious and complete work, a few general ideas on the composition of the different parts of the fruit, and figures relating to the principal *cépages* of the South of France.*

With regard to its apparent structure, the grape is divided into two parts.

The *stalk*, that is to say, the ligneous and herbaceous parts; and, secondly, the *berries* borne by it.

* A. Girard and L. Lindet. Composition des raisins des principaux cépages de France. *Bulletin du Ministère de l'Agriculture*, Paris, 1895.

The berry comprises three principal organs: the *skin* or *pellicle* (outside envelope); the *pulp*, mass of cells filled with juice; the *pips* or *seeds*, reproductive organs, generally disposed symmetrically around the centre of the berry.

Each of the four parts composing the fruit—the support, pellicle, pulp, and seed—has a special composition. Each brings to the vat special substances exerting a favorable or unfavorable influence on the wine, proportional to the absolute quantity of active substances they may contain.

As far as vinification is concerned, the grape consists of a liquid part—the *must*, and a solid part—the *marc*.

The *must* alone contains all the substances necessary to the fermentation of white wine, sometimes even of a reddish wine, and contains all the substances necessary to the life of the vinous yeast.

These are, placed in their order of importance (water excepted):—

Glucoses: dextrose and levulose.

Organic compounds, acid or not.

Salts of organic acids (bitartrate of potash).

Mineral or inorganic salts, phosphates, sulphates, traces of chlorides, &c.

The mixture of dextrose and levulose is the most important part of the must, these sugars constitute its value, determining the future alcoholic strength, and give to the wine its *vinosity* through the three principal bodies formed as the result of their transformation, *alcohol*, *glycerine*, and *succinic acid*.

The organic acids and the acid salts of the must are of secondary importance, but of such relative importance that every vine-grower ought to be able to determine the exact amount of *acidity* in must.

It is this acidity which renders the must more favorable to the alcoholic than any other fermentation, when its percentage is sufficient. It may therefore be necessary to increase in practice the amount of the acidity. This operation is often done; although very frequently in a rather empirical manner, sometimes by acidifying musts which would do much better without it, and not acidifying musts enough which really need the addition.

We shall refer again later on to this operation, as the only one we consider useful for the improvement of certain defective vintages.

The other substances contained in the must contribute to the formation of extractive and mineral matters, after having served to nourish the yeast.

The must extracted from the interior of a berry without coming in contact with the outside of the fruit is sterile, and will not ferment. It is through the crushing of the grapes, and washing of the skins by the must, that the sowing with yeast occurs.

The *marc*, constituting the solid part of the grape, includes the stalks, skins, ligneous part of the pulp, and seeds.

The fermentation of red wine takes place in the presence of all these organs, unless submitted to special treatment, such as stemming or removal of seeds ; each of these may impart to the wine defects or qualities which it is well to know. Stemming, and removal of the seeds, are operations, especially the latter, rarely used in the manufacture of common wines.

The *stalks* contain a number of substances studied by the Italian Professor Comboni. It would not serve any useful purpose to describe these in detail, it will suffice to indicate the principal effect of the stalks.

They contain tannin which is dissolved by the wine. This is beneficial, but we must not confuse the true tannin existing in small amount in the stalks with certain substances of a disagreeable, bitter, and astringent taste which may pass into the wine.

These substances, which may all be summed up under the heading, *organic acids* and *salts*, are detrimental to the *finesse* of the wine, as well as to its preservation and improvement. It is this particular astringent taste of wines fermented on the stalks which resulted in erroneously attributing to them an excessive richness in tannin. This was a mistake; for Coste-Floret, who advocates with firm conviction the operation of stemming, has proved that the difference of richness in tannin was very slight between a stemmed and non-stemmed vintage.

On the contrary, Prof. Bouffard asserts that stemming sensibly diminishes the richness in tannin in the proportion of 1·15 to 1·60 for the Aramon.

We are, therefore, confronted with two conflicting statements.

In reality, the stalks of ripe grapes contain only a small amount of tannin, and even if they did not furnish any to the wine, their presence would play a useful part, that of subdividing the marc and facilitating the penetration of the surrounding liquid.

They may prove inconvenient on account of the detrimental substances already mentioned, and this will certainly be so if the proportion of stalks is too great. This is very rarely the case for the *cépages* in the South of France, if the length or duration of the maceration is not too prolonged, and if the temperature of fermentation does not become too high.

Under the influence of excessive temperature and prolonged contact with the liquid, the cells of the stalks are softened and disintegrated, and the matters or bodies they contain are directly exposed to the solvent action of the surrounding liquid, helped to a great extent by the elevated temperature. This inconvenience is considerably diminished, or even stopped, if the duration of maceration is reduced and the temperature maintained between recognised limits. As the stalks introduce into the wine elements which assist in the formation of a good foundation, and their presence being mechanically useful, we are inclined to think that preliminary stemming should not be employed in the case of wines for ordinary consumption. We do not find in this practice marked economical advantages, especially if we reduce the noxious influence of the stalks by well-conducted fermentation.

Later on, when discussing stemming, we will go into the question more fully, and give precise opinions about this practice.

The *pellicle* or *skin* constitutes the most important solid organ of the grape in the vinification of red wine. It brings with it the colour, most of the tannin, a notable proportion of extractive and mineral matter, and the greater part of the germs of yeast.

Armand Gautier* has carried out important researches on the colouring matter of the grape, and more successfully than previous investigators. From the study of this subject he was enabled to establish the formation in the leaf of coloured matters, derived from colourless substances producing *ampelochroic acids*, which, migrating from the leaf towards the fruit, constitute in the pellicle different colouring matters now known as *œnolic acids*.

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* *Comptes rendus*, vols. 84 and 114.

These œnolic acids are all red, but of various shades, according to the *cépage*. They give the colour to the skin of the grape, and exist in great variety, their chemical composition, although not exactly identical, is close enough to allow it to be practically considered so.

These colouring bodies are distributed in the cells at the periphery of the grape under the epidermis, in the majority of *cépages*.

Quite characteristic is their insolubility in water, except, however, in *cépages teinturiers*, or varieties derived from them, such as Bouschet hybrids.

They are slightly soluble in strong, but not in weak acids. This explains the possibility of making white wine from red grapes (a great number of *cépages* at least) as the colouring matter does not find in the must before fermentation a proper solvent.*

The œnolic acids form a chemical group, the properties of which closely resemble those of the tannins, as has been established by Louis Hugounenq.† We, therefore, see at once the importance of the pellicle, for through its œnolic acids and pure tannins it furnishes the wine with useful tannin-like substances.

The action of the tannins is very favorable, they are good antiseptics and powerful preservatives against the possible future deterioration of the wine. On the other hand, they communicate to the wine that special flavour called by wine tasters *charnu*, *mâche*, *grain*.

The pellicle also contains an important odoriferous substance which has been carefully studied by Girard and Lindet.

"One of the most interesting facts, noticed by us during the analytic study of the different parts of a grape, is the localization in the cellular tissue of the skin of an odoriferous substance which gives to the wine of each *cépage* an essential and peculiar character—this substance is totally distinct from the bouquet, which is only formed gradually as the wine becomes matured.

* According to recent experiments made by Rosensthiel, this opinion may be disputed, at least as far as the fruit sugars are concerned, if not the water. Rosensthiel proved that, when out of contact with air, the colouring matter of fruits is dissolved in their juice by prolonged contact, and especially at an elevated temperature; this, it is understood, without interference of fermentation, in other words, in absence of alcohol. He goes so far as to state that we may preserve the must with the colour, flavour, and perfume of the fresh fruit. A very easily conducted experiment shows that the colouring matter of the grape is not soluble in water. It suffices to dilute with water a concentrated alcoholic solution of the colouring matter to precipitate it as a powder.

† *Recherches nouvelles sur le vins.* Imp. A. Storck, Lyon.

"All œnologists know that every wine resulting from the fermentation of a particular *cépage* has, especially while the wine is young, a characteristic flavour. The wines made from Aramon and Carignane, for instance, from the South of France, and those from Pinot and Gamay, from the Bourgogne *cépages*, differ entirely from each other.

"Expert tasters can differentiate these odours, which must not be confused, as is often done, with the so-called earthy taste. It is not the climate nor soil which determines it, they are peculiar to each *cépage*, and are often sufficient to characterize it. The influence of climate and soil only modifies them.

"The origin of these odours has not been indicated up to the present. Our researches enable us to state that they must be sought for in the cellular tissue of the skin, where, ready formed, this odorous matter, which imparts the character to the wine, exists side by side with the colouring matter, which determines the *robe* of the wine.

"Vergnette-Lamothe had, it is true, so far back as 1867,* originated the idea that certain essential odoriferous oils existed in grape skins, but the part played by them, and their nature, had not been ascertained so far.

"It is only in studying the weak alcoholic solutions from macerated skins for the estimation of the colouring matter and tannin, that we recognise the importance of this observation.

"Each of these solutions after a few days was impregnated with a strong odour reminding us of the flavour of young wine, and were easily differentiated from one another even by non-expert observers."

The *seeds* contain a fatty oil which is fairly abundant, and a number of substances some of which would be detrimental to the wine, if they were dissolved.

Fortunately, the most useful substance the seeds may yield to the wine, tannin, is placed near the periphery in such a way that it enters into solution before any of the others are appreciably affected. The increase in tannin due to the presence of the seeds is not positively proved, although some authorities believe that that substance is completely and quickly dissolved.

According to Girard and Lindet, "the seed also contains a resinous matter, the formation of which seems to be in direct

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* *Le Vin*, by Vergnette-Lamothe, p. 335.

proportion to that of the tannin; volatile acids are also contained, which apparently belong to the fatty series. They result from the saponification and oxidation of the neutral oil contained in the nucleus of the seed.

"The resinous matter is easily soluble in alcohol, slightly soluble in boiling water, and almost insoluble in cold water.

"By evaporation of these solutions it is deposited in the form of a light-brown powder, which tastes harsh when recently prepared but gradually becomes sweetish.

"It may be dissolved in alkaline liquids and precipitated from the combination so formed by the addition of an acid. It is easily oxidizable, especially in the presence of alkalies, and through oxidation loses the above-mentioned properties.

"To summarize, it is analogous to ordinary resins, but more rapidly alterable, and may be placed provisionally on a level with the product extracted from the bark of certain trees by Hoffstetter and Stähelein, and named by them *Phlobaphenes.*

"Amongst the properties mentioned above, one of them cannot fail to attract the attention of œnologists, namely, that the harsh taste is progressively attenuated by time—that attenuation enables us to account for certain long-known changes in the taste of maturing wines.

"But the presence of volatile acids detected in the seeds is still more important—they probably play an important part in the production of the bouquet."

We are inclined to think that Girard and Lindet place an exaggerated importance on the substances contained in the seeds. The analogy of the action of time on those substances, compared with its action on wine itself, does not seem to be sufficient to credit them with such importance. The harshness of young wines is generally recognised; it exists in stemmed red wine, and even red wines fermented without the seeds; and even in white wines, fermented without contact with either skins or seeds.

However, if the seeds are not crushed—and they never should be—their presence is harmless. The epidermis is impermeable enough to prevent the solution of the substances contained in them, which might exercise a detrimental influence on the wine. Besides, they are contained in the centre cells, and their solution is not to be feared, provided that the epidermis is not softened by too prolonged maceration.

In short, in the South of France, all the solid parts of the fruit may remain in contact with the must during fermentation, in the manufacture of red wine. Their presence presents some advantages and very few inconveniences.

COMPOSITION OF GRAPES OF THE PRINCIPAL "CÉPAGES" OF THE SOUTH OF FRANCE.

ARAMON "CÉPAGE."

Constitution of the bunch.

	1893.	1894.
Stalks	4·07 ...	3·65
Berries	95·93 ...	96·35
	100·00	100·00

Constitution of a berry of average weight 3·69 *gr.*

Pulp	88·81
Skin	9·45
Seeds	1·74
	100·00

The 88·81 per cent. of pulp represented 83·4 litres of juice per 100 kilos. of berries.

Chemical composition of the pulp representing 88·81 *per cent. of the weight of berries.*

	1893.	1894.
Density of juice	1·064 ...	1·056
Water	82·46 ...	—
Fermentable sugar... ...	14·09 ...	11·48
Bitartrate of potassium ...	0·62 ...	0·51
Free tartaric acid } * ...	0·39 ...	0·12
Malic and other acids } *		0·68
Nitrogenous matter ...	0·27 ...	—
Matters not estimated ...	1·61 ...	—
Mineral matters†	0·13 ...	—
Ligneous insoluble ...	0·43 ...	—
	100·00	

* Expressed as malic acid. The figure for 1893 appears very small and is met with quite rarely.—L. R.

† The potash in combination with tartaric acid deducted.

Chemical composition of the skin = 9·45 *per cent. of the weight of the berry.*

	1893.	1894.
Water	76·80 ...	—
Tannin	1·27 ...	—
Bitartrate of potash ...	— ...	0·88
Free acids*	— ...	0·69
Ligneous	20·10 ...	—
Mineral matters	1·83 ...	—
	100·00	

Chemical composition of the seeds = 1·74 *per cent. of the weight of the berry.*

	1893.
Water	34·82
Oil	6·92
Volatile acids†	0·57
Tannin	2·56
Resinous matters	4·45
Ligneous	48·82
Mineral matters	1·86
	100·00

Chemical composition of the stalks = 3·85 *per cent. (average) of the grapes.*

	1893.	1894.
Water	79·66 ...	78·91
Tannin	1·23 ...	2·52
Resinous matters	1·07 ...	0·87
Bitartrate of potash ...	— ...	0·92
Free acids‡	— ...	0·33
Ligneous	15·71 ...	14·49
Mineral matters	2·33 ...	1·96§
	100·00	

* Expressed as tartaric acid.
† Expressed as sulphuric acid.
‡ Expressed as tartaric acid.
§ The potash in combination with tartaric acid deducted.

CARIGNAN *CÉPAGE.*

Constitution of the bunch.

	1893.		1894.
Stalks	3·00	...	2·91
Berries	97·00	...	97·09
	100·00	...	100·00

Constitution of a berry weighing 2·58 grammes.

	1893.
Pulp	89·40
Skin	7·60
Seeds	3·00
	100·00

The 89·40 per cent. of pulp represented 83 litres of must per 100 kilos. of berries.

Composition of the pulp=89·40 per cent. of the weight of berries.

	1893.		1894.
Density of juice	1·076	...	—
Water	77·85	...	—
Fermentable sugar ...	16·12	...	12·64
Bitartrate of potash ...	0·62	...	—
Free tartaric acid ... ... Malic and other acids ...	0·58	...	1·04
Soluble nitrogenous matters ...	0·18	...	—
Matters not estimated ...	3·80	...	—
Mineral matters	0·17	...	—
Ligneous insoluble ...	0·68	...	—
	100·00		

Chemical composition of the skins=7·60 *per cent. of the berry.*

	1893.	1894.
Water	73·76 ...	—
Tannin	1·61 ...	—
Bitartrate of potash ...	— ...	1·07
Free acid	— ...	0·70
Ligneous and not estimated ...	22·73 ...	—
Mineral matters	1·90 ...	—
	100·00	

Chemical composition of the seeds=3 *per cent. of the weight of the berry.*

	1893.
Water	33·28
Oil	7·81
Volatile acids	0·81
Tannin	0·31
Resinous matters	1·35
Ligneous and not estimated	54·66
Mineral matters	1·78
	100·00

Chemical composition of the stalks = 2·41 *per cent. of the weight of the bunch.*

	1893.	1894.
Water	69·50 ...	72·00
Tannin	1·01 ...	1·02
Resinous matters	0·85 ...	1·21
Bitartrate of potash ...	— ...	1·10
Free acids	— ...	0·48
Ligneous and not estimated ...	25·96 ...	22·09
Mineral matters	2·68 ...	2·10
	100·00 ...	100·00

PETIT-BOUSCHET *CEPAGE.*

Constitution of the bunch.

	1893.	1894.
Stalks	4·40	3·82
Berries	95·60	96·18
	100·00 ...	100·00

Constitution of a berry weighing 1·95 *grammes.*

	1893.
Pulp	85·80
Skin	11·36
Seeds	2·84
	100·00

The 85·80 per cent represented 80·8 litres of must per 100 kilos. of berries.

Chemical composition of the pulp=85·80 *per cent. of the weight of berries.*

	1893.	1894.
Density of juice	1·061 ...	—
Water	82·11 ...	—
Fermentable sugar ...	15·74 ...	15·80
Bitartrate of potash ...	0·66 ...	—
Free tartaric acid, Malic and other acids ...	0·18 ...	0·56
Soluble nitrogenous matters ...	0·22 ...	—
Matters not estimated ...	0·68 ...	—
Mineral matters	0·08 ...	—
Ligneous insoluble... ...	0·33 ...	—
	100·00	

Chemical composition of the skin=11·36 *per cent. of the weight of the berry.*

	1893.	1894.
Water	77·94 ...	—
Tannin	1·06 ...	—
Bitartrate of potash ...	— ...	1.03
Free acids	— ...	0·43
Ligneous	19·95 ...	—
Mineral matters	1·05 ...	—
	100·00	

Chemical composition of the seeds=2·84 *per cent. of the weight of the berry.*

	1893.
Water	38·02
Oil	4·48
Volatile acids	—
Tannin	2·26
Resinous matters	4·07
Ligneous and not estimated	49·41
Mineral matters	1·76
	100·00

Chemical composition of the stalks = 3·82 *per cent. of the weight of the bunch.*

	1893.	1894.
Water	80·30 ...	76·52
Tannin	0·89 ...	1·05
Resinous matters	1·01 ...	1·24
Bitartrate of potash ...	— ...	1·26
Free acids	— ...	0·26
Ligneous and not estimated ...	15·40 ...	17·63
Mineral matters	2·40 ...	2·04
	100·00	100·00

PICQUEPOUL BLANC *CÉPAGE.*

Constitution of the bunch.

	1893.	1894.
Stalks	4·15 ...	3·04
Berries	95·85 ...	96·96
	100·00 ...	100·00

Constitution of a berry weighing 2·62 *grammes.*

	1893.
Pulp	91·90
Skin	5·63
Seeds	2·47
	100·00

The 91·90 per cent of pulp represented 86·6 litres of must per 100 kilos. of berries.

Composition of pulp = 91·90 *per cent. of the weight of the berries.*

	1893.	1894.
Density of juice	1·060 ...	—
Water	80·67 ...	—
Fermentable sugar ...	15·88 ...	16·68
Bitartrate of potash ...	0·53 ...	—
Free tartaric acid } Malic and other acids } ...	0·66 ...	0·81
Nitrogenous matters ...	0·21 ...	—
Matters not estimated ...	1·42 ...	—
Mineral matters	0·30 ...	—
Ligneous insoluble	0·33 ...	—
	100·00	

Chemical composition of the skin = 5·63 *per cent. of the weight of the berry.*

	1893.	1894.
Water	73·52	—
Tannin	0·50	—
Bitartrate of potash ...	—	0·80
Free acid	—	0·49
Ligneous and not estimated ...	24·29	—
Mineral matters	1·69	—
	100·00	

Composition of the seeds = 2·47 *per cent. of the weight of the berry.*

	1893.
Water	31·31
Oil	8·81
Volatile acids	0·64
Tannin	0·81
Resinous matters	1·40
Ligneous and not estimated	55·66
Mineral matters	1·33
	99·96

Chemical composition of the stalks = 3·50 *per cent. (average) of the bunch.*

	1893.	1894.
Water	75·48	72·24
Tannin	1·30	2·33
Resinous matters	0·81	1·40
Bitartrate of potash ...	—	1·15
Free acids	—	0·35
Ligneous and not estimated ...	20·59	21·14
Mineral matters	1·82	1·38
	100·00	99·99

The grapes used for the manufacture of red wine bring to the vat soluble and insoluble matters, which co-operate in the formation of the wine. The former are submitted to a chemical transformation or are simply dissolved in the liquid ; the latter play a mechanical part, which cannot be disregarded.

The soluble matters are far the most important; in the manufacture of white wine they are limited to those contained in the pulp, the white wines being fermented without contact with stalks, skins, or seeds.

This amply explains the difference in richness of extractive matter observed between red and white wine, even in white wine made from red grapes.

However, the substances contained in the must alone are sufficient to insure largely the healthy life of the vinous ferment whose function it is to transform it into wine.

We shall see later on in what degree it is useful to modify the composition of the must.

MATTERS BROUGHT TO THE VAT BY 100 KILOS. OF VINTAGE.

We have already stated that each of the four constituent parts of the complete fruit—stem, skins, pulp, and seeds—bring to the vat special products influencing the wine, either favorably or otherwise, proportionally to the absolute quantity of active substances they contain.

We have just been studying the percentage composition of each of the four parts of the fruit; we are now going to show in the following tables, borrowed from Girard and Lindet's work, what is in absolute value the quantity of active or inactive substances brought to the vat by 100 kilos. of Aramon, Carignan, and Petit-Bouschet *cépages*, that is to say, the three red *cépages* most widely cultivated in the South of France.

Name of Product.	100 kilos. of Entire Bunches bring to the Vat—				Total.
	Pulp.	Skins.	Seeds.	Stems.	
	kil. gr.	kil. gr.	kil. gr.	kil. gr.	kil. gr.
	Aramon *cépage*.				
Fermentable sugar	11·910	...	...	...	11·910
Bitartrate of potash	0·434	0·079	...	0·030	0·543
Free tartaric acid	0·102‡	0·062	...	0·013	0·756
Malic and other acids ...	0·579				
Tannin	...	0·114	0·043	0·097	0·254
Resinous matters	...	...	0·074	0·032	0·106
Soluble nitrogenous matters ...	0·230	...	...	...	0·230
Oil	...	...	0·115	...	0·115
Volatile acids *	...	...	0·009	...	0·009
Mineral matters †	0·110	0·136	0·031	0·075	0·352

NOTE.—For references (*), (†), and (‡) see footnotes to next page.

Name of Product.	100 kilos. of Entire Bunches bring to the Vat—				Total.
	Pulp.	Skins.	Seeds.	Stems.	
	kil. gr.	kil. gr.	kil. gr.	kil. gr.	kil. gr.
Carignan *cépage.*					
Fermentable sugar	13·980	...	...	...	13·980
Bitartrate of potash	0·537	0·079	...	0·032	0·648
Free tartaric acid ... ... / Malic and other acids	0·502	0·052	...	0·017	0·571
Tannin	...	0·118	0·009	0·029	0·156
Resinous matter	...	...	0·039	0·034	0·073
Soluble nitrogenous matters ...	0·156	...	...	...	0·156
Oil	...	...	0·227	...	0·227
Volatile acids*	...	...	0·023	...	0·023
Mineral matters †	0·147	0·110	0·052	0·061	0·370
Petit-Bouschet *cépage.*					
Fermentable sugar	12·960	...	...	...	12·960
Bitartrate of potash	0·543	0·112	...	0·040	0·695
Free tartaric acid ... ... / Malic and other acids	0·147§	0·047	...	0 011	0·205
Tannin	...	0·115	0·061	0·042	0·218
Resinous matters	...	...	0·110	0·050	0·160
Soluble nitrogenous matters ...	0·181	...	...	...	0·181
Oil	...	...	0·124	...	0·124
Volatile acids*	...	...	not estimated	...	...
Mineral matters †	0·065	0·073	0·048	0·081	0·267

* Expressed as sulphuric acid.

† The potash in combination with tartaric acid deducted.

‡ At complete maturity, we have not noticed free tartaric acid in the Aramon grapes, nor in several other *cépages.*

§ The figure given is very small.

CHAPTER III.

VINTAGE.

The word *vintage* has a very wide signification ; it means the gathering of the grapes, the result of the gathering, and the general cellar operations connected with it. In the following pages we will mean by the vintage the gathering of the grapes and the produce of that operation.

The choice of the time for the vintage is an important question to the vine-grower.

In the South of France, in the few days preceding perfect maturity, the transformation of the berry is so rapid, and the crop exposed to so many dangers, that we may easily conceive the haste with which the vine-grower endeavours to place in safety, sheltered against the inclemency of the weather, the fruit of the year's hard labour and uninterrupted care.

Logically, for the manufacture of table wine, the vintage must be made when the grapes have acquired their maximum of saccharine richness and maximum weight. It is well, therefore, to know some of the processes enabling us to fix the precise moment at which the grapes cannot gain anything by remaining longer on the vine.

These processes are of three kinds, empirical, physical, and chemical. The first, based on the exterior alterations and appearance of the grapes—the browning at the base of the stem, the increased transparency of the skin, the way in which the pedicel can be detached from the berry, with a portion of the pulp remaining attached to it, and, above all, the Pollacci process, relying on the close observation of the phenomena of ripening.

Pollacci noticed that ripening always commences from the outside and works gradually towards the centre of the grape; it suffices, according to him, to taste the pulp in contact with the seed, and compare it with the pulp in contact with the skin. Complete maturity is indicated at the moment that no difference in taste is detected.

The physical and chemical means, necessitating special though fortunately simple apparatus, are preferable and more accurate.

DETERMINATION OF SUGAR.

The method most employed in determining the saccharine richness is, according to the density of the must, determined by means of a densimetre, known also as glucometre, mustimetre, gluco-œnometre, &c.

If accurately graduated, or even if not, provided that the correction is known, they give reliable indications. They differ slightly from one another, in some cases the graduations read on the instruments can only be transformed into sugar by calculation. In other cases the graduation indicates directly the quantity of sugar present.

They all depend on the well-known law of Archimedes—"*All bodies plunged into a liquid are submitted from top to bottom to a pressure equal to the volume of liquid displaced.*"

It is clear, therefore, that if an instrument capable of floating is plunged into the must, the heavier the must, that is to say, the more sugar it contains, the less it will sink.

The density of a liquid containing a substance in solution is submitted to variations almost proportional to the quantity of the substance dissolved. Grape must, it is true, contains besides sugar a fair proportion of other substances, but their total weight compared with the sugar is negligable.

The glucometre devised by Dr. Guyot, and constructed by the Salleron firm, is, we think, the most convenient of these instruments. It consists of a thin glass tube, widened in cylindrical shape for one-third of its length, and provided at its base with a small bulb.

The instrument so constructed is adjusted by placing mercury or shot in the bulb, in such a way that when plunged into pure water at a fixed temperature it sinks almost to the top of the tube—at that point the zero is marked.

If now we allow the instrument to float in a saccharine liquid of which the strength is known, it will sink less, and level with the liquid a figure corresponding with the known strength is marked.

To complete the graduating, it suffices to divide into proportional intervals the space between the zero and the point determined by the experiment.

The graduation of these instruments is usually ready printed on a piece of paper, fixed inside the tube at the required height.

The graduation of the Guyot glucometre, shown in the drawing, presents the advantage of enabling us to read under three different forms from one observation, giving the richness in sugar expressed as kilogrammes per hectolitre, the degree Baumé, also called liquor degree, and the quantity of alcohol expressed in volume per cent., which will result from the fermentation of the must, if it is done under favorable conditions, and completely.*

The Salleron *mustimetre* only indicates the density of the must, and by means of a special table sold with the instrument we can ascertain from one observation:—

First. The corresponding degree Baumé.
Second. The weight of sugar in grammes per litre of must.
Third. The alcoholic strength of the wine after fermentation.
Fourth. The weight of crystallized sugar to be added to one litre of must for the wine to contain 10 per cent. of alcohol by volume.
Fifth. The density of the resulting wine, and therefore the weight of one hectolitre—the results enabling us to gauge a cask without measuring the liquid.

The very complete indications obtained from a single observation, followed by the reading of the table, make it a very handy and useful instrument.

The gluco-œnometre simply gives the degree Baumé.

The shape of all these instruments is similar, they are simply areometres of constant weight and variable volume, which means that the volume submerged varies with the density of the liquid.

* A correction, however, must be made. The Guyot scale always indicating for the determined sugar the weight and alcoholic volume a little in excess, namely, 0·8. This, no doubt, is the result of this scale being calculated on the basis of the theoretical chemical equation.

The different indications given by these areometres directly or indirectly are useful, but not indispensable. It is necessary in order to determine the moment of perfect maturity to rapidly test for the stationary state of the saccharine weight. For this purpose any densimetre, correct or not, may be used, provided the same instrument is used for each trial.

The chemical processes for determining sugar are very exact, but are too complicated to be usefully recommended to vine-growers.

We only attach secondary importance to the exact knowledge of the sugar content of the must. If it is necessary to operate with precision in scientific researches, it is not so when we have to deal with wine-making on a large scale, and densimetrical observations are sufficiently accurate.

DETERMINATION OF ACIDITY.

This is of great importance, and gives a very good indication of the state of maturity.

The acidity of the grapes decreases from the change of colour of the berry till maturity, remaining at that time almost stationary, and then increases when the grapes are drying.

The increase after maturity is only apparent, and does not affect the percentage weight.

If we measure the absolute quantity of acid in a ripe berry, and in a berry of equal size taken at the same moment, but left attached to the stalk to dry, we do not find a notable diminution in the acids.

In practice, however, it is easy to detect the above-mentioned stationary state.

We have often mentioned in previous publications and lectures the necessity for the wine-maker to be able to determine exactly the acidity of the musts, for it is an important factor in the future quality of the wine.

We will explain later on the reasons which lead us to attach such importance to the acidity.

In a laboratory, no doubt, and to any one used to chemical manipulations, the determination of acidity is a very simple operation. The necessary apparatus for it always exists even in the most elementary laboratories. In the vineyard it is complicated to any one unacquainted with the exact measurements made on small masses, and with the necessary calculations to bring the result to concrete figures.

The acidimetric apparatus consists essentially of an instrument measuring a known volume of the liquid to be examined, a graduated tube or burette for delivering the alkaline solution accurately, and an alkaline solution of previously determined strength as compared with a known weight of acid.

The neutral point is rendered easily detectable by the use of colouring matters, called in chemistry *indicators*, which have the property of changing colour in the presence of acids or alkalies. It suffices to have an extremely slight excess of either acidity or alkalinity for these changes of colour to be manifested.

The natural colouring matter of the grape is itself a good indicator, red in acid solution, changing to green with alkalies.

For white musts, *phenolphthalein* dissolved in alcohol is a very convenient indicator. It remains colourless in acid solutions, and becomes purple red in presence of an infinitesimal quantity of alkali. Acidimetres are numerous and varied in arrangement. They do not all render the measurement of acidity easy of performance by the vine-grower.

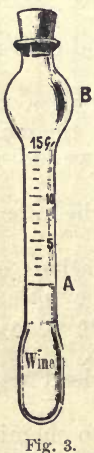

Fig. 3.
Acidimetric Tube,
Dujardin.

One of these, constructed by Dujardin,* called Acidimetric tube is the smallest and most simple. It consists of a cylindrical glass tube, closed at its lower end, and bearing graduated marks on the central part. The first division from the bottom indicates the volume of wine or must to be used; the divisions over it serve to measure the quantity of alkaline liquid necessary to obtain the reaction marking the end of the operation.

The *modus operandi* is simple.

Pour the must or wine into the tube up to A, adjust the liquid to the level of the division by means of a pipette, and add, if operating on white musts, two or three drops of phenolphthalein solution.

Pour in carefully, and in small quantity, the titrated alkaline solution, a rosy tint

* J. Dujardin, successeur de Salleron, Paris.

appears, which, however, disappears on shaking. Add the alkaline solution in successive small portions till the last drop colours the solution a *permanent* rose tint.*

The acid strength expressed as tartaric acid per litre is given by the figure opposite the level of the liquid in the tube.

It is a very simple operation, but perhaps less simple in practice than it seems through reading the description.

The drawback of most acidimetres is that they are operated with small quantities of liquid, and therefore any error in measurement becomes greatly increased when calculated to one litre.

When the must is measured by means of a pipette it gives good results, but is rather difficult to an inexperienced person. The operation seems easier when the measurement is made in a tube, as in the above acidimetre, but the slightest error in agreement between the level of the liquid and the division leads to a considerable error. As for the reading of the volume of alkaline solution, in a burette or tube it always remains uncertain, and leads to errors, and falsifies the result, varying more or less the smaller the quantity of liquid that is operated upon.

We must, therefore, if we want the vigneron to get into the habit of measuring the acidity of the grape must, devise a simple apparatus, facilitating the operation and working on a sufficiently large volume of liquid to render the errors of reading the divisions negligable; and giving the acid strength of the must per litre from one observation only.

We may easily make such an acidimetre with the following pieces of apparatus: Fig. 4. First, a burette, or cylindrical tube, 1 centimetre in diameter, and divided into $\frac{1}{10}$ths from 0 to 20 cubic centimetres, B. Second, a graduated flask with a narrow neck cut off exactly at 100 c.c.m. to allow the measurement of the must to be made simply by filling it, I. A large glass beaker holding 400 cubic centimetres, D. A titrated alkaline solution (potash or caustic soda), E.

A solution of phenolphthalein, F, of which two or three drops are placed in the must before the operation, and by turning red indicate the end of the operation.

The acidity of the wine is usually expressed in terms of sulphuric acid per litre. This is a conventional arrangement

* In the case of red must a greenish colour marks the completion of the reaction.

not calling for criticism, but when we have to deal with musts it is preferable to express the acidity as tartaric acid, as it is the only acid used to correct the vintage. It would suffice to titrate the alkaline solution in such a way that one cubic centimetre would neutralize exactly 10 centigrammes of tartaric acid, so that the figure read on the burette would represent the weight of tartaric acid per litre.

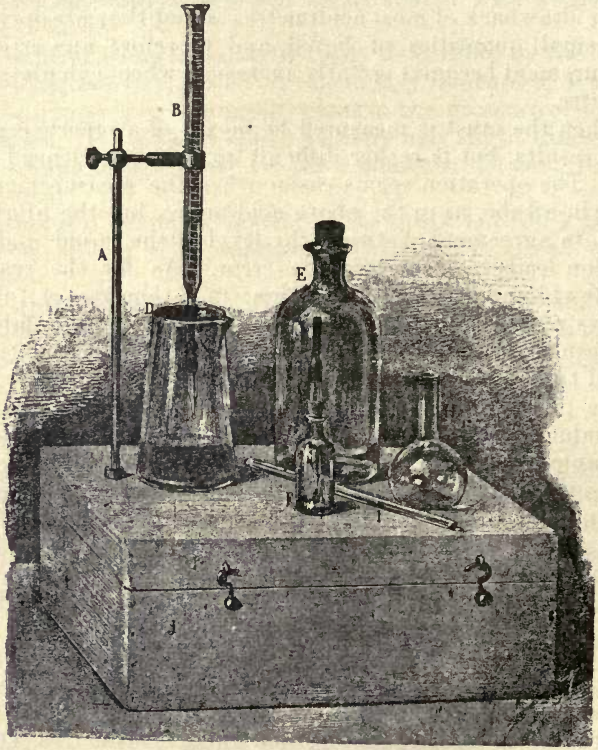

Fig. 4.—Portable Acidimetre.

But, however simple the use of an acidimetre of this kind may be, we must draw the attention of the vine-grower to a few details as to the method of operating in order to obtain exact results.

MODE OF OPERATING.

Crush with the hands, about 500 grammes of grapes, and squeeze the juice through a cloth.

Fill the flask with the must thus obtained until it overflows.

Pour the contents of the flask into the 400 cubic centimetre beaker; rinse the flask with an equal quantity of water (rain water or distilled, if possible) and add it to the must.

Add to it 4 or 5 drops of phenolphthalein solution.

Fill the burette to the zero point with the alkaline solution; deliver the alkaline solution gradually from the burette into the must until the reddish coloration appears permanently.

When that result is obtained, read on the burette the graduation level with the surface of the alkaline solution. Let us assume, for the sake of argument, that it is 9·7; this means that the must contains 9·70 grammes of tartaric acid per litre, or 970 grammes per hectolitre. In this case it would be unnecessary to add any acid to the must.

Under these circumstances, even if placed in unskilful hands, this apparatus will give sufficiently exact results, especially if care be taken to make previously a rapid trial giving the approximate acid strength.

To do so one operates as above described, adding the alkaline solution in fractions of 1 cubic centimetre each. At 8 cubic centimetres, for instance, the liquid has not yet become red; at 9 cubic centimetres it is completely red, this meaning that the result is between 8 and 9 grammes per litre. It will, therefore, suffice to commence the operation again, adding at once up to 8 cubic centimetres of the alkaline solution, and continuing drop by drop till the appearance of the permanent rose tint.

A little before obtaining the final tint the liquid becomes slightly brownish. This renders the determination of the end of the reaction rather difficult for beginners. This colouring occurs with all musts, even when there is no indicator added, and should not be taken into account. It is in order to diminish it that the must is diluted with water.

As long as the colour remains brown it need not be further considered than as a precursory sign of the end of the operation; an additional two drops ($\frac{1}{10}$th cubic centimetre) of alkaline solution added to the must will cause the colour to turn from brown to red quite decidedly.

A final experiment on the range of colours as above will render this quite clear.

The pieces of apparatus required are easily procured from commercial houses. With regard to the alkaline solution, any scientific pharmacy can supply it to order. The wine-maker may, however, rectify the alkaline solution by dissolving a known weight of tartaric acid in an accurately measured litre of distilled water (8 grammes, for instance), and using that solution in place of the must it should show on the burette the figure 8, if the titrated liquid furnished by the pharmacist is exact.

The tartaric acid of commerce is sufficiently pure to be used for the trial, and any pharmacist will weigh it accurately.

All non-coloured or slightly reddish musts may be tested in the manner above described, but for coloured musts, such as those of the Bouschet hybrids, the end reaction is not so distinct. It is preferable, in this case, to work on must diluted with twice its volume of water, and without an indicator. The *modus operandi* would then be as follows :—

Fill the 100 cubic centimetre flask with must, and pour the contents into the 400 cubic centimetre beaker ; rinse the flask twice with water, filling it each time, and add the rinsings to the must.

Run in, with constant shaking, the alkaline solution from the burette.

The diluted must will pass through the following range of colours : —Red, violet red, violet, brown, and suddenly become deep green. This indicates the end of the reaction.

The green colour must not be observed by transmitted light, the liquid being too deep in colour to allow a clear perception of the transition tint, but by rotating the beaker it is easy to detect it in the thin film of liquid wetting the sides of the beaker.

The wine-maker, therefore, has at command two means quite sufficient to enable him to ascertain the maturity of his crop. First, the glucometre shows when the grapes are not increasing in sugar content ; second, the acidimetre shows when they are not diminishing in acidity.

It is desirable for the vintage to be made at that precise moment, for then only can the maximum of alcoholic strength be obtained, and therefore the maximum of pecuniary value, considering, as goes without saying, the common wines of the South of France. The correction of the acidity, which one is very often obliged to increase, is a simple and economical operation considering the gain of alcohol it brings about.

However, that desideratum is not always easy to realize in practice, as the wine-maker is not always able to wait till the opportune moment.

Many circumstances, amongst which we will note the necessity of assuring the indispensable labour, restrict the desired objects of the large growers; the small grower alone remains master of his vintage.

In the South of France there is a very marked tendency to vintage sooner than is necessary. We know there are many good reasons to justify this tendency, but we have still better reasons to combat it.

INFLUENCE OF THE TIME OF VINTAGE ON THE QUALITY OF WINES.

General observations have shown that early vintages ferment well, and that the resulting wines are judged more favorably by expert tasters.

We will endeavour to explain why this is so.

For fermentation to take place under favorable conditions, it is necessary for the yeast, which has to transform the sugar into alcohol and secondary products, not to be retarded by the composition of the must or its temperature during fermentation. We know that the yeast cannot withstand a high temperature, nor too large a proportion of alcohol. Moreover, the higher the temperature the smaller the quantity of alcohol the yeast can withstand.

If, in the fermentation of an early vintage, we do not notice a slackening in the activity of the ferment, although the temperature is often very high, it simply means that the alcoholic strength is low.

In a late vintage, on the contrary, the alcohol being in greater abundance, adds its detrimental effect to that of the temperature, and the result of the two actions is to paralyze the ferment, preventing it from transforming the remaining sugar into alcohol.

The complete disappearance of the sugar will, it is true, in many cases, take place through a slow fermentation, but, at the same time, other organisms will be at work communicating to the wine characteristics which will have the effect of diminishing its *organoleptic* value.

Even in admitting a complete and rapid fermentation (which is often obtained with a late vintage notwithstanding the unfavorable conditions of temperature, if the wine is not to contain more than 10 or 11 per cent. of alcohol when completely fermented), the wines resulting are more often than not less appreciated by expert tasters.

The tasting is very complex, and exceedingly difficult to analyze, especially when we have to judge the pecuniary value of a wine. We must apply for the tasting trial to wine merchants, who always have a tendency to judge more favorably types of wine adapted to their own particular trade. All wine merchants have not the same requirements; a wine adapted to an export wine merchant's trade would command a higher price than another wine which would have been paid for at the same rate by a merchant selling locally.

There is, in this instinctive tendency of the wine taster to judge the value of a wine from his own personal stand-point, something disconcerting for scientific researches.

However, these divergences of appreciation are not very considerable, and if we sometimes find many wine tasters agreeing with each other, to award the same number of marks to a wine submitted to their judgment, they often indicate by different terms the qualities distinguished by them. It is therefore very difficult to determine to what element the wine owes its quality or value, and chemists cannot fail to recognise that an analysis of wine, however complete it may be, cannot give its real *organoleptic* value

By comparing these two methods of examination, chemical analysis and tasting, we may endeavour to discover if some of the results of the analysis, are constant for a comparative tasting appreciation, and therefore if we cannot deduce a rule from the great number of cases observed and see if that rule is absolute and shows no exceptions.

Indeed, a rule may be deduced from the numerous analyses of natural wines of different regions, and to that effect we have studied the analyses published :—

By Professors Gayon, Blarez, and Dubourg, of the wines of the Gironde, for two successive years (1887 and 1888).

By Prof. Margottet, Director of the Agronomic Station of the Cote-d'Or, of the wines of Bourgogne.

By Giraud, David, and myself, of the wines of the Hérault vintages of 1889 and 1890.

The wines of the Gironde and Bourgogne are unquestionably superior, owing to their origin; their average acidity is 5·21 for the former, and 5·98 for the latter,* acidity expressed in terms of sulphuric acid per litre.

The analyses of the wines of the Hérault furnish us with still more suggestive results; the acidity of the wines for the 1889 vintage averaged 5·15, for the 1890 vintage 4·80; and everybody knows that the quality of the wines of the 1889 vintage was unquestionably superior to that of the wines produced the following year.

To sum up, the conditions under which the samples of the 1890 crop were taken enable us to deduce conclusive results from the analyses made.

A jury of wine tasters was asked to express their opinion of the wines; before analysis the bottles were specially marked, to enable them to be identified later on. The wines judged to be the best were those in which the average acidity was highest. The average result of the analysis gave 5.44, being 0·64 above the average acidity of the other wines of the same year, analyzed at the same time. The opinions of the expert tasters, therefore, very fortunately corroborate what we have been saying respecting the acidity of the must; and this is not a blind judgment, for the appreciation is constant with regard to natural acidity. The judgment is quite different with regard to artificial acidity; if we take a wine of medium quality with an acidity of 4·00 for instance, and if that acidity is brought to 5 or 5·5 by the addition of tartaric acid, it will still be declared to be of medium quality by the expert wine taster, for the impression perceived by his palate will be totally different to that resulting from a wine naturally containing 5·5 acidity.

All wines favorably judged by skilful tasters possess a relatively high acidity, which is never below 4·50 grammes, expressed in terms of sulphuric acid per litre.

It does not follow that all acid wines are good. It only means that wine cannot be good if deficient in acid.

We cannot hope, therefore, to make a good wine if the average total acidity does not reach 4·50 per litre.† And in

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*Figures given by P. Paul in his work on *Vinification*, already mentioned.

† This amount, however, is only sufficient in the case of a wine of high alcoholic strength. It is too low, for wines containing 8 per cent. of alcohol.

To calculate the acidity as tartaric acid, the figures expressing it, as sulphuric acid must be multiplied by 1·53.

southern regions with our *cépages*, a well-ripened vintage does not reach that indispensable acidity, but contains it only in under-ripened vintages.

For these two reasons; difficult fermentation and lack of acidity, the wines of late vintages are often classified as inferior when compared with the wines of an early vintage.

We have tried to discover if by properly correcting the acidity of the vintage it is possible to obtain wine of equally good flavour, but richer in alcohol, by retarding the time of gathering. With this object two lawful means may be used; the addition of tartaric acid extracted directly from the grape, seems most simple and practical, on account of the facility of estimating it, and its small market price.

There are also cases where the second crop may be used with advantage,* as advocated by eminent œnologists, such as Prof. A. Gautier.

Both of these means lead to the same result, for, as we have said in another work,† the acidity of the second green crop is mainly due to tartaric acid.

During two successive years we made laboratory tests, the results of which have always been excellent, the temperature of fermentation being easily regulated in the laboratory. In cellars this is not possible, at least, not yet, therefore we cannot expect on the commercial scale such satisfactory results, but we have made large scale experiments, amongst which we quote the two following:—

1st. At Frontignan (Hérault).

Vineyard well sheltered against cryptogamic diseases (heavier yield than previous year)‡. On the 6th September a small vat of 15 hectolitres, was filled with Aramon and Carignan, in the proportion of three to one; the first racking took place four days afterwards.

On the 21st September the same vat was filled in, exactly the same way, with the only difference that 60 grammes of tartaric acid per hectolitre were added. The racking again took place four days later.

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* In the *Revue de Viticulture*, dated 7th September, 1895, an article appeared on this subject. Owing to its importance for local wine-makers, it was translated by one of us (W. P. W.). See the *Australian Vigneron*. Dec., 1895. And applied by us at the last vintage at the Viticultural College, Rutherglen (R. D.).

† Roos and Thomas. Contribution à l'étude de la végétation de la vigne. —*Ann. Agronomiques.*

‡ The trials were made in 1895, when mildew was very prevalent.

From September to February the two wines were kept in 25 litre casks, without any special care, or racking or filling up, which allows conclusions to be drawn, as to their respective power of conservation under unfavorable conditions.

The following are the results obtained by the analysis of these two wines :—

	Early Vintage (Frontignan).	Late Vintage (Frontignan).
Alcohol (by volume) ...	8·6 per cent.	10·5 per cent.
Dry extract	16·0 grammes per litre	18·90 grammes per litre
Reducing matters (sugars)	traces	traces
Acidity (total)	5·75 grammes per litre	6·01 grammes per litre

The wine of the late vintage is of richer colour than that of the earlier vintage ; the latter did not keep well, it turned and became cloudy. The wine of the late vintage kept in a much more satisfactory manner.

2nd. In the environs of Thuir (Pyrénées Orientales).

Vineyard well protected against cryptogamic diseases. On the 12th September, a 70 hectolitre vat was completely filled with Carignan gathered in equal parts from two plots of the same soil, one being manured, the other not ; the racking took place five days later.

On the 28th September the same vat was filled with Carignan, gathered in the same proportion from the same plots, but 70 grammes of tartaric acid per hectolitre were added.

The racking took place five days later, and the two wines were afterwards submitted to the same treatment. Here are the results of the chemical analysis :—

	Early Vintage (Thuir).	Late Vintage (Thuir).
Alcohol (by volume) ...	10·50 per cent.	11·60 per cent.
Dry extract	18·50 grammes per litre	25·00 grammes per litre
Reducing matters (sugars)	traces	1·25 grammes per litre
Acidity (total)	5·10 grammes per litre	5·90 grammes per litre

The wine of the late vintage is richer in colour. It is, therefore, perfectly certain that the time of vintage has a very great influence on the composition of the wine. The figures expressing the alcohol and dry extract are notably higher for the late vintage wine.

But are those wines really better, or will they simply bring a higher price when placed on the market ?*

Personally, we think they are better, if the fermentations were not too poor, and if the wines have a sufficient quantity of acid. If, in other words, the vintage has been corrected in such a manner as to obtain wines of an average acidity of 4·50 or over, per litre. It is also to be noticed that the detrimental influence of high temperatures is diminished by high acidity.

Therefore, this reason alone should be sufficient to induce us to increase the acidity of the must before fermentation. The temperature appears of greater importance when we examine the phenomena accompanying the use of tartaric acid in the vintage.

If the acidity of wine is an important factor for its quality, the ratio of acidity is not alone sufficient to constitute that factor. It is necessary that the acidity should be due exclusively to the acids existing normally in the vintage, even if not quite ripe. Amongst these acids the tartaric acid alone is of importance. We have frequently tried to increase the acidity of a wine deficient in acid (otherwise well constituted, but of medium quality only) by adding tartaric acid; and to submit it to the judgment of skilful tasters. In most cases the wine was improved, but never enough to be considered a good wine.

The acidity of the wine should never be due to free tartaric acid in notable proportion; the tartaric acid disappears in the grape as maturity advances, and does not exist at all a few days before complete maturity.

This is a phenomenon noticed by different authorities, one of them being Prof. Bouffard.

From researches undertaken in collaboration with Eugene Thomas, in 1891,† it appears that on the 10th of August the acidity of the grape, expressed as 19·90 of sulphuric acid per litre, was half of it due to free tartaric acid, whereas on the 21st September the acidity had fallen to 5·60, which was exclusively due to fixation of the other acids of the grape.

* These four wines were presented to the Central Agricultural Society and to the Departmental Society for the Advancement of Agriculture of the Hérault. The wine tasters of the former society called to express an opini n, concluded in favour of the early vintage wines from Thuir, and in favour of the late vintage wines from Frontignan. The wine taster of the latter society found in both cases that the late vintage wines were superior.

† L. Roos and E. Thomas. Contribution à l'étude de la végétation de la vigne.—*Ann. Agron.*, 1892.

The above figures show the percentage proportion. The analysis made on that occasion enable us to establish the real disappearance of the tartaric acid, so far as free tartaric acid is concerned, but they do not yet show the diminution of the acid in actual value.

This disappearance, however, is certain, as the following absolute values drawn from the same researches go to prove.

On the 10th August, 343·60 grammes of grapes contained a total amount of acids equivalent to 6·83 grammes, expressed as sulphuric acid, whereas on the 21st of September the same grapes weighing 753 grammes contained only 4·21 grammes of total acidity. This disappearance affects, so far as free acids are concerned, the tartaric and other acids of the fruit, and it is quite probable that it is simply the result of the plant absorbing chemical bases from the soil, converting them into neutral salts through combination with the acids.

There was, in fact, in the 343·60 grammes of grapes on the 10th August, 1·27 grammes of mineral matters, of which 0·55 grammes were potash. At the same time, in the 753 grammes of grapes gathered on the 21st September, there were 2·86 grammes of mineral matters, of which 1·20 were potash in presence of 4·21 grammes of acidity.

Complete maturity has, therefore, the effect of fixing as saline compounds, especially potassic, a part of the acids forming the normal acidity of the grape, in such a way that if the vintage does not possess at maturity the required acidity, it is not that it does not contain the required acids for that purpose, but that the excessive amount of potash partially neutralizes their properties.

The addition of tartaric acid to the vintage has the effect of immediately entering into combination with the potash, and has, therefore, the secondary effect of increasing the acidity, by causing the re-appearance in the liquid in a free state of the acids pre-existing in neutral combinations. This effect is so true, that not only do we fail to find any free tartaric acid in the wines resulting from an acidified vintage, but, further, we can by laboratory experiment find the total tartaric acid added in the form of a surplus of bitartrate of potash.

This fact has been verified by us frequently, as well as by Prof. Bouffard, who established it a few years ago in the course of experiments on the vinification of Jacquez.

These considerations explain why the addition of tartaric acid to the vintage produces much more favorable effects than the addition of tartaric acid to the wine.

In the latter case, unless we deal with very small quantities, a part of the added tartaric acid remains free, and imparts to the wine that harsh taste, setting the teeth on edge, and contracting the muscles of the mouth in a disagreeable manner, which is so characteristic of tartaric acid.

The experiments we have just been considering are no doubt incomplete. We should also have made trials on late vintage wines non-acidified in order to judge them comparatively. This did not occur to us at that time, but we intend to complete these experiments at an early date.

A most remarkable fact noticed during the above experiments is that, although we tried to bring the acidity of all the late vintage wines up to the same standard of acidity as those of the early vintage, the late vintage wines remain *more acid* than those of the early vintage. We expected a diminution of the acidity, as the increase of the alcoholic strength checks the solvent action of the liquid on the bitartrate of potash. The only possible cause we can see to explain the increase of the acid is an increase of succinic acid.

There is another plausible explanation. It is a fact that the wines resulting from the above experiments varied considerably in intensity of colour, the late wines being much richer in colour. The colouring matters which play the part of acid in the wine are not measured in the must, and it is to the increase of colouring matter that the unforeseen increase of the acidity may be due. But this yet remains to be cleared up.

The results obtained are, however, of a nature to cause new experiments to be made in cellars, in correcting the vintage, firstly by acidification, and secondly by regulating the temperature.

We feel convinced that if these two conditions are realized, wine of a much higher class will be obtained by vintaging later than is usually done.

M. Coste, Departmental Professor of Agriculture of the Hérault, informed us recently that in any vineyard, small enough to allow the vintage to be made rapidly, the date of vintaging should be postponed as much as possible and the musts corrected subsequently.

It is not within the scope of this work to discuss the viticultural reasons that may interfere with this practice. But if the economical advantages of late vintages were well established, means might be found to reduce the danger there is of leaving grapes too long on the vine.

We have only aimed at showing by comparative trials that it is possible to obtain wines of very different composition, taste, and value, according to the time the vintage is made.

IMPROVEMENT OF CERTAIN VINTAGES.

We have already seen* the quantities of soluble matters brought to the vat by 100 kilos. of different *cépages.* In the great majority of cases the vintage does not require to be modified in composition, in order to furnish wines of clean taste and good keeping quality.

There are cases, however, where improvement of the vintage is necessary.

The defects most frequently met with are:—

An imperfect bloom on the berries, caused by heavy rains, which also soil the grapes with earth.

A deficiency in saccharine strength, due either to an invasion of cryptogamic diseases or of unfavorable climatic conditions.

A lack of acidity, always noted during hot and damp seasons.

In the first case the use of cultivated yeasts is indicated. Selected pure yeasts may now be obtained in commerce, or they may be cultivated by vine-growers, carefully choosing only healthy grapes to start with.

We have had occasion to point out† that some vintages resulting from flooded vines, which had yielded under ordinary conditions a turbid muddy liquid, deserving any name except *wine*, had given, by the use of cultivated yeasts, wines of clean taste and excellent keeping qualities.

It is, therefore, to cultivated yeasts that recourse should be had, whenever the skins of the grapes, from whatever cause, are deficient in yeast germs, as is often the case in some regions of France.

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* Girard and Lindet, *loc. cit.*

† Vinif. et lev. cultivées. *Progrès agricole et viticole.*

The addition of sugar to the must is the remedy for deficiency of sugar in the grapes.*

DEFICIENT ACIDITY.

This is very frequently noticed in the South of France. It is a true defect, for the quantity of acid in the must has a very great influence on the development of the yeast. We may lay down as a general principle that the more acid a vintage is, the greater difficulty ferments other than alcoholic will find in developing.

The standards of required acidity for a few important *cépages* are:—

8 grammes of tartaric acid per litre for musts of Aramon, Carignan, and other varieties used for making ordinary wines.

10 grammes of tartaric acid for Bouschet hybrids.

12 grammes of tartaric acid for Jacquez.

Whenever the acid strength is below these standards, it should be brought up to them in order to obtain the maximum quality.

The acidification of the vintage with *tartaric acid* is a lawful operation, for it does not add anything to the resulting wine, if the addition to the must be properly made.

The acidified vintage, as we have just pointed out, does not furnish a harsh wine, as in the case of wine acidified after fermentation.

The acidification of the vintage is a common practice in the South of France. Very often it is badly conducted, and frequently done when not necessary. The explanation offered by some vine-growers is that a neighbour did it the previous year and made a fairly good wine.

The measurement of the acidity of the must is not an impossible operation for vine-growers. Commerce places at their disposal a cheap apparatus reducing the operation to its simplest expression. They are thus enabled to know when it is necessary to add tartaric acid to the vintage, and the figures we have given will enable them to know in what proportion the addition of acid should be made.

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* We have omitted the details of this practice as it is rarely necessary in Victoria. (Trans.)

When the quantity to be added to a given vat has been calculated, the acid is distributed by hand, over the grapes in the crusher, as they are passing through.

We may operate in another way by filling a bucket with the crystals of tartaric acid, and washing with a stream of must from the vat, by means of a pump, until completely dissolved.

It may sometimes happen, as was frequently observed in 1896, that, although resulting from well-matured grapes, the must shows a percentage of acid higher than the figures above mentioned as desirable. This is generally the result in dry and warm seasons. L. Mathieu, in a study on the improvement of acid wines,* does not advise any special process.

It does not appear that a superabundance of acid is an inconvenience. Wines resulting from rather acid vintages, but well ripened, are always good. In these not very frequent cases, it is to a superabundance of bitartrate of potash that the excessive acidity is due. It simply results in the lees being richer in cream of tartar.

It is not so, however, if we consider a badly-ripened vintage, as is too often the case in the Centre and East of France.

We have only addressed ourselves to the hot climates in what we have said so far, where complete maturity can always be obtained.

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* L. Mathieu. Amélioration des vins verts. *Revue de Viticulture.*

CHAPTER IV.

VINIFICATION.

We will not describe here the details relating to the gathering, or the various methods used to convey the grapes to the cellar, but will only study the fermentation proper.

VINIFICATION OF RED WINE.

The first manipulation the grapes are subjected to is the *crushing*.

Crushing, with very few exceptions, is recommended by all œnologists and practised by all vine-growers. It consists in disintegrating the grapes in such a way that the juice and pulp are expelled from the skin without the stalk or seeds being crushed. The machines used for this purpose are called *crushers*.

CRUSHERS.

The most old-fashioned form, still used in a few small vineyards, is a kind of kneading trough, with the opening placed above the fermenting vat, in which the grapes are squashed by the rosy feet of young farm girls.

This is an excellent means of crushing, the stalks and seeds remaining intact, while the vintage is submitted to prolonged contact with the air, for the surface being incessantly agitated insures perfect aeration of the must.

Crushing by the feet is, however, a tedious and expensive operation, and can only be used by small proprietors. It presents a repugnant feature, however, no matter what cleanliness be attributed to the crushers. This reason alone amply justifies the progressive abandonment of the old-fashioned kneading trough, to the advantage of mechanical crushers.

M. Paul, civil engineer, in his work *De la vinification*,* classifies crushers into four groups :—

Simple crushers, operating by compression or projection.
Stemmer and crusher combined.
Extracting crushers, also called continuous presses.
Extractor and classifier crushers.

This last group does not seem to us applicable to true crushers, but rather to a series of apparatus performing a number of operations; which are not all indispensable.

The best-known mechanical crusher is that constructed with two cylinders. This is the oldest and most used. It acts by compression (like a rolling mill), the grapes being forced to pass through a limited space, too narrow to allow the berry to escape being crushed.

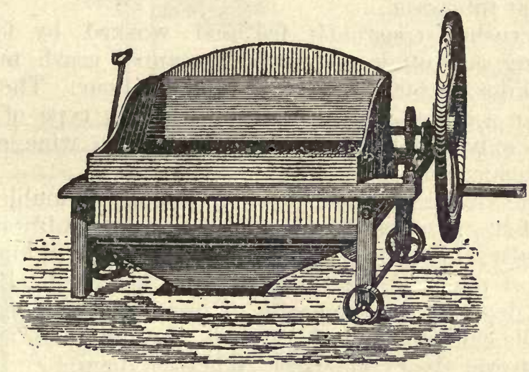


Fig. 5.—Cylinder Crusher fixed above the Vat.

It is composed of two cylinders. (Fig. 5.) One with grooves running parallel to the axis, the other with helicoidal grooves. The distance apart of the cylinders is carefully regulated. If too close, only a limited amount of the work is utilized, and if too far apart the crushing is insufficient. The cylinders are rotated at different speeds, in the ratio of 1 to 3, the cylinder with helicoidal grooves revolving fastest.

They are worked by hand or mechanical power, the work performed corresponding to the regularity of feeding.

* Paris. J. Fritsch, 1894.

Those worked by hand are usually mounted on wheels and placed above the opening of the vat; under these conditions the aeration of the vintage is imperfect, the contact with air being almost nil.

This is, fortunately, a defect which may easily be remedied, as we shall show when discussing aeration.

One of the greatest inconveniences of the cylinder crushers is that the accidental introduction of a hard body (a stone, for instance) may break the cylinders and stop the work. Attempts have been made to minimize this defect, but so far unsuccessfully.

The working of such a crusher is laborious. The men must often be relieved, but this only becomes an inconvenience in the case of large cellars. In small cellars, on the other hand, this does not apply, the work being intermittent, on account of the loads of grapes arriving at the cellar at intervals.

A crusher constantly fed and worked by four men, relieving each other at intervals, cannot crush more than 3,000 kilos. (6,600 lbs.) of vintage per hour. The yield of juice for a given *cépage* is poor with this type of crusher. This is only a defect in the case of white wine, especially when made from red grapes.

If the vintage is crushed by means of a double crusher (with four cylinders) the yield of juice is notably increased.

Finally, this type of crusher is good, and will long remain the most practical, for small and medium sized cellars.

The depth of the grooves is of importance; if too shallow the rolls cannot draw the grapes through, and they form a vault over the cylinders or slide over them.

If too deep they cannot do good work, if the cylinders are too far apart; or crush both stalk and seeds if the rolls are too close together. This is an objection raised by P. Paul against large grooves.

In a report on cellar appliances read before the International Viticultural Congress held at Montpellier, in 1893, Paul states that grooves geared into one another do not give good results.

This criticism does not seem to be fully justified.

If we consider the case of grooves sufficiently large to allow the grapes by their elasticity to become adapted to the shape of the grooves, without being torn to pieces, we may hope for satisfactory crushing, without the seeds or stalks being ground.

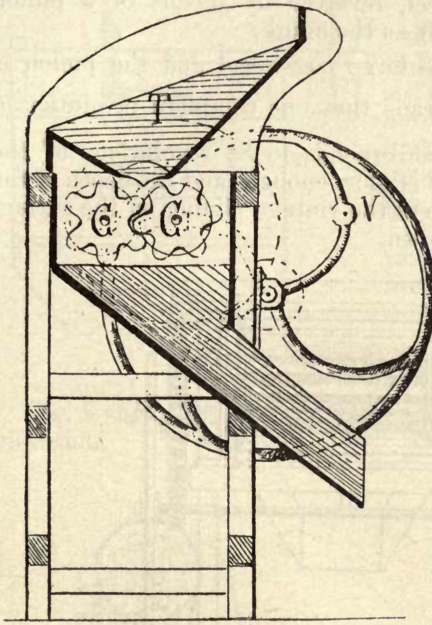


Fig. 6. – Blaquière's Crusher (side elevation).—G G, crushing cylinders ; T, hopper ; V, crank wheel.

This is exactly what M. Blaquière, of Béziers, tries to realize with his *fluted cylinder grape compressor*, which consists of two cylinders with six large longitudinal flutes, G G, geared without touching, in such a way that all the surfaces during rotation are at a constant distance apart, and are revolved in opposite directions by means of outside cog-wheels worked by hand, whim (horse), or steam power.

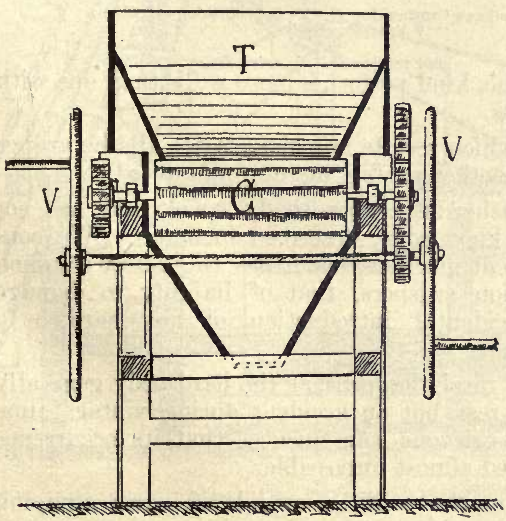


Fig. 8. – Blaquière's Crusher (front view).—G, crushing cylinders ; T, hopper ; V V, crank wheels.

The fluted cylinders of the hand model are 75 cm. (30 inches) long, with an exterior diameter of 29 cm. ($11\frac{1}{2}$ inches). They are mounted parallel to one another on steel shafts, and revolved in unison by two equal pinions. At the extremity of one of the shafts is another large cog-wheel, revolved by means of a pinion keyed on the same shaft as the crank.

The ratio between the large cog-wheel and the pinion is $\frac{14}{120}$ or $\frac{8 \cdot 57}{1}$, which means that one complete revolution of the fluted cylinders corresponds to $8\frac{1}{2}$ revolutions of the crank. The movement is slow enough, and the depth of the flutes sufficient to prevent the vintage sliding on the surface without being drawn down.

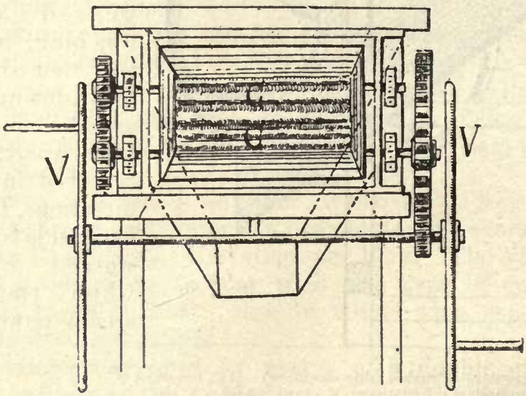


Fig. 7.—Blaquière's Crusher (top view).—G G, crushing cylinders; V V, crank wheels.

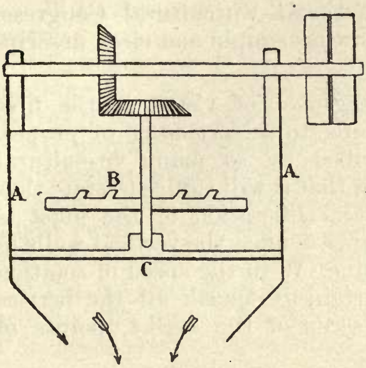
A crusher of this kind performs more work than one with ordinary cylinders.

The crushing which results is satisfactory; all the grapes get squashed, the other parts remaining uninjured.

Blaquière's crusher is comparatively novel, and has not yet been, to our knowledge, described in detail. We consider it an excellent machine, but it has the defect common to all compression crushers, that of liability to damage through the accidental introduction of any hard body (stones, &c.).

This, however, rarely happens, as the hard body generally crushes with the rest, but an accident during vintage time leads to so many grievous consequences that its occurrence should be rendered almost impossible.

Later on this matter will be considered when studying stemmers, as the stemmer attached to this crusher presents some interesting details of construction.



A new, very interesting, and original crusher, based on a principle which has never been applied before to grape crushing, has been invented by P. Paul, called the *Aero-crushing-turbine*.

Although only four or five years old, the machine has been modified in several details by the inventor.

Fig. 9.—Aero-crushing-turbine.—P. Paul (diagram).

Fig. 9 shows the outline of the machine, and Fig. 10 its elevation.

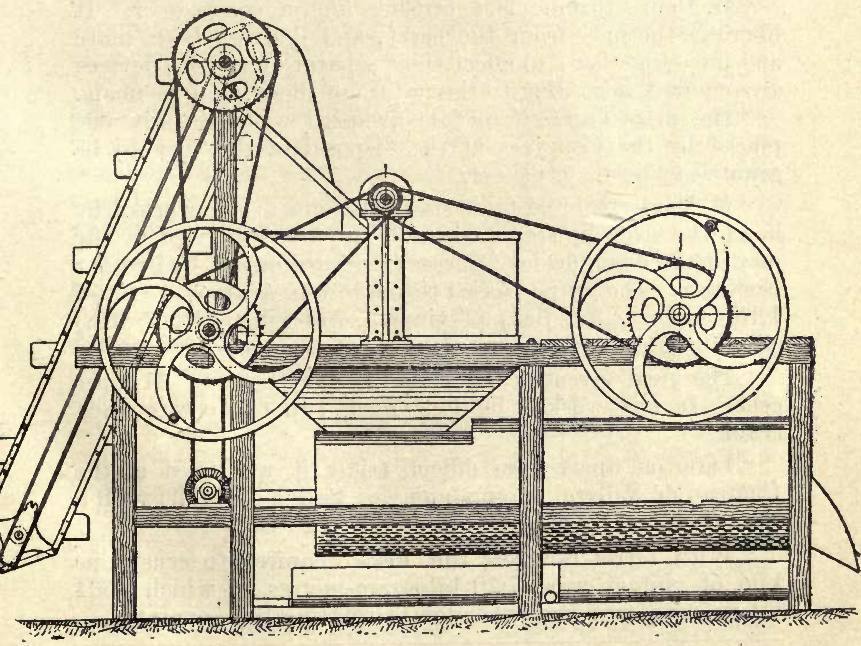


Fig. 10. - Aero-crushing-turbine, P. Paul, provided with an elevator feeding stemmer and drainer.

In the report of the International Viticultural Congress, held at Montpellier,* the following simple and clear description of this machine is given :—

"P. Paul, constructing engineer of Cette, is the first to have applied centrifugal force to the crushing of grapes. His system has been described by so many viticultural authorities in various reviews, that it will suffice to state that the squashing of the berry and liberation of the must is obtained by projecting the grapes against the vertical walls of the fixed cylinder of the turbine. With the speed of rotation properly controlled we are certain to squash all the berries without crushing either the seeds or the stalks, points of great practical importance.

"To break the tissue of the seeds or stalks the speed of rotation requires to be infinitely greater ; and in this lies the original and important point, the perfect selection between the matters to be crushed, and those the crushing of which would prove useless, or even detrimental.

"M. Paul's turbine is a crusher, not a compressor. It liberates the juice from the berry, and delivers both marc and juice together ; to effect their separation various devices are required, according to the nature of the wine to be made.

"The prize (*vermeil* medal) awarded was the only one placed by the Congress at the disposal of the jury to be granted for grape crushers.

"M. Paul exhibited two types of turbine :—one worked by hand, the other by steam power. The first was tried by the jury at the domaine des Causses (vineyard owned by Prosper Gervais). The grape passed through, was Aramon. Out of 1,150 kilos. (2,530 lbs.) of vintage, 708 kilos. (1,557 lbs.) of white must were extracted in twenty minutes.

"The yield given by the machine was therefore 61·5 per cent. It was worked by four men, two to operate each crank.

"Later on, apart from official trials, it was tried at the Château de Villeroi (Compagnie des Salins du Midi) with a dynamo-metric crank, with the following results :—

"With Terret-Bourrets the force required to crush one kilo. of vintage was 27·20 kilogram-metres, of which 3·504 kilogram-metres was expended in rotating the apparatus.

* Etienne Gervaise. *Congrès International Viticole de Montpellier.*

"With Aramon the force required was 23·10 kilogrammetres.

"Therefore two men are not sufficient to work the machine, as they cannot develop more than 12 kilogrammetres (Claudel. Formules, &c., p. 14.)

"It would be interesting for the constructor to try and manufacture a machine capable of being worked by two men. It is easy to see from what has been said that such a machine, might crush 20,000 kilos. (44,000 lbs.) of vintage per day, which is all that is required by the medium proprietor.

"The Aero-crushing-turbine worked by steam power, was seen by the jury working in the domaine du Môle, near d'Aiguesmortes, with the vintage in full swing.

"It was fed by an elevator (Burton system), at the same time the must was elevated by a rotary pump, the whole being worked by a 5 h.p. engine.

"The yield of must was rather difficult to determine, for marc and juice fell together into a tank, from which it was conducted to the press. The following are the results obtained, taking as liberated must that which flowed naturally after the press was charged :—

"From 2,879 kilos. (6,333 lbs.) of vintage (Aramon) 1,379 kilos. (3,033 lbs.) of white must were extracted. The yield in must was therefore 47·8 per cent. But it should be remembered that the marc still remaining in the press contained a large quantity of must, liberated from the pulp, which further drainage would have removed.

"The machine is of very simple construction, and we cannot see *a priori* any possibility of its getting out of order. We may mention that at the cellar of Villeroi (Compagnie des Salins du Midi), after being used last year on trial, the machine was installed permanently this year, and that it has worked without a breakdown, and crushed from 180 to 200 tons per day. Dynamo-metrical tests have not been made on this turbine, but it is supposed that it requires a motive force of from 4 to 5 h.p.

"At Villeroi, as well as at Môle, the turbine is fed by two elevators. This is a very important item for the successful working of the machine. But the turbine is not the only machine requiring regular feeding, this being a *sine quâ non* condition for the proper working of all continuous machines.

"Finally, another important advantage of the turbine is that the marc is much easier to press, the cellular tissue of the berry being completely destroyed, and with it the elasticity which is such a great obstacle in the pressing of the fresh vintage."

Such is the judgment of the Commission of the International Viticultural Congress. It is favorable to the machine worked by steam, but perhaps rather vague with regard to the turbine worked by hand.

The report of the Commission ends up with "The Aero-crushing-turbine gives excellent results where mechanical power is available," but adds it "has not yet received the sanction of general usage."

However, the turbine working on a large scale has been installed in a number of cellars long enough to enable us to appreciate it. In conclusion, it is an excellent machine for large cellars.

We must add to the advantages expressed in the above report the perfect aeration of the vintage. The must coming out of the turbine is, so to speak, an emulsion of air and must.

We have not measured the amount of air emulsionized, but according to various reports published by the inventor, it is 5 per cent. in volume.

These are, as we shall see later on, very favorable conditions for a good start in the fermentation.

The various advantages of this highly original crushing machine justify the as yet uncontradicted success which welcomed it from its first appearance.

As we have already stated, the regularity of the feeding of crushers has a great bearing on the perfection of their work. The mode of feeding will vary greatly according to local conditions, and the various means by which the elevation of the vintage to the crusher are obtained.

In most cases the arrival of the drays to the level of the top of the vats by means of a gradient is recommendable; in that case the feeding takes place by pouring the contents of the tubs directly into the crusher.

Chain and cup elevators are good, and comply with various required conditions. They are recommendable for large cellars, but may also be arranged and worked by hand in small places.

These elevators may be used with either fixed or movable crushers. In the first case, it is necessary to have means of conveying the must from the crusher to the vats (in many cases simply by a wooden shute); in the latter, the elevator being fixed on a truck running on rails, may be moved alongside the cellar; when established in this manner, even if outside the cellar, the elevator may fill two parallel rows of vats with a simple shute conveying the crushed vintage from the top of the elevator to the fermenting vat. The crusher in this case is moved on another truck parallel to the elevators.

We must add that a few vine-growers (though quite exceptionally) consider crushing useless, regarding the result of the different manipulations the grapes are subjected to, before being placed in the vat, as quite sufficient.

Whether the vintage is elevated by a cup elevator, or thrown into the vat by means of shovels, it acts certainly as a partial crushing; but the use of crushers is preferable and indispensable when making white wine.

Crushing is praised by the majority of œnologists, and is an excellent practice, as it enables the fermentation to get a good start, and facilitates the drainage of the marc.

In uncrushed or badly-crushed vintages, we always find grapes remaining attached to their pedicle, intact, and filled with unfermented must. When pressed these grapes burst and contaminate the wine with fermentable substances, which only have at their disposal old yeast, living with difficulty in a liquid almost completely fermented. The work done by the ferment in this case is very slight, frequently the sweetish wine resulting becomes the prey of noxious ferments, which, except in the case of sterilized must, always exist in the wine, awaiting favorable conditions to multiply.

The presence of unfermented sugar fills one of these conditions.

STEMMING.

This operation, which consists in separating the grape from the stalk, has been known from ancient times, and is a necessary practice in some viticultural regions, such as Bordeaux.

In the South and South-west of France, however, it is only occasionally practised.

In former times it was performed by means of a kind of rake, with teeth fixed far enough apart to allow the grapes to pass between, but placed close enough to retain the stalks, the operation being done over a screen ; it is an expensive method and gives very imperfect results.

STEMMERS.

Only mechanical stemming is employed nowadays. It is done by means of special machines called stemmers, generally attached to the crusher, and performing the sorting as the crushing is going on.

The stemmer consists of a horizontal perforated cylinder or cylindrical envelope, in the axis of which a shaft revolves bearing helicoidally mounted boards (Fig. 11) or spikes.

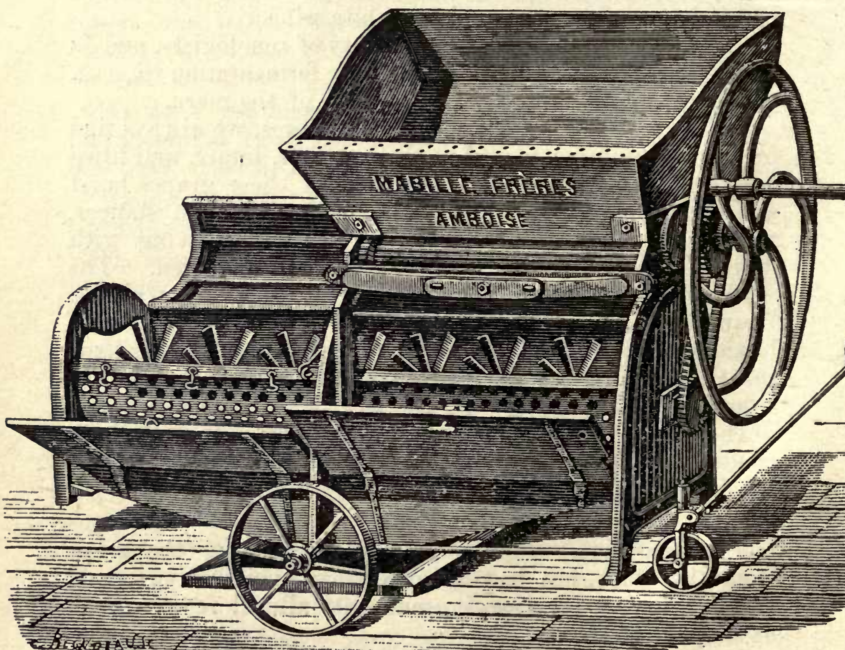


Fig. 11. – Stemmer fixed above the Vat.

The shaft, studded with spikes, or carrying boards, is revolved rather rapidly together with the crusher.

The crushed vintage falls into the stemming cylinder. It is then energetically beaten by the spikes, separating the grapes from the stalks. The former, together with the juice, fall through the perforations into the collecting trough; the latter gradually work their way to the extremity of the cylinder, and are then expelled.

Blaquière, the constructor of the crusher previously described, has also invented a stemmer, which differs in many respects from the ordinary appliance.

It consists of a perforated cylinder revolving round an axle. This cylinder is provided inside with from three to six pieces of wood, projecting a few centimetres, and placed parallel to the axis. The cylinder is inclined horizontally and revolves slowly.

The crushed vintage falls into the raised end of the stemmer, and is then caught by the projecting pieces of wood and carried onwards to the lower end by its own weight.

The shocks resulting from the successive falls of the bunches completely detach the grapes from the stalks, the grapes falling through the perforations. The forward movement of the stalks results from the inclination of the cylinder, every fall carries the stalks towards the outlet, and

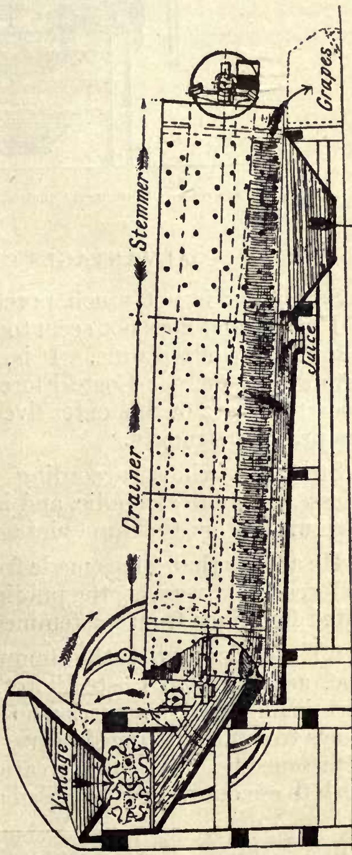


Fig. 12.—Blaquière's Combined Crusher, Drainer, and Stemmer (side view).

with a machine of this kind it is only after a considerable number of falls that the stalks are finally expelled.

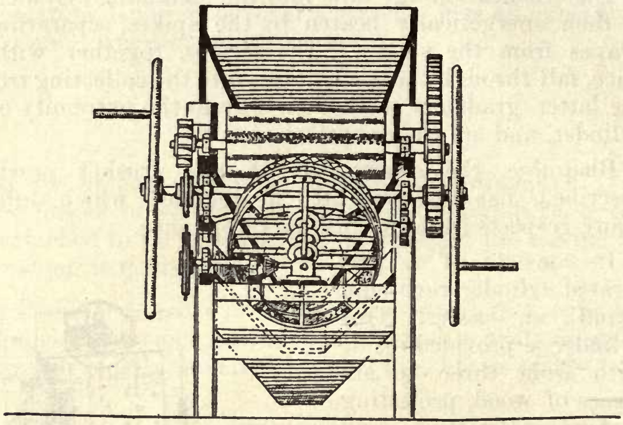


Fig. 13.—Blaquière's Combined Crusher, Drainer, and Stemmer (front view).

ADVANTAGES OF STEMMING.

Stemming is not much practised in the southern regions of France, and does not seem to be generally called for in the manufacture of red wine. It is, however, advocated by many authorities, such as Coste-Floret, who has used it for more than ten years on his extensive vineyard*, and recommends the practice strongly.

Stemmed wines, according to Coste-Floret, have more *finesse*, are more alcoholic, and have better keeping qualities, than wines from the same vintage made without stemming.

He admits that wines made from stemmed grapes will have to force their way, as the public taste has been always cultivated for wines from unstemmed grapes.

"The difficulty that the stemmed wines have to encounter is due, according to Coste-Floret, to the depraved taste of a certain class of consumers who formerly drank our common wines from non-stemmed grapes, but who appear to have now abandoned us. We must create a new market if we do not wish to see our wines discarded and used as raw material for

* Saint Adrien, near Béziers.

manipulations which do not deserve to be encouraged, and we must make wines of good quality, able to be sold directly as natural pure wines."

Indeed, it is truly desirable that our wines should not be discarded, and they should certainly be consumed without sophistication, but is it not excessive to think, as Coste-Floret appears to, that an important class of consumers no longer drink our wine, and that it should be necessary to stem the grapes to induce them to return to this custom.

We are not of the same opinion. Wines made from stemmed grapes have more *finesse* and are slightly more alcoholic than wines from unstemmed grapes, but, contrary to Coste-Floret's opinion, they have poorer keeping qualities, and contain less dry extract.

The greater richness in dry extract of wines from unstemmed grapes is a well-known fact, and we shall presently quote some figures to prove this; but is the excess in dry extract due to the stalks? We do not think so.

We have previously seen how small the proportion of stalks is in our southern regions, and how small also the percentage of soluble matters contained in the stalks. It is only by grammes that we express the soluble matters brought to the vat by 100 kilos. of vintage of Aramon, for instance, and, even then, the greater proportion consists of tartar and tannin.

The great richness of wine from unstemmed grapes in dry extract cannot therefore be attributed to the stalks, but simply to the mechanical part played by them in dividing the marc and facilitating the penetration of the surrounding liquid, and therefore its solvent action. We must reject any idea of unfavorable influence of the stalks, on account of their small proportion in all our southern *cépages*, and of the small quantity of soluble matter they contain, provided they have not been bruised by the crusher, and that the fermentation has been well conducted.

We do not deny the usefulness of stemming in some special cases, in that of damaged vintages for instance, but if its efficacious action is evident in such a case, it must not be attributed to the fermentation of the grapes after separation from the stalks, but rather to the more or less perfect rejection of damaged from undamaged vintage, which is the result of the stemming, owing to all the rotten and dried grapes being separated with the stalks. In the case of a healthy vintage, and of *cépages* where the proportion between the stalk and the grape is not greater than in our *cépages* in the South of France, we do not see the necessity of advocating the general adoption of this operation.

In any case, the action of the stemming is only secondary, not direct. The properties distinguishing stemmed from non-stemmed wine, are only the result of bad fermentations due to unfavorable temperature, or of remaining too long on the marc. The defect in the case of wine from non-stemmed grapes is not to be imputed to the stalks, but to an increased maceration of the other parts of the marc, to which the penetration of the wine is facilitated by the presence of the stalks.

M. Vincens, Professor in the School of Agriculture at Ondes, starting from the idea that the market value of wine depends on four principal factors — the *alcoholic strength*, *dry extract*, *acidity*, and *coloration*— studied methodically the influence of stemming on these four factors.

The trials were carried out for three *cépages*—Negrette, Aramon, Petit-Bouschet—an equal quantity of wine being made from each, with and without stemming.

We will quote his results.* Noting that the stemming was done by hand.

Composition of Experimental Wines.

	Alcohol per cent. by volume.	Dry Extract.	Acidity as H_2SO_4 per litre.	Shade.	Coloration Intensity.
Negrette, stemmed	8 9	16·5	3·66	3rd violet red	175
,, not stemmed	8·7	17·5	3·80	—	200
Aramon, stemmed	8·8	19·5	5·58	4th —	440
,, not stemmed	8·75	20·4	5·11	—	445
Petit-Bouschet, stemmed	8·9	19·4	4·37	3rd —	80
,, not stemmed	8·9	21·3	4·46	—	65

" The above trials were made with the usual instruments found in trade—Salleron's ebulliometre; Houdart, œnobarometre, and Salleron's colorimetre.

The acidity was determined with a normal potash solution.

" The observations of temperature, which we consider useless for this table, show that in all cases the maximum temperature was 1° higher, and took place one day earlier, in the non-stemmed than in the stemmed vintages. These

* *Revue internationale de viticulture et d'œnologie* t. I., No. 4.

results confirm the well-known fact, that the presence of stalks in the vat accelerates the fermentation.

"When examining the composition of the wines, we see that the increase in alcoholic strength due to stemming is very slight. It is nil for Petit-Bouschet, insignificant for Aramon, and reaches two-tenths of a degree for Negrette. This difference is evidently due to the fact that during the submersion of the marc, which was only done in the case of Negrette, the stalks absorbed a greater quantity of alcohol.

"The differences between the figures for dry extract is much more noticeable. It varies from 0·8 to 1·9 grammes per litre, and constitutes a disadvantage for the non-stemmed wines* which contain less. We noticed, in estimating the astringent matters according to the process of Aimé Girard, that the difference was almost entirely due, with the exception of Aramon, to the œno-tannin, an excellent agent in the preservation of wine.

"Except for the Aramon, which has a very peculiar composition, the acidity is higher in non-stemmed wine; although the difference is very slight, we must take into consideration, in the case of our southern wines, which are generally flat, a lack of fresh, cool, acid taste.

"If we now examine the colour, the figures representing its intensity being in inverse proportion, we see that the differences in favour of non-stemmed wines are nil for Aramon, one-eighth for Negrette, one-fifth for Petit-Bouschet.†

"To the taste the stemmed wines were less harsh or rough than the non-stemmed, but these were more *fruités*, *corsés*, and they would unquestionably be preferred by wine merchants.

"As the stalks always absorb a certain quantity of wine, an increase in yield of 2 per cent. is due to the stemming, but this augmentation not covering the cost of extra manipulation we need not take it into consideration.

"To sum up, in our experiments stemming has always furnished inferior wines, less rich in dry extract and colouring matter, and only slightly different in alcoholic strength.

* We quote exactly, although it is easy to observe on examining the above table that it is *stemmed* wine that should be read in place of *non-stemmed.*

† There is a contradiction between this conclusion and the figures of the table, but it is without importance, the result being in both cases very slightly different.

"As the advantage resulting from the aeration of the vintage, and the expulsion of foreign matters and germs of noxious fermentation, may be realized without stemming, we may conclude that for wine made from heavy-bearing kinds of the south-west, of which the three experimented upon are the most important, that this practice is useless, if not actually injurious."

We concur entirely with the views expressed by Vincens, taking exception however to those referring to altered (injured) vintage, and for special vinifications, such, for instance, as the vinification of red wine with grapes partly drained for white wine.

Later on we will discuss these exceptional cases when describing the manufacture of white wine from red grapes.

THE VATTING.

The squashed vintage delivered from the crushers is fermented in vats. For the fermentation to take place in a satisfactory manner, so that the resulting wine will possess the maximum qualities compatible with the nature of the vintage, it is necessary:—

First—That the vinous ferment which causes the phenomena be the only one at work in the must.

The presence of healthy, vigorous, and abundant yeast is indispensable to attain this object.

The aeration of the crushed vintage is an important factor in the multiplication of the ferment.

Second—That the transformation be effected as rapidly as possible. The rapidity of the work depends on the life of the ferment, which will only furnish its maximum yield if the chemical and physical conditions of the liquid are suitable.

Third—That the solid parts of the grape be sufficiently in contact with the liquid part to enable it to dissolve the necessary substances. This is obtained by various methods and special manipulations.

AERATION OF THE VINTAGE.

Let us assume the grapes to be introduced into the vat without being crushed, and the air in the vat replaced by an inert gas, such as nitrogen. If we then prevent the access of any air and crush the grapes *in situ*, it would be noticed that the phenomena following the crushing were not at all comparable to what takes place under ordinary circumstances. The fermentation would be very difficult to start, and if it started at all would have no energy and probably be the seat of a great many alterations. If this be so it means that the germs of the ferments existing on the surface of the grape have only had at their disposal the small quantity of oxygen remaining in the grape, and that it is indispensable for the yeasts to have at their disposal a quantity of air sufficient for their normal development. It is not so for all the micro-organisms existing on the surface of the grape, for a number of these find the conditions congenial, and succeed in changing the must into a liquid having nothing in common with wine.

Let us suppose again a vintage crushed in contact with the air, but with a limited aeration, such as would result from crushing grapes in a bottle almost full, and closed before crushing so as to prevent the access of any additional air. The fermentation would start and become rather active. The activity may be measured by the amount of carbonic acid produced in a given time. If we study this fermentation we will see that it diminishes rapidly, although there is a great quantity of sugar left, showing that the ferment still has food left, and that the cells of the ferment require after their first work a certain quantity of air to restore them to activity and enable them to multiply.

This statement made by Duclaux, and deduced from Pasteur's classical experiments, is easy to verify.

If the above must is racked in contact with air it will be seen that disengagement of gas increases at once. Aeration, we therefore maintain, is not only useful but absolutely indispensable to enable the germs on the grape skin to develop, and it is necessary to restore the ferment while the fermentation is proceeding, to enable the complete conversion of the sugar to take place.

The first aeration takes place during the crushing, and it is the imperfect aeration in cylinder crushers which causes the inferiority so often noticed in wines so made, as compared with those from crushing by the feet. In the latter case the vintage remains longer in contact with the air, consequently the aeration is more perfect.

In some districts (Bordeaux) they even go further. The vintage is thrown up in the air with shovels, before being placed in the vat.

Does this mean that we must place the mechanical crushers aside and return to ancient methods?

Certainly not. Sufficient aeration may be obtained with machines. Some machines, such as the aero-crusher, effect the aeration during the crushing, in other cases, especially if the grapes have to travel in a long and open shute, it produces the same result. The paddles of the stemmers also have an aerating effect. We may also, immediately after the crushing, pump the must over the head (marc floating in the vat), being careful to spread it all over. This practice is quite sufficient to introduce into the must the quantity of oxygen necessary for a good start. The pumping over of the must may be repeated if necessary, and will prolong the fermentation until the sugar has entirely disappeared.

Stemming, as we have seen, has not got a very direct influence on the quality of the wine, but it acts indirectly through the intense aeration it furnishes, and many think it is the only benefit we can get from the adoption of this practice in the South of France.

We cannot do better than support our views by those of Pasteur. The following is his opinion, built on the irrefutable experimental methods everybody grants to that scientist, taken from his *Études des Vins:*—

"I have noticed that when musts are exposed to contact with the air in a shallow vessel for many hours and stirred that fermentation is much more active than with non-aerated musts. The fact that aeration produces such apparent effects even during fermentation, while the liquid is already charged with carbonic acid and alcoholic ferments, is worthy of attention."

Pasteur describes experiments which leave no doubt on that subject, and which show conclusively that non-aerated must produces more acid wines than those aerated.

To any one who reads between the lines, abnormal increase of acidity is not a good sign, but rather a sign of defective fermentation, for the increase of acidity is generally due to the formation of volatile acids so characteristic of diseased wines.

Apart from this, the aeration of the vat has a very beneficial influence on the ultimate preservation of the wine.

We have no experiments to support this fact, as convincing as those of Pasteur, but it seems logical, and many authorities admit it.

Ott, an American scientist, lays down the principle that the more abundant the oxygen in the must, the more albuminoid matters the ferment will absorb, and that the wines resulting will keep better—the presence of albuminoid matters in excess in the wine being conducive to diseases.

Ott's opinion is, we believe, annually confirmed in the vineyards of California, where aeration is a common practice.

It consists in forcing air by means of a pump to the bottom of the vat, and discharging it in a fine stream through a perforated rose. This operation is repeated each day for ten minutes. The forcing of air through the fermenting must is no doubt a good thing, and tends to the preservation of the resulting wine; but it has a decided inconvenience in the case of wine required in commerce to be *brilliant* and *frais*.

According to Ott, aeration matures the wine quickly, and gives it that tawny colour so characteristic of old wines.

We may obtain certain advantages by well-conducted aeration, but it must be well conducted, for it may become injurious if practised to excess and under bad conditions.

Aeration before the fermentation starts, can never be too thorough or complete.

When once fermentation has started, we must act with caution, for given with circumspection, the oxygen maintains the life of the various ferment and enables it to work with proper activity. It slightly oxidizes the colouring matter, and gives it a greater facility of dissolution, without modifying its tint. If the oxidation is excessive the colouring matter alters and becomes brownish, and loses its fixity in solution.

This applies specially to fermentation in the South of France and Algeria, where very often the temperature is so high that the ferment dies. Excessive aeration under these circumstances acts on the colouring matter in a disastrous way. Notwithstanding this great inconvenience aeration must not be rejected, for it still has a marked utility. It allows the complete conversion of the sugar, which is indispensable if we wish to avoid making wine which will certainly be of doubtful keeping qualities.

Rietsch and Herselin* pointed out these advantages in a series of laboratory experiments bearing on *apiculatus* and *ellipsoideus* yeasts.

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* *Progrès Agricole et Viticole*, 1895

They were able to obtain in all the fermentations at high temperatures at 36° C. (97° F.) a more rapid and complete decomposition of the sugar when aeration was used.

The vine-grower, therefore, is confronted with an unpleasant situation if the temperature of the vat is allowed to rise too high. Without aeration he will obtain wine of uncertain keeping quality, with aeration better keeping wine but less fine will result.

The maintenance of the temperature of the vat between proper limits is the only way of avoiding this embarrassing situation.

The process has also many other advantages. We have had an opportunity of making a series of experiments in Algerian cellars on this subject, and these have since been continued in our laboratory in conjunction with F. Chabert, as studies on the different actions of high temperature on alcoholic fermentation. These studies are not yet completed, but allow us to clear up certain obscure points in the above observations.

We will reproduce, *in extenso*, these studies, and hope they will prove the absolute necessity for controlling the temperature during fermentation.

CONTRIBUTION TO THE STUDY OF VINOUS FERMENTATIONS.

INFLUENCE OF TEMPERATURE.

(By L. Roos and F. Chabert.)

The temperature of fermentation plays a part in vinification which recent studies have shown to be so important, that it is to-day a subject of thought for every œnologist.

The flavour and keeping qualities of wines, depend to a great part on the temperature at which the transformation of the must is made. If it is too low the fermentation does not start, or starts too slowly, for the ellipsoideus yeast does not develop well, and bacterial actions take place which alter the value of the product. If it is too high the wine retains untransformed sugar, which forms a suitable medium for and favours the development of bacteria, which may so alter the nature of the liquid as to render it unfit for consumption. The natural consequence of this double observation leads us to heat our musts in cold climates, a very old practice justified by experience, and to keep the temperature between given limits in hot regions.

The study of the various processes of heating or refrigerating musts, does not come within the scope of this paper. We have simply tried to discover the temperature preferred by the wine yeasts, that is to say, the temperature at which they perform a maximum of work in a minimum time.

High temperature during fermentation has an unfavorable influence on the resulting wine. It reduces its alcoholic strength, alters its taste, and diminishes its keeping quality.

The consecutive alterations of fermentations at high temperatures are well established, but have according to us, been too generally attributed to the development of micro-organisms, called parasitic, to distinguish them from those which transform the sugar into alcohol.

Our experiments tend to show that, together with the bacterial action (an indirect result of the excessive temperature) there is another action of the same class, but perhaps less important, attributable to the yeast itself, the evolutions of which, and its conditions of work, are profoundly modified.

Our experiments were made on raisin must, during the year, and with fresh grape musts during the vintage of 1896. We did not use yeasts of a special character, but simply took them from the wine lees of the district, making sure, however, that the wine yeasts were self-cultivated. The colonies were obtained in solid gelatine and multiplied in sterilized must. The lees from which we extracted the yeasts came from the environs of Mudaison (Hérault) and Saint Laurent d'Aigouze (Gard).

We tried to keep as far as possible within general viticultural conditions, but do not pretend not to recognise the difference there is between laboratory practice and cellar operations. This simply means that we cannot give our results as the exact expression of what takes place in a cellar, but that they are simply land-marks placed on the path of this very complex study.

Before giving our results, and describing the apparatus used by us, we will briefly summarize the previous work on this subject.

OPINIONS OF VARIOUS AUTHORITIES AS TO THE BEST TEMPERATURE FOR FERMENTATION.

Chaptal * states that the most favorable temperature is 15° R. (66° F.) It languishes below that temperature, becomes too tumultuous above it, and if the temperature is too high or too low does not take place at all.

According to A. Gautier † the most favorable temperature is between 28° and 32° C. In no case should it fall below 18° C. or exceed 36° C. Once that extreme maximum is reached the glucose not only forms alcohol, but also other products, and the rapid disengagement of carbonic acid carries away a notable quantity of alcohol.‡

Gautier points out already the formation of "other products" is a result of fermentation at high temperature. Our experiments verify this opinion, for they show in the fermenting liquid the existence of products, not yet well defined, but exerting a distinct action.

Prof. Bouffard § fixes 25° C. as the temperature required for a good fermentation. "The temperature of 20° C. which sometimes cannot be exceeded in Bourgogne and that of 35° C. always reached in Algiers are unfavorable. Wines made between 20° and 32° C. have more suavity in perfume and taste. Those obtained between 30° and 35° C. are flat, less perfumed, and possess foreign tastes due to the development of parasitic ferments."

L. Rougier,‖ in his *Manuel Pratique*, also studies the influence of temperature. Below 8° or 10° C. fermentation is impossible. The activity of the ferment increases little by little as the temperature rises to 25° or 30° C., above 40° or 45° C. the fermentation tends to stop before the sugar is completely transformed. When the temperature gets over 30° C. the carbonic acid carries away a certain quantity of alcohol and volatile principles constituting the bouquet.¶

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* *L'Art de faire le Vin*, p. 94, by Count Chaptal. 1819. We must draw attention to the correspondence between the Centigrade and Reaumur—15° Reaumur, 18·75° Centigrade.

† *Dictionnaire de Chemie de Wurtz.* Art. Vin.

‡ We will see that if a notable quantity of alcohol is carried away it is to be attributed to the elevation of the temperature, and not to the rapidity of the evolution of gases, which, on the contrary, become slower.

§ Rôle de la Chaleur et du Froid dans la Vinification. *Progrès Agricole et Viticole.* 1891.

‖ *Manuel Pratique de la Vinification.* L. Rougier, p. 25. 3rd Ed. 1895.

¶ This remark corroborates Prof. Bouffard's opinion above given, that wines made at high temperatures are deficient in perfume.

Dr. Frederic Cazalis * quotes the experiments of Müller-Thurgau. These experiments show that "the fermentation of a must between 9° and 36° C. proceeds so much the more rapidly, and with more bubbling, as the temperature is higher, but past that point it stops the more rapidly, leaving a part of the sugar unconverted, as the temperature is higher." Cazalis notes afterwards the considerable influence the temperature has on the yield in alcohol, quoting the following figures:—

Fermentation at	9° C.	...	17·29°/₀	alcohol	by volume
,,	18° C.	...	15·09 ,,	,,	,,
,,	27° C.	...	12·23 ,,	,,	,,
,,	36° C.	...	8·96 ,,	,,	,,

These results, exact no doubt under the conditions of the experiments of Müller-Thurgau, cannot be generalized. The factor time, is missing from the table, and it is one of the most important. If we may admit the accuracy of the results with the Rhine yeasts, when treated in laboratories, it is easy to oppose against their generalization the fact well known to the vignerons of the South of France that we may easily obtain up to 10 or 11 per cent. of alcohol at temperatures over 36 C.

Dr. Fred. Cazalis concludes that the temperature for a good fermentation lies between 15° and 25° C. Prof. Müller-Thurgau noticed that fermentation ceases between 25° and 36° C. before all the sugar is transformed into alcohol, because "the alcohol at such a high temperature acts upon the ferment, and even small amounts can arrest its activity."† We admit this action of the alcohol but only as one of the factors causing the stoppage of fermentation.

We will show by experiments that the presence of alcohol is not the only cause retarding the work of the ferment.

If it were possible, it would be sufficient to bring the liquid back to a proper temperature to see the yeast regain its former activity, but this does not happen. The fermentation only proceeds slowly, and is not even sensibly increased by the addition of fresh yeast taken from another vat in full activity.

U. Gayon‡ gives as a limit 27° to 38° C., which should not be exceeded in any case if we do not wish to see the must

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* *Traité Pratique de l'Art de faire le Vin.* Dr. Frederic Cazalis, p. 144. Montpellier. 1890.

† This is only true for quantities of alcohol varying between 8 and 10 per cent., and for temperatures exceeding 36° C. (Roos and Chabert.)

‡ U. Gayon, *Rapport sur la Vinification dans les Années Chaudes.* Bordeaux, 1895.

attacked by disease ferments, and especially by the mannitic ferment.* It is the toxic action of the alcohol, the absence of oxygen, and the high temperature of 40° C. which paralyzes the ferments.

Müntz and Rousseaux † define the "*critical point*" as the temperature the yeast cannot support without suffering; if that temperature is exceeded by a slight degree, its influence on the course of the fermentation has an important influence. This critical point is characterized by the fact that the yeast, still living if that point is just reached, dies directly it is exceeded. We can enable the ferment, therefore, to recover by refrigeration, provided that the critical point is not exceeded. Should it be exceeded and the yeast destroyed, nothing can be done. These authors give an instance, the critical point being supposed to be between 38° and 40° C.

We admit with Müntz and Rousseaux a morbid state of the yeast at high temperature, increasing as the temperature exceeds 35° C., we admit also a kind of critical point:—38° to 40° C., which should not be exceeded if we wish to bring the ferments back to activity by refrigerating; but we think that 38° to 40° C. conduces only to a more accentuated morbid state, and not to the death of the ferment, as this only occurs at a high temperature, for when sown in fresh must these yeasts start fermenting regularly again.

H. Dessoliers,‡ in a study on vinification in hot countries, explains at length the influence of temperature on fermentation. "The temperature is a dominant and essential element in fermentation. The duration of fermentation will be so much the greater that the must has been the longer exposed to a high temperature (40° to 42° C.). The duration of the action of the high temperature must be taken into consideration more than the temperature itself." Dessoliers shows that high temperature produces sweetish wines liable to alterations, and quotes an observation due to Maerker, who asserts that yeasts do not multiply at temperatures over 28° C. This statement cannot be accepted without reserve. At 35° or 40° C. the yeasts multiply, not under favorable conditions perhaps, but nevertheless they multiply.

* Gayon points out that the mannitic ferment starts during the true fermentation. We have shown that this disease easily develops in a sweet wine at 40° C. L. Roos, *Journal de Pharmacie et de Chimie,* 1892.

† Müntz and Rousseaux. Etudes sur la Vinification dans le Roussillon, faites aux Vendanges de 1894. *Bulletin du Ministère de l'Agriculture,* 1895, p. 1208.

‡ H. Dessoliers, *Vinification en Pays Chauds.* Alger. 1894.

Dessoliers states that yeast cannot germinate if it has been submitted to too high a temperature. We have, however, shown above that it can germinate normally if placed in new must.

One of us, taking into consideration numerous experiments made on yeasts from many different countries, fixed the maximum vitality of the vinous ferment, whatever species it may belong to, at between 28° and 32° C. At 20° C. the activity is very slow. At 40° C. it is nil. At 45° C. it dies, or is of no further use.* "*The very best temperature is 30° C., and the must cannot go much above or below this limit without becoming liable to bacterial diseases*, those made at the higher temperature becoming most liable. The vinous yeast may be killed at temperatures insufficient to kill other ferments. At high temperatures the yeasts eliminate products detrimental to the wine, which may even render the must sterile, although still containing sugar, and the other conditions apparently seeming favorable; or the yeast in full activity develops badly, or perhaps not at all."†

To summarize, different authorities agree that in high temperature lies the most important cause of the defects of wines made in hot regions. The sugar they often contain, through the fermentation not being completed, is a favorable ground for the development of bacterial diseases.

The numerous applications of refrigeration to musts confirm this opinion of scientific authorities.

METHODS AND APPARATUS EMPLOYED.

Exact estimations of acidity calculated as sulphuric acid were made for all the musts experimented upon.

Reducing Sugar.—We used, for the estimation of this, the ordinary cupro-potassic solution, but substituting the electrolytic determination of the precipitated copper for the volumetric method, relying on the disappearance of colour. The musts, although diluted, were rich enough for the slightest divergency in measurement of the volume of liquid in the burette, corresponding to the end of the reaction to

* L. Roos. Principes generaux de la vinification en rouge. *Progrès agricole et viticole*, 1894.

† L. Roos. Etudes sur la vinification en pays chauds. *Revue de Viticulture*, 1894.

result in notable errors. The musts were examined in Laurent's polarimetre. We used Salleron's mustimetre to obtain approximate indications.

Acidity.—Determined by titrated lime water. The wines resulting were more closely examined. We determined :—

Reducing Matters, always expressed as glucose, estimated by the ordinary method, that is, decoloration of a cupro-potassic solution by the wine previously treated with sub-acetate of lead.

Alcohol in Volume, per cent. determined by distillation, and density by pyknometer, this being the most accurate method.

Acidity is expressed as sulphuric acid per litre.

Total Nitrogen (with the exception of nitrogen existing in the shape of pyridine compounds) was estimated by the Kjeldahl process.

By the way, we draw attention to an experimental point. It is often difficult to obtain a complete decomposition without loss, when examining wine rich in sugar. By evaporating on a water bath from 50 to 100 c. c. of wine in a small flask of 200 to 300 c.c., and adding to the residue a few drops of concentrated sulphuric acid, a spongy carbonaceous mass is formed well adapted to complete decomposition, without producing the violent frothing so liable to occasion trouble or loss.

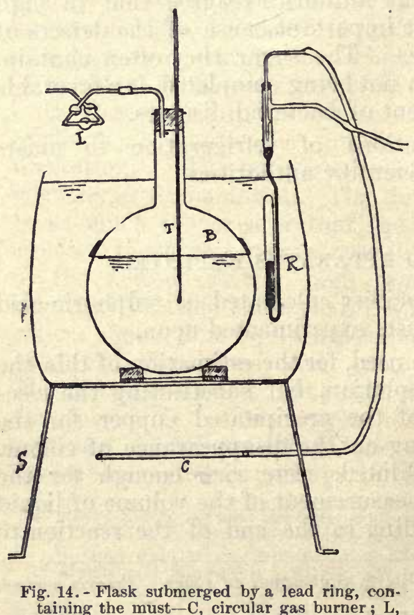


Fig. 14.- Flask submerged by a lead ring, containing the must—C, circular gas burner; L, Liebig bulbs, containing sulphuric acid; R, thermo-regulator; S, tripod; T, thermometer.

The fermentations were conducted at four different temperatures, including the maximum and minimum generally observed in our regions, 25°, 30°, 35°, and 40° C.

These temperatures were maintained constant by means of the apparatus shown in Fig. 14. The receptacle contains water in which the thermo-regulator is placed. The regulator is influenced to a certain extent by the pressure of the gas supply. We were, therefore, obliged to interpose between it and the gas supply a Moitessier pressure regulator.

A flask, B, of two litres capacity, containing 1·5 litres of must, kept submerged by a lead ring, supported in the tank on a wood-lead ring, and closed with a doubly perforated cork. Through one hole a thermometer, T, passed, through the other an exit tube, connected with a Liebig's absorption apparatus, L, where the alcohol and the water vapour escaping were caught.

The quantities of gas disengaged were measured either by the balance, or the self-registering gas disengagement machine of Houdaille.* In either case the temperature of the must inside the flask and of the surrounding water were recorded every other hour. In the first case the weighings were made at even intervals. In the second case the carbonic acid was measured by the Houdaille self-registering apparatus, of which we will now give a short description, Fig. 15.

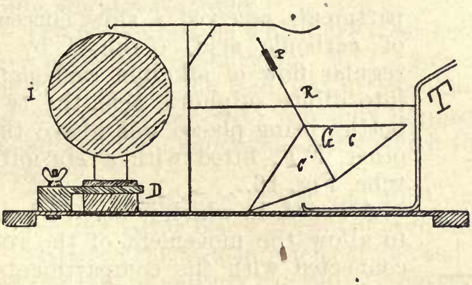


Fig. 15.—G G', compartments of the gasometer, G; D, groove; I, cylinder; P P', counterpoise; R, trough containing the water; T, tube leading gas to register.

It consists of a kind of gasometer, G, with two compartments, C and C, plunged in water, oscillating on a horizontal axis in such a way that, moving round the pivot under the pressure of the gas, one of the compartments may empty itself while the other is filling. Each oscillation, by means of a very simple system of levers, prints a point on the cylinder moved by clock-work.

The cylinder may move normally in the direction of the lever; in front of it is a groove, D, and as it revolves once in twelve hours, it suffices for a small lateral displacement of the cylinder, to avoid the overlapping or super-position of the points, and therefore allows the continuous observation

* Houdaille. Sur un appareil enregistreur des fermentations alcooliques. *Annales de l'Ecole d'Agriculture de Montpellier*, 1887.

of a few days' fermentation. We used a four-compartment register, one being applied to each fermentation.

This apparatus works very accurately in the case of a gas insoluble in water, but is not so satisfactory with carbonic acid. The solubility of carbonic acid in water is an obstacle to its perfect action. This might be avoided in using a liquid in which carbonic acid is insoluble.

It is very difficult to find such a liquid; glycerine is the only one not exerting a solvent action, but it has the disadvantage of being too viscous, and diminishing the mobile action of the compartment.

We endeavoured to render the solution of the carbonic acid almost nil, by maintaining the water in the trough constantly saturated with carbonic acid, by interposing an atmosphere of that gas between the water and the atmosphere.

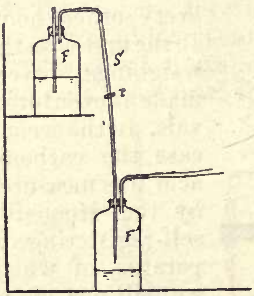


Fig. 16.—F, bottle containing carbonate of soda; F', bottle containing dilute sulphuric acid; P, clamp; S, syphon; T, exit tube for the carbonic anhydride.

With this object each of the compartments received a slow current of carbonic acid, obtained by a regular flow of alkaline carbonate into dilute sulphuric acid, the two bottles being placed one above the other, F F, fitted with a Mariotte tube, Fig. 16.

A board, in which is bored a hole to allow the movement of the rod connected with the compartments, shelters the surface of the water against draughts which might sweep away the liberated gas. This slight modification enabled us to obtain with the Houdaille apparatus results quite comparable with those obtained by weighing.

We will, later on, describe the device by which we tried to measure the quantities of alcohol carried over mechanically by the carbonic acid.

STUDY OF FERMENTATIONS.

At 25° C. the start is very slow, the froth only appears on the fourth day, although the disengagement of gas shows the fermentation to be already well established. The liquid is rendered turbid by the yeasts, and the sulphuric acid in the Liebig bulbs is coloured brown by the gas.

At 30° C. very rapid start, very regular course, slacking down before the sugar is completely transformed, the liquid is very turbid, and the sulphuric acid in the bulbs is coloured more intensely brown than before.

At 35° C. the start is also very rapid, and the activity is very regularly maintained as long as the alcoholic strength is below a certain limit. It slacks off sooner than the fermentation at 30° C. and leaves more sugar untransformed. The liquid is very turbid at the beginning, and becomes clear after the yeast diminishes its activity, the sulphuric acid in the bulbs becoming very intensely coloured.

At 40° C. the start is not very noticeable, and the fermentation is always very slow. The liquid did not get very turbid, although there was an abundant deposit of yeast at the bottom of the flask. A great part of the sugar remained undecomposed. The sulphuric acid in the bulbs becomes only slightly coloured.

The fermentations which are most active at the beginning are, in order of rapidity 35°, 30° C.; sometimes, however, that at 30° C. takes the lead, but in most cases the fermentation at 35° C. overtakes it; this only happens at the commencement and for a short time, after which they keep at the same rate.

The fermentations at 25° and 40° C. start with more difficulty, the latter being always slower and less active.

Between the fermentations at 25° and 30° C., the difference of the rate of activity can only be observed at the beginning. The start is more difficult at 25° C., but when once the fermentation has commenced it proceeds very regularly with much greater loss of weight than that of the fermentation at 30° C. In such a way that by prolonging the experiment we arrive at the decomposition of the sugar quite equally in both flasks. While by that time the flasks at 35° and 40° C. have already stopped fermentation.

A constant and remarkable fact noticed in our experiments is that, with the same must, the higher the temperature rises the deeper the colour becomes. We can evidently not put this down to oxidation of the colouring matter of the must, for it is isolated from contact with the air by the Liebig bulbs. In the cases where we tried the action of the air during fermentation, we observed this modification of colour before the introduction of air, and did not observe any influence of this kind due to the air in that operation.

The sulphuric acid in the Liebig bulb becomes differently coloured, the density of the brown colouring being deeper for the fermentation at 35° C., a little less for the fermentation at 30° C. This coloration seems to depend on two factors, the temperature and the rapidity of the evolution of gas, and this explains the coloration of the acid corresponding to the flasks fermenting at 40° C., for if in this case the temperature is higher, there is only a very slight quantity of carbonic acid passing through the sulphuric acid bulbs.

The brown coloration turns to a very fine pink on the addition of water to the sulphuric acid. We thought that the turning to pink was peculiar to dry grape musts (raisin must), but fresh grape musts gave the same results.

INFLUENCE OF TEMPERATURE ON THE YIELD OF ALCOHOL.

Two cases will be considered, the absolute yield of alcohol independently of the quantity of sugar decomposed, and the relative yield—that is to say, the ratio between the alcohol obtained and the sugar which has disappeared.

In both cases the yield in alcohol is less as the temperature is higher. In absolute yield this result only holds if we consider fermentations lasting more than ten days; below this limit the fermentations at 25° C. furnished less alcohol than that at 30° C., but the relative yield always remains greater.

In short, for a normal duration of eight days the fermentation at 30° C. is the best, then follow in order 25°, 35°, 40° C., the latter always taking much longer than the others. If we allow the fermentation at 40° C. to remain undisturbed, it continues to gain in alcohol, but very slowly, and then only under the influence of a fermentation, the exterior characters of which are very different from those of an ordinary fermentation. Two of our experiments (on must from fresh grapes), which did not contain:—One, 4 per cent. of alcohol on the seventh day, and the other, 6 per cent. on the tenth day, showed for the first 9·5 per cent. two months after, and the other 6·4 per cent. after eighteen months.

We have never obtained 47 per cent. of alcohol per 100 of sugar decomposed, considered as a practical yield, although we have closely approached it.

This might be because our temperatures were too high, even that of 25° C.

The yield of 47 per cent. which can be obtained in cold regions is never obtained to our knowledge in warm regions, and we think that the measurement of the sugar, based on the transformation of that body by fermentation, must be done in order to be exact, when the operation is effected at a very low temperature, and during a long time.

The following tables summarize the analytic results obtained on some of our wines, and give the differences observed in relative and absolute value :—

Raisin Must, No. 1.

Reducing matters ...	... 174 grammes per litre.
Mustimetre ...	... 170 ,, ,,
Polarimetric deviation	... — 22° (sugar degree)

	25° C.	30° C.	35° C.	40° C.
Alcohol in volume, per cent. ...	10·1	9·7	9·2	2·1
Alcohol in weight, per litre ...	80·8	77·6	73·6	16·8
Sugar remaining	2·0	2·5	4·5	*
Sugar transformed	172·1	171·6	169·6	
Ratio of alcohol to sugar transformed	46·94	45·22	43·39	—
Difference from the practical yield of 47 per cent. ...	0·06	1·78	3·61	—
Difference from the theoretical yield of 48·5 per cent. ...	1·56	3·28	5·11	—
Quantities of alcohol condensable hypothetically, in absolute volume	1·57	3·17	4·70	—
Quantities of alcohol condensable hypothetically, in weight, per litre	1·42	2·54	3·76	—

Raisin Must, No. 5.

Reducing matters ...	... 174·5 grammes
Mustimetre	... 167·0 ,,
Polarimetric deviation	... — 32·4° (sugar degree)

	25° C.	30° C.	35° C.	40° C.
Alcohol in volume, per cent.	9·9	9·7	9·1	7·3
Alcohol in weight, per litre	79·2	77·6	72·8	58·40
Sugar remaining ...	3·0	3·0	10·0	41·0

* An accident prevented the determinations being made for the fermentation at 40° C.

RAISIN MUST, NO. 5—*continued.*

	25° C.	30° C.	35° C.	40° C
Sugar transformed ...	171·5	171·5	164·5	133·5
Ratio of alcohol to sugar transformed	46·17	45·25	44·25	42·24
Difference from the practical yield of 47 per cent. ...	0·83	1·65	2·65	4·66
Difference from the theoretical yield of 48·5 per cent. ...	2·43	3·25	4·25	6·26
Quantities of alcohol condensable, hypothetically, in absolute volume ...	2·40	3·27	3·86	4·57
Quantities of alcohol condensable, hypothetically, in weight, per litre ...	1·92	2·62	3·10	3·65

RAISIN MUST, NO. 6.

Reducing matters	247 grammes
Mustimetre	247 "
Polarimetric deviation... ...	— 28·2° (sugar degree)

	25° C.	30° C.	35° C.	40° C.
Alcohol in volume, per cent.	11·1	10·6	9·3	*
Alcohol in weight, per litre	88·8	84·8	74·4	—
Sugar remaining ...	56·8	63·2	83·3	—
Sugar transformed ...	190·2	183·8	163·7	—
Ratio of alcohol to sugar transformed	46·68	46·13	45·44	—
Difference from the practical yield	0·32	0·87	1·56	—
Difference from the theoretical yield	1·82	2·37	3·06	—
Quantities of alcohol condensable, hypothetically, in absolute volume ...	2·02	2·51	2·84	—
Quantities of alcohol condensable, hypothetically, in weight, per litre ...	1·62	2·01	2·28	—

After eight days, even when the flask had returned to the temperature of the surrounding air, the fermentation did not start, which leads us to think that the temperature of 40° C. had killed the yeast. We only noticed this in one instance.

* The fermentation at 40° C. did not move appreciably. This was due, no doubt, to the great saccharine richness of the must.

Fresh Grape Must (Terret-Bourret and Picquepoul), No. 8.

Reducing matters ...	190 grammes.
Mustimetre	190 ,,
Polarimetric deviation ...	— 40° (sugar degree).

	25° C.	30° C.	35° C.	40° C.
Alcohol in volume per cent.*	10·9	10·9	9·6	9·3
Alcohol in weight, per litre ...	87·20	87·20	76·80	74·4
Sugar remaining	2·50	2·00	22·90	27·0
Sugar transformed ...	187·50	188·00	167·10	163·0
Ratio of alcohol to sugar transformed	46·5	46·38	45·96	45·64
Difference from the practical yield	0·50	0·62	1·08	1·36
Difference from the theoretical yield	2·00	2·12	2·58	2·86
Quantities of alcohol condensable, hypothetically, in absolute volume ...	2·18	2·31	2·48	2·66
Quantities of alcohol condensable, hypothetically, in weight, per litre ...	1·04	1·85	1·98	2·1

Fresh Grape Must (Aramon), No. 11.

Reducing matters ...	203·40 grammes.
Mustimetre	200·00 ,,
Polarimetric deviation ...	—37° (sugar degree).

	25° C.	30° C.	35° C.	40° C.
Alcohol in volume, per cent.	...	9·6	7·2	6·1
Alcohol in weight, per litre ...	...	76·80	57·60	51·2
Sugar remaining	...	39·15	76·90	86·9
Sugar transformed... ...	...	164·25	126·50	110·5
Ratio of alcohol to sugar transformed	...	46·75	45·50	43·9
Difference from the practical yield	...	0·25	1·50	3·1
Difference from the theoretical yield	...	1·75	3·00	4·6
Quantities of alcohol condensable, hypothetically, in absolute volume ...	...	1·68	2·15	2·94
Quantities of alcohol condensable, hypothetically, in weight, per litre ...	...	1·34	1·72	2·35

* The analyses of these wines were made three months after the start of the fermentation.

In this trial the experiment at 25° C. was not made, the analyses were only made one month and a half after the start.

We see that fermentation left for a few days at a high temperature can only be completed after a long time—four months at least, for fermentations that have been submitted to a temperature of 40° C. during ten days. This excessive duration of slow fermentation, seems to depend on the time during which the flask has been submitted to the high temperature ; however, we repeat, one may obtain complete fermentations, giving sound wines, but that result can only be obtained in the laboratory, that is to say, in must previously sterilized and sown with pure yeast.

INFLUENCE OF THE TEMPERATURE ON THE WORK OF DIFFERENT YEASTS.

High temperatures, therefore, have a retarding action on the yeasts of the Hérault, which were used in these experiments.

We tried to ascertain if, as suggested by Marchand, Director of the Experimental Cellar at Mascara, in Algeria, the yeasts suffer more or less at high temperatures, according to the cold or hot regions they originate from.

Marchand having studied the working of two yeasts taken from the same *cépage*, but from different regions, and working in the same musts, noticed that these yeasts could stand very different temperatures, the one originating from the hot district suffering less than the other.

This observation led us to think that the most favorable temperature found by us for the yeasts of the Hérault (30° C.) might be high for yeasts originating from cold climates, and low for those from hot climates.

To verify this idea, we have made a series of experiments with yeasts from the Rhine, Burgogne, and Hérault. But we only obtained the divergent results given in the following table :—

	25° C.	30° C.	35° C.	40° C.
Mudaison yeast ...	105 20	164·00	109·00	85·20
Bourgogne yeast ...	95·40	140·00	131·20	106·50
Wolbrath yeast ...	130·98	112·00	112·90	90·00

These figures do not seem sufficient for rejecting Marchand's theory, for the Rhine and Burgogne yeasts we used had been reproduced many times in the laboratory, at somewhat high temperatures, which may have enabled them to acquire special resistance.

If this were so, we may foresee the possibility of creating a race of yeasts capable of withstanding without difficulty the temperature of the South of France, but this is only an hypothesis.

INFLUENCE OF TEMPERATURE ON THE LOSS OF ALCOHOL.

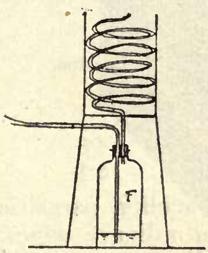


Fig. 17.—F, bottle containing the water; R, condenser; S, worm; T, tube carrying the gas evolved during fermentation.

We used, to collect the alcohol, the following device, Fig. 17:—The exit tube, the Liebig bulbs having been removed, leads to a bottle, F, containing a small quantity of water; the vapours not caught by this, pass through a condenser surrounded by ice.

The results obtained by this means are not accurate, and not comparable, for there is a condensation of alcohol taking place on the portion of the flask projecting above the water bath, and therefore cold. The higher the temperature of the liquid, the greater the condensation.

The quantity of alcohol carried over is subordinate to the rapidity of the disengagement of gas, and the gaseous disengagement being equal, is so much the greater as the temperature is higher, for the tension of the vapour of alcohol increases rapidly with the temperature.

In all our experiments the disengagement of carbonic acid did not differ much between the 25°, 30°, and 35° fermentations, but was very slow at 40° C. As the strengths of alcohol are always greater in the three first fermentations than in the last, we should expect to find more alcohol carried away from the fermentations at 25°, 30°, and 35° C. than that at 40° C., even considering the high tension of alcohol at 40° C. The following figures calculated for one litre confirm our expectations:—

	25° C.	30° C.	35° C.	40° C.
	c.c.	c.c.	c.c.	c.c.
Raisin must ...	1·3	2·0	2·1	traces
Fresh grape must...	1·8	2·1	2·85	1·5

These figures are quite sufficient to show that there is a loss of alcohol through mechanical means. We do not think, however, that this loss is the only cause of the diminution of the yield, but, on the contrary, that the most important cause resides in the incomplete utilization of the sugar.

INFLUENCE OF TEMPERATURE ON THE TOTAL ACIDITY OF WINE.

The temperature has a marked influence on the total acidity of wine. Experiments have shown us that the acidity always increases with the temperature. Here are several of our results:—

	Raisin must.	Raisin must.	Terret-Bourret Picquepoul.	Aramon.
25° C. ...	2·5	2 3	3·8	—
30° C. ...	2·6	2·4	3·8	4·1
35° C. ...	2·7	2 8	4·1	4·8
40° C. ...	2·8	3·0	4·9	5·1

We cannot blame for this increase of acidity, parasitic fermentations which are the cause of it in ordinary wines, as our experiments were made with sterilized must, sown with pure yeast; the only reason we can see, therefore, is that the yeast modifies its work with the temperature, and produces acid substances, as the precipitation of a part of the bitartrate of potash, always greater at low temperature, is insufficient to explain the differences observed.

ACTION OF TEMPERATURE ON THE YEAST.

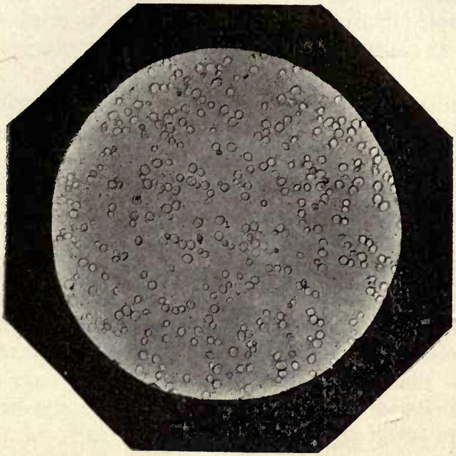
One of us has already shown that it is possible to recognise, by microscopical observation, if the yeast has worked at a proper temperature.*

The morphological differences of yeasts worked at different temperatures are very noticeable. The yeast at 25° C. is turgid, with hyaline and homogeneous protoplasm, and spherical. That at 40° C. is elongated, less regular shaped, and coloured, its membrane seems thick, generally wrinkled, sometimes star-like, a few cells only remaining refractive.

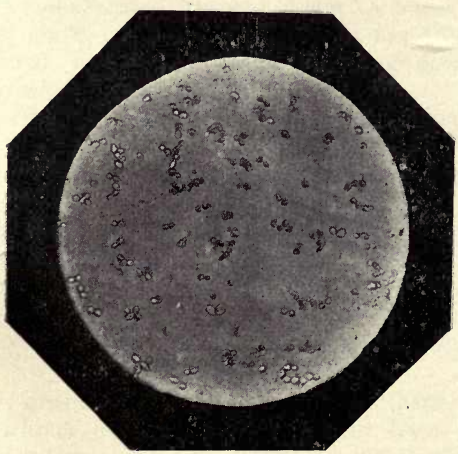
In a chemically neutral liquid (distilled water), for instance, the deformations are still more marked, the wrinkles distorted and pigmented, an appearance common with yeast

* L. Roos. *Vinification en pays chauds.*

PLATE II.

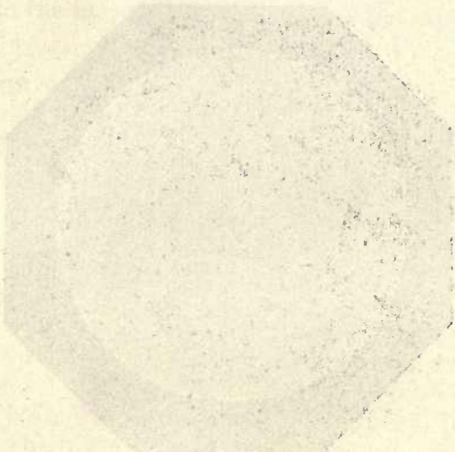


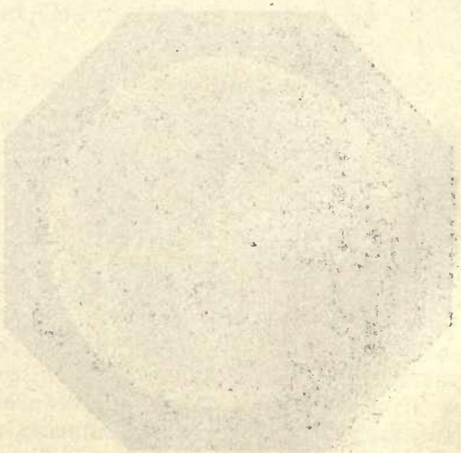
Wine Yeast of the Hérault working at 25° C.



Wine Yeast of the Hérault working at 40° C.

PLATE II.





fermented at 40° C. If after being washed, the yeast is placed in distilled water, after having been submitted for eight days to a temperature of 40° or even 25° C., there is also, apart from the special action of the temperature, that of the complete lack of nutritive substances in the liquid; the yeast produces endogenous spores (Rees spores) at both 25° and 40° C.

Therefore, the temperature has an action on the shape of the yeast in the must, sufficient to be detected under the microscope. It is rational to think that these morphological appearances are the exterior manifestations of a morbid state, the limit of which causes the death of the yeast.

Riestch and Herselin state that in two series of experiments made with Musigny yeast, the yeast, died, after nine days' fermentation, at 36° C.

Müntz, who we have already quoted, asserts that the morbid state is at 37·5° C., which he calls the critical point.

Our experiments lead us to a different opinion. Our yeasts did not die at 40° C., even after remaining ten days in the must at that temperature. Some have even been kept at 42° C. without dying.

It is evident that if we consider as the death of the ferment, the fact that the must brought down to a proper temperature cannot start fermentation again, we agree with the above authorities, for it is a fact that overheated fermentations brought down to lower temperatures will not start again. This is not due to the death of the ferment, but to the impossibility of developing in the liquid in which it is.

To strengthen this opinion, we may mention that we have always obtained active yeast cultures by sowing them in new must, even after they had reached the temperature of 40° C. It does not seem possible to us to fix a limit to the temperature at which yeast is killed, for the composition of the liquid itself is an important factor advancing or retarding this limit.

INFLUENCE OF THE TEMPERATURE ON THE QUANTITY OF NITROGEN.

Under ordinary circumstances fermentation does not take place without the yeast, which absorbs from the liquid the nitrogenous principles necessary to its constitution, eliminating nitrogenous products. It is a general observation of

Schutzenberger that the elimination of nitrogenous matters increases when the yeast is under unfavorable conditions.

It appeared to us that the influence of high temperature, which determines the morbidity of the yeast, might also determine a greater elimination of nitrogen, for we noticed in our fermentations that, generally speaking, starting from the same must, the wine obtained is so much the richer in nitrogen as it has been fermented at a higher temperature.

	Nitrogen, per Litre			
	25° C.	30° C.	35° C.	40° C.
Raisin must	...	0·265	0·322	0·490
Terret-Bourret and Picquepoul	0·115	0·115	0·120	0·135
Aramon	...	0·112	0·193	0·183
Carignan	0·187	...	...	0·205

Experiments made by Müntz on this subject have attracted scientists' attention. He noticed that wines obtained at 40° C. contain more ammoniacal salts than those made at temperatures below 37° C. But there is this great difference between the experiments made by Müntz and ours, that his bear only on ammoniacal salts, and ours on more complex compounds ; and, what is more, he attributes the increase of ammoniacal salts to the destruction of the nitrogenous molecules by the yeast, and that the yeasts themselves can become the prey of micro-organisms.

In our experiments nothing of the kind could happen, for, we repeat, we used must sown with pure yeast ; the yeast, far from producing ammonia, would, on the contrary, have used all the ammonia that might have been in the must.

We have found traces of ammonia only in wine fermented at high temperatures, while Müntz found it in wines fermenting at a normal temperature.

It is therefore a fact, not before stated, that high temperatures produce wines rich in complex soluble nitrogenous compounds.

What is the nature of this nitrogenous matter ? We can only offer a suggestion. We think that the sterility acquired by the must ought to be attributed, partially at least, to these nitrogenous bodies.

The result of practical observations made in Algeria shows that fermentations, languishing at 40° and 42° C., completely stop and cannot start again, when brought back to a low temperature.

Two explanations may be advanced—first, the death of the yeast; second, the liquid has become toxic, and therefore either unfermentable or only fermentable with difficulty.

We have already seen that at 40° C. the yeast was still living. We have sown new must, previously sterilized, with yeast that had remained ten days at 40° C., the fermentation having stopped. This yeast became prolific.

This experiment has been repeated often, and has always given concordant results.

Our laboratory experiments confirm the second hypothesis, which is supported by H. Dessolier's practical observations in Algeria.

From a filled and fermenting vat, six hogsheads of wine were racked when the temperature reached 25° C., then successively six others, each at temperatures of 30°, 35°, 40°, and 42° C., the rest of the vatful was refrigerated, and fresh hogsheads taken from it when the temperatures were falling, passing 35°, 30°, and 25° C. The following table shows the number of days required to completely transform the sugar in each of these séries:—

Hogsheads.	Time required for complete fermentation.
25° C	10 days
30° C	10 „
35° C	10 „
40° C	20 „
42° C more than	225 „
35° C	80 „
30° C	50 „
25° C	36 „

The maximum temperature reached only lasted a few hours; its influence, however, was sufficient to more than treble the normal duration of fermentation.

Our results are still more definite, but we prolonged the action of the temperature from eight to ten days, and thus observed fermentation not completed after four months, in the flask, at 40° C. brought down to 25° C.

To verify the toxicity towards the yeast, of a liquid fermented at 40° C., we tried it by adding a certain proportion of fresh must, and sowing the mixture with active yeast.

With this object, eight volumes of wine at 25° C. and eight volumes of wine at 40° C. were respectively mixed with two volumes of fresh must. The quantity of sugar and alcohol was rendered uniform in the two mixtures by additions of alcohol and pure glucose. They were both sown with yeast from the same culture, and both kept at a temperature of 28° C.

Regular weighings showed that the course of fermentation was much more satisfactory in the flask containing the initial wine at 25° C. than in that at 40° C. The loss of sugar was twice as great in the first mixture, and was complete in nine days, while in the mixture of the wine at 40° C., the fermentation proceeded slowly, and a month after the start the liquid still contained 16 grammes of sugar per litre.

Our experiments show, therefore, that a liquid previously sterilized, and sown with pure yeast, may become unfermentable under the sole action of a high and prolonged temperature. We must put aside the hypothesis of the toxicity brought about by secondary fermentation, and only attribute it to the action of the products eliminated by the yeast. We do not deny the intervention of parasitic fermentation in that sense. We simply desire to point out that the same phenomena take place without it.

We intend to try and show that it is, without doubt, due to the presence of albuminoid matters eliminated by the yeasts.

The yeast eliminates volatile acids, mainly acetic and propionic acids, but these exist in any fermentation, even normal, and do not seem to have any action on the work of the yeast, provided that they do not exceed a limit above that normally given by the yeast.

Kayser has observed that the temperature of fermentation has no influence on the quantity of volatile acids produced.

	Volatile Acids calculated as Acetic Acid. 25° C.	35° C.
Yeast 2	0·979	0·780
,, 8	1·112	1·504
,, 9	0·862	0·828

U. Gayon has recently pointed out* that whenever the proportion of volatile acids increased, that phenomenon coincided with the presence of micro-organisms other than yeasts, which is in accord with the observations of Kayser.

As regards the production of higher alcohols and the alkaloids which accompany them, it is very small, and these substances have not a very energetic action on the yeasts. The same may be said of substances such as leucine and tyrosine, which are produced in such small quantities, that it is necessary to operate on large volumes of liquid to detect them. As also for pyridine and collidine, noticed by Ordonneau, and proteine matters as yet undetermined which we merely mention, and classify with the toxalbumens, according to Roussy, who observed them in beer yeast.

To ascertain if these substances have an analogy with those observed by Roussy, we injected rabbits with liquids obtained by macerating wine yeast previously washed for eight days in distilled water at 25° and 40° C. We noticed rises of temperature, in the animals which were given a few centimetres of the solution from the maceration at 40° C. after filtration through a Chamberland candle.

The infusion at 25° C. does not give any apparent results, but the injection of an equal volume of a yeast culture, that had not been submitted to an abnormal temperature, also produced hyperthermy. As the filtrate from the maceration at 25° C. does not produce any effect, we may infer that the active substances liable to be developed by the yeast are elaborated in the organs of the animal, the temperature of which is too high for the yeast.

It is therefore to these albumenoid substances, which we consider analogous to those of Roussy, that we attribute the sterility acquired by must, when left for a few days at a too elevated temperature.

This sterility, however, is not permanent. According to our experiments we cannot say that fresh yeast will not develop at all in the liquid. It works there, but very slowly at the commencement, and, what is very remarkable, more actively later on, although the contrary would have been expected, the activity of the yeast diminishing as the alcoholic strength increases. If such a result takes place,

* U. Gayon. Sur les acides contenus dans des vins. *Revue de Viticulture*, April 24, 1889.

it is due, no doubt, as Schutzenberger observed, to diastases, amongst which are classified the toxalbumens, the diastase being submitted to a progressive alteration, the effect of which is the diminution, and even the complete loss, of the specific power of the yeasts.

CONCLUSIONS.

First.—For indigenous yeasts (South of France) the most suitable temperature for fermentation is 30° C. (86° F.). We think winemakers will with advantage keep their vats about that temperature.

Second.—The rise of temperature above 35° C. causes a noticeable diminution in the final alcoholic strength.

Third.—The qualities of a wine, its organoleptic, and perhaps pecuniary value, are in inverse proportion to the temperature at which it fermented.

Fourth.—The difficulty noticed in completely fermenting a wine remaining sweet on account of excessive temperature, is due to the liquid containing substances eliminated by the yeast, and exerting a toxic action on it.

Fifth.—Fermentations at high temperature give wines richer in albuminoids, than those fermented at normal temperatures.

Sixth.—In our experiments, the greater amount of nitrogen yielded cannot be attributed to parasitic ferments, for we experimented with sterilized musts.

INFLUENCE OF THE TEMPERATURE OF FERMENTATION ON THE YIELD IN ALCOHOL.

A fact which has attracted the attention of a few œnologists for some time, and which we have often observed, is the enormous disproportion between the alcoholic strength and the initial sugar contents of Algerian wines. The musts are very rich in sugar, but the wines from them relatively deficient in alcohol. This is so frequent that an incorrect opinion is held by many Algerian vignerons. They consider the mustimetre as an inaccurate instrument, always giving exaggerated results. In many cases the differences are even much greater than they think.

The observations with the mustimetre are generally made without taking the temperature into account, and without making any correction, and as in Algeria the temperature is always above 15° C., this faulty method of observation always gives results below the normal. On the other hand, it is the rule in Algeria to put into the fermenting vat grapes dried by the hot winds blowing from the desert (the Great Sahara). These grapes are rich in sugar, and increase the percentage of sugar in the vintage without its being shown by the mustimetre, as the sugar only dissolves slowly from the mass.

It is inadmissible that an instrument giving accurate indications in France should give inaccurate indications in Algeria. We must therefore acknowledge a loss, and we have ascertained that the loss is considerable. We tried to measure it in fermentations resulting from leaving the must to itself after crushing, as is generally done in Algeria.

After having, as far as possible, rendered the must homogeneous in a vat of 250 hectolitres (5,500 gallons), samples were drawn at different depths, and carefully tried with the mustimetre, applying corrections for temperature. The indications obtained from the samples were concordant. They were also checked by determination of the sugar with Fehling's solution. The differences found were inconsiderable. The must tried contained 243 grammes of sugar per litre. According to Pasteur's experiments, inverted sugar (identical with grape sugar) gives after fermentation 48·5 per cent. of its weight in alcohol; in practice, however, this yield is not reached. A yield of 47 per cent. may be considered as normal, corresponding to 1 per cent. of alcohol in volume for 17 grammes of sugar transformed. The above-mentioned must should therefore have furnished—

$$\frac{243}{17} = 14{\cdot}3 \text{ per cent. alcohol.}$$

Here are, in its main lines, the course of the fermentation:—

It started eight hours after filling the vat, which was filled on the 3rd of September. During the whole day on the 4th and first half of the 5th September the fermentation remained very active. On the 5th of September, at two p.m., there were only 83 grammes of sugar left untransformed, but the fermentation was visibly slackening; the temperature taken at that moment in the vat was—

At 50 centimetres below the head, 38° C.
„ 1 metre „ „ 40°.
„ the bottom of the vat 39·5°.

On the same day, at six p.m., the maximum temperature was 41·5° C., and the fermentation seemed to have stopped, a determination of the sugar gave 78 grammes. Twenty hours after the sugar strength had not varied, the fermentation had stuck.

Racking was advised and took place the day after. The wine tested after racking, contained 7·9 per cent. in volume of alcohol, and 78 grammes per litre of untransformed sugar. A few days afterwards the fermentation started again, and continued at a low temperature (25° to 28° C.) outside, in casks of 550 to 600 litres (130 gallons). The wine, when completely finished, showed 12·5 per cent. alcohol, and only traces of sugar.*

There has been, therefore, 14·3–12·5 = 1·8 per cent. of alcohol less than the amount calculated. The yield in this case has only been 87·3 per cent. of the normal, that is to say, a net loss of 12·7 per cent.

This observation is not exceptional, it has been given with details, because it was followed up with concordant results, but we consider it as expressing the minimum loss that takes place, as the fermentations last year in Algiers took place under most favorable circumstances.

With regard to the vat studied, the temperature of the grapes was not excessive, 22° C. The hot winds (Sirocco), it is true, had blown during the night of the 1st and 2nd September, but the temperature had fallen on the evening of the 2nd, and remained relatively low during the remaining period of fermentation.

There are, therefore, in this particular case, favorable circumstances, tending to render it comparable with our fermentations in the South of France. What can we expect, then, when fermentation takes place under less favorable conditions, such as those, for instance, the result of which we have seen at Relizane, and which took place at temperatures varying from 40° to 44° C. in the shade?

From information gathered from several vine-growers, the difference between the indications of the mustimetre and the final alcoholic strength reached in some cases the extreme figure of 3°.

* We must draw attention to the fact that the sugar remaining after the principal fermentation, was ultimately transformed, furnishing the normal yield of alcohol.

We can only see one cause, for these small yields, having a direct action of a physical nature, and, perhaps, also of a physiological order.' This cause is the excessive elevation of temperature. This we may easily ascertain, and we have done so; the presence of notable quantities of alcohol in the gases evolved during fermentation when the temperature exceeds 36° C. being readily detected. The alcohol may also be carried away mechanically at lower temperatures, but in much smaller amount, and to measure it, we need to use more effective means than those employed above. It is, probably, to the alcohol carried away, that the difference between the theoretical yield obtained in the laboratory (48·5 per cent. of the weight of sugar), and that which we may call normal (47 per cent. which results from wine-making practice in France), is due.

There is therefore always a loss which seems inevitable, but we must try not to increase it.

To estimate the alcohol in the gases from the fermentation we used Müntz's accurate process, which consists in transforming the alcohol into iodoform, by means of iodine and carbonate of soda, at moderate temperatures. If we plunge into the gases escaping a cold body, such as the carefully cleaned outside of a cold bottle, it will become immediately covered with a condensed film, in which alcohol exists in considerable proportion. It suffices, in order to detect it, to wipe it with a brush into a test tube, and to apply to the liquid thus obtained Müntz's test. One generally perceives the odour of iodoform. If the test is made when the temperature of the vat is approaching 40° C., not only does the odour appear stronger, but the liquid contains numerous crystals, which, when shaken, appear to the eye to have a silky appearance, and deposit in a mass varying in size as the experiment is continued longer, and as the surface of condensation is colder, or as the temperature of the vat is high.

If we rack into a recipient some of the wine while at a high temperature, the presence of alcohol is still more accentuated, the odour being easily noticed.

In the experiments we were able to make, the surface of condensation was about 4° or 5° C. above zero, as there was alcohol condensed at that temperature, the tension of the alcoholic vapours in the gaseous mass must at least have been equal to that corresponding to the temperature of the condensing surface. The tension at 4° or 5° C. is represented by about 18mm. of mercury, and we may easily conceive that the loss of alcohol through being mechanically carried away may be considerable, if we consider the enormous volume of gas resulting from the phenomena of fermentation.

The quantitative determination of the loss under given circumstances could only be experimentally determined, but we feel sure that it is very considerable in Algeria, far more so than is generally thought to be the case, and this is explained by the comparison of the tension of vapour of alcohol at the average temperatures of 30° C. in France and 40° C. in Algeria.

The tensions in mm. of mercury are 78· at 30° C. and 134· at 40° C.

In what has been said so far, we mean by *yield* the amount of alcohol obtained, as compared with the sugar transformed, and not in relation to the total amount of sugar. For it would be a very different thing if we meant by yield the alcohol obtained, without taking into account the quantity of untransformed sugar. Another important action of the temperature is to completely arrest the fermentation at 40° C.; if the liquid remains in that state, the natural decrease of temperature is not complete or rapid enough to allow the yeast to recover its activity, and a part of the sugar remains untransformed, which contributes to the diminution of the yield in alcohol, and constitutes a cause of future alterations.

If the temperature of the fermenting must is carefully maintained below 32° C., in Algeria or anywhere else, the resulting wine shows a normal yield of 47 per cent. of alcohol per 100 of sugar transformed in weight, and the whole of the sugar is transformed, even in the case of wine of high alcoholic strength. We have been able to verify this fact in the most positive manner, in a cellar, where two fermentations only differed in their temperatures.

By applying to the fermenting must a slight refrigeration, the losses are simply diminished, and we obtain a medium yield.

If we represent the normal yield as 100, the yield of a vat allowed to rise to 40° C. would be 87·3, that of the same vat refrigerated would be 92, and that of the vat not allowed to exceed 32° C. would be 100.

To sum up, we consider that any elevation of temperature above 30° C. is an important cause in the diminution of the alcoholic strength, and that the installation of refrigerating plant is necessary in every cellar exposed to high temperatures.

Whatever expense is incurred by this improvement of the process of vinification will be amply repaid by the superior value of the wines made by this method. They will be more alcoholic, brighter, and, above all, possess better keeping qualities than wines made in the ordinary way.

INFLUENCE OF THE TEMPERATURE OF VINOUS FERMENTATION ON THE QUALITIES OF WINE.

As has been already said, the excessive temperature influences the yield of alcohol in two ways—one physical the other physiological. It is necessary to study the physiological or indirect influence, for it results, not only in the diminution of the alcoholic yield, but also constitutes the principal cause of the poor quality of wines.

The activity of the wine ferment is considerably slackened down when the temperature gets over a certain limit. The curve described above allows us to see easily the slackening of the fermentation, and the stoppage of its action. The functions of the alcoholic ferment are destroyed, and in many cases noxious ferments take its place, consuming the sugar without producing alcohol, and introducing into the wine new products altering its organoleptic properties.

This is not the only alteration. The alcoholic ferment is not dead, for sown again in new must, and under favorable conditions, it will regain its activity; but it is morbid, and shows morphological differences, detectable by the microscope, so definitely, that by simply observing it under the instrument we are able to say if the temperature has risen above 36° C.

We are inclined to think that the products of elimination of a living organism sufficiently diseased, for its shape to be altered, must differ from those eliminated normally. In confirmation of this opinion, we have, by means of the microscope, classified many wines made from the same *cépages* under similar conditions, containing foreign bacteria in notable numbers. At M. Debonno's well-known vineyard at Boufarick we were able to control this classification with the microscope, assisted by two expert wine-tasters—MM. Aury and Vielle, of Algiers.

Among the wines tasted were four samples of white wine, racked a few days previously, and still cloudy but quite dry, that is to say, containing only traces of sugar. The absence of sugar was a sign that the temperature had not risen enough to completely paralyze the ferment. The microscopical examination disclosed that all the fermentations had not taken place at equal temperatures, as some of the yeasts appeared to have suffered. Methodical refrigeration is used in M. Debonno's cellar, but the instalment is insufficient to refrigerate effectively the huge quantities of vintage manipulated each day. By microscopical observation the wines numbered 1, 2, 3, and 4 were classified according to their value, 1, 3, 4, 2. MM. Aury and Vielle, simply by tasting, classified them in exactly the same way. This test has been repeated frequently, and always with success, and with wines completely turbid, in which condition it was not possible to make any conjecture as to their future quality.

The same observations were carried out on two white wines made from the Cinsaut *cépage*, the grapes having been gathered the same day, and fermented, some in a metallic vat (Toutée system), and some in a wooden vat of 125 hectolitres capacity; the temperature did not exceed 29° in the metallic vat and was 38·5° C. in the wooden one. The fermentations started on the 15th September, and they were both almost finished on the 18th.

Microscopical observation showed that the wine made in the metallic vat contained only vigorous turgid yeasts, highly refractive; in the wine from the wooden vat, the yeasts were unhealthy, shrivelled, and wrinkled; they did not in either case contain bacteria, but to the taste the wine made in the metallic vat was much superior.

These facts certainly support the opinion we have already given—*the wine yeast eliminates at high temperatures products injurious to the wine.* The elimination of abnormal products, by the ferment in a visibly morbid state, is one of the principal reasons of the inferior yield of alcohol, in wine fermented at a high temperature. But we are far from denying the analogous action of foreign injurious bacteria—often developing at a temperature detrimental to the alcoholic yeast itself.

These foreign fermentations happen very frequently. Dessoliers, in a very thorough study on "Vinification in Hot Climates," published in the *Algerie Agricole*, mentions this, but we maintain that the predominant effect is due to the wine yeast itself. In the wines just mentioned there were no foreign organisms in appreciable quantity, the alteration of the organoleptic qualities cannot therefore be attributed to the secondary fermentation, but to defective vinous fermentation.

When the fermentation rises to a temperature high enough to prevent the transformation of the sugar, the damage is still more serious, especially if it remains for some time at this temperature.

We think, without being able to positively assert it, that the yeast accumulates morbid products in the must in sufficient quantity to render the must sterile. It is from this sterility that the sweetish acid taste of incompletely fermented wine arises. The must is then invaded with a host of organisms, amongst which may be found germs of all the wine diseases, which develop with extreme rapidity, living no doubt at the expense of the sugar, and converting the wine into an undrinkable liquid, only fit for the still, which even then only produces spirit of inferior quality.

We have observed a great number of these wines in the Chelif plain, when travelling from Oran to Algiers, where the conditions for the vintage were not found this year to be as favorable as in other viticultural centres in Algeria. Several days after the first racking, and even on the marc, these wines contained a great quantity of sugar, and only a few wrinkled yeast cells could be detected under the microscope. On the other hand, they were real breeding grounds for a great variety of bacteria. We only found exceptions to this fact in cellars where wine was fermented in small quantities, and therefore could not reach a high temperature.

The excessive temperature acts in a third manner in diminishing the value of wine. White wines, fermented without contact with the marc, are not submitted to this action in the same way, or to the same extent, as red wines fermented on the marc. Wine tasters are unanimous in recognising the relative inferiority of red wines which have fermented at a high temperature. They find that they taste of the marc, and that they *terroitent*, to use the expression employed locally. We are, therefore, led to suppose that the products dissolved by the wine from the marc, at least at different temperatures, are not the same quantitatively. Chemical analysis does not reveal positive differences. We can only note as a constant fact that the reduced dry extract of wine, made at a high temperature, is in excess of normal wines made from the same *cépage*. In fact, if we examine the marcs from fermentations made at 30° and 40° C., the tissues of the latter are found to be much more disorganized.

To conclude, we consider that the elevation of the temperature above a certain limit (32° C.) diminishes the quality of the resulting wines. It is therefore necessary, in order to improve our wines, to check elevation of temperature by the use of refrigerating appliances.

INFLUENCE OF THE TEMPERATURE OF FERMENTATION ON THE KEEPING QUALITIES OF WINE.

After what has been said about the influence of the temperature of fermentation on the quality of wine, it is almost superfluous to speak of its action on the keeping quality of wine, for the two terms quality and keeping quality are almost synonymous when applied to wines having the same origin. However, we consider it advisable to dwell a little longer on this subject, to show the detrimental effects of high temperatures.

Wine is a liquid composed of different parts, which can be divided into two groups. The first includes alterable substances such as albumenoid matters, sugar, acid-tartrate of potash, &c.; the other comprises antiseptic matters protecting the first group against possible alterations. These are alcohol, glycerine, tannin, and various acids. In the manufacture of wine, therefore, we should try and diminish the quantity of alterable matters, and increase the quantity of natural antiseptic substances.

In fermentations made at 30° C. the quantities of these various substances seem to exist in proper proportion; experience has proved that wines obtained at that temperature, even if only submitted to summary care subsequently, are able to keep well.

Experience has also proved that fermentations made above that temperature, which we will call the optima for the yeast, yield wines much more liable to alteration, this liability to change varying in proportion as the temperature rises or falls from that optima, and being greater for high temperatures. It is to this that Algerian wines owe their reputation for bad keeping qualities. An opportunity occurred in 1892 of noticing a disease in Algeria which seemed peculiar to

Algerian wines, but which has since been found more general; this is known as mannitic fermentation. We were able to show in 1892,* from experiments made in the laboratory, and in Algeria during the vintage, that the disease was due to bacteria, and that it was simply the result of the extreme temperature, which had killed the yeast without killing the bacteria, which always exist in great quantities even in healthy vintages. Gayon and Dubourg have recently isolated the mannitic ferment, and confirmed these observations, and proved, as a result of their study, that the mannitic fermentation can only take place after an incomplete alcoholic fermentation. This disease is very frequent in wines made at a high temperature, for there undecomposed sugar is always left, but if the temperature of the fermenting wine is brought down it will not occur. There will be no sugar left, and consequently no fermentation is possible.

Other wine diseases, it is true, may develop even in completely fermented wines, but their development is infinitely more frequent if the fermentation has been defective.

High temperature is therefore injurious to the keeping quality of wine. It leaves in the wine a large proportion of alterable substances, and is the cause of the diminution in the alcohol as also of the glycerine, both of which are excellent preservative substances.

REFRIGERATION OF MUSTS DURING FERMENTATION.

The refrigeration of musts during fermentation has not yet obtained the sanction of being an old practice, but trials made since 1892 in our African† colony, and considerably increasing every year in various parts of Algeria, have shown decisively that the solution of the problem of wine making in hot countries depends entirely on this operation.

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* *Journ. de Pharm. et de Chimie*, 1893.

† In connexion with the recent extensive application of the system of refrigerating musts during fermentation, in the South of France and Algeria, it is interesting to refer to an Australian work by Dr. A. C. Kelly, *The Vine in Australia*, pp. IX., 215, published in 1861, Melbourne and Sydney. In this work Dr. Kelly described a simple system of refrigerating must during fermentation. His remarks and experiments on this subject are very conclusive and convincing, but were greatly in advance of the times, for, although written some 40 years since for the immediate benefit of Australian wine-makers, it is well-known that they are even now only tardily availing themselves of the advantages to be derived from fermenting their musts under proper conditions.

The paragraphs of Dr. Kelly's work dealing with the importance of the temperature during fermentation are, on account of their present interest, reproduced completely in the Appendix to this work. (Trans.)

In the South of France, the difficulties met with in Algeria exist to a lesser extent, and if refrigeration there is not indispensable it is nevertheless so useful that results obtained in different vineyards during the last two or three years enable us to predict the general adoption of this system at an early date.

How should the fermentation be conducted?

Two systems have been proposed: the first consists in cooling the must in the vat, the second in cooling it outside.

The first system may be applied in two ways: one as used at Jaffa, by Ermens, consists in a long pipe (coiled spirally) fixed in the vat itself, and through which cold water circulates during the fermentation. (Fig. 18.) The application of

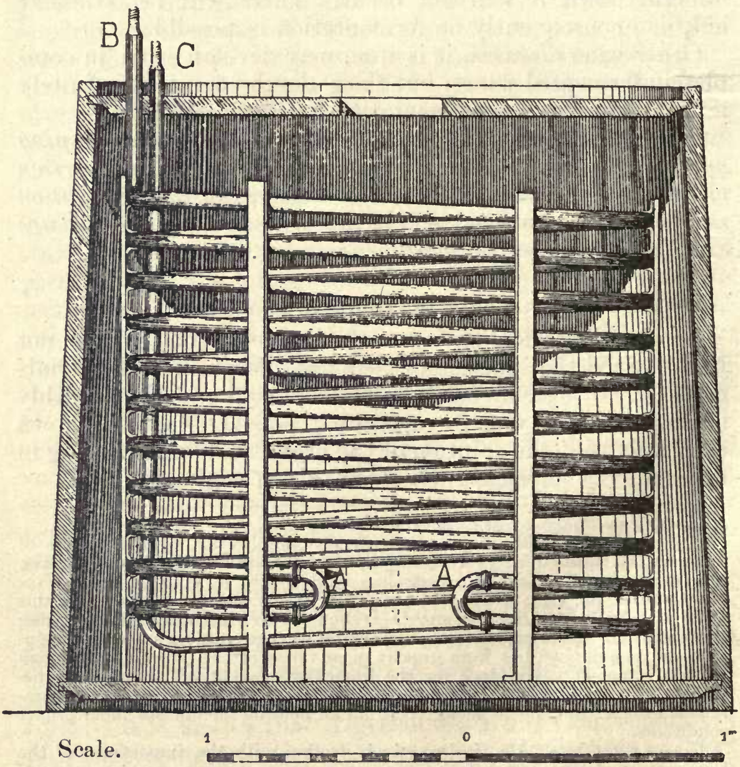


Fig. 18 —Ermens arrangement for refrigerating inside the Vat.

this system is so very expensive, and according to the inventor necessitates the use of such large quantities of cool water to give good results, that it cannot be advocated.

The second method of refrigeration of the must inside the vat is more tempting, because it is more simple. It consists in facilitating the exterior radiation of the heat of the must, by the use of vats made of material of great conductivity. These are the metallic vats of Toutée.

We had an opportunity of watching two fermentations, one in a wooden vat of 125 hectolitres capacity, the other in a metallic vat of the same size. The maximum temperature in the wooden vat was reached at 38·5°, and in the metallic vat at 29°, a difference in favour of the metallic vat of 9·5° C.

This decrease of temperature was ample, but we must take into account that it was white grape must, in which the homogeneity of the temperature is greater than in red must. In the latter the head, or mass of marc, is a danger zone, and ought to be refrigerated first. It forms a compact felted block, which does not partake much of the diminution of the temperature produced by the conductivity of the walls of the vat. It would be necessary in order to obtain in the fermentation of red musts a result equivalent to those of white must fermentations, to establish continuous circulation of the liquid pumped from the bottom of the vat to the top of the head. This manipulation already used to a great extent with any system of fermentation would not be very complicated, the only question to be considered is the monetary outlay, the adoption of the Toutée system meaning the integral renewal of all the vats.

Refrigeration of the must by circulation outside the vat may be effected in two different ways, sometimes it is spread in contact with the air over a great surface. This leads to evaporation and therefore refrigeration, increased if necessary by a strong air blast, or else the must circulates in a closed space refrigerated outside by a current of cool water, by damp cloths, or sometimes by the air itself, for it is only a question of surface. This latter system, we consider, should be preferred.

The refrigeration of musts in contact with the air creates energetic oxidation of the wine.

The oxidation is an advantage, if done before the start of the fermentation, but it is not so in the case of wine partly or completely fermented. When the fermentation is started the aeration may be useful, but it should be sparing if we desire to protect the wine against the disadvantages which it leads to.

Fermenting wine, if kept too long in contact with the air, becomes flat and insipid.

It is therefore better to adopt the system of refrigeration without contact with the air, and aerate afterwards if judged necessary.

It is by no means difficult to obtain simple and very effective cooling apparatus. It is not necessary, as in the case of a brewery, to reduce the temperature very low, but simply to keep the fermentation about 30° C.

Water and air are the only two refrigerators that can be used economically.

The air at vintage time in the South of France is generally below 30° C., and is always at the disposal of the vine-grower in unlimited quantity, and might be used.

Water, unfortunately existing in too limited supply, is much more convenient, as it is generally at a lower temperature than the air, and even if it were at the same temperature, it produces an equal cooling effect from a smaller surface of contact.

Water therefore should always be the refrigerating means, whenever sufficiently plentiful.

A simple tube, more or less long, wetted outside by a current of water, constitutes the machine, and is connected with the bottom and top of the vat. Tinned copper tubes are all that is required to make a wine refrigerator when water is at disposal. The pipes may be joined by pieces of rubber hose and placed in a suitable trough, in one length or in a tank zigzaging, divided by partitions to regulate the circulation of the water. This form presents the advantage of being easily pulled to pieces and used afterwards as ordinary conducting pipes.

The decrease of the temperature of the wine induces a considerable deposit of tartar, which necessitates the use of tubes of large diameter, easily dismantled for cleaning.

An apparatus of this kind may be fixed without much expense in a cellar having water available, and can if necessary, even be placed outside the cellar.

If only a limited supply of water is available this device can still be adapted, if the water is collected to be used over again when its temperature has decreased, or, preferably, another system may be used utilizing more completely the cooling power of the water, with or without the intervention of air.

The cooling effect of the air may take place directly, simply by exchange of temperature, the surrounding air being generally cooler than the wine, or indirectly by evaporation of part of the water used for refrigerating. This physical phenomenon being always accompanied by a decrease of temperature. In the latter case it is not indispensable for the air to be colder than the wine.

The metallic vats of Toutée only utilize, when bare, the refrigerating effect of the air, but if covered with cloth kept wet they utilize the refrigerating effect of the evaporation also. It goes without saying that in this case the cooling effect is greater.

We have seen by the figures quoted relative to fermentation in metallic vats, that these are quite sufficiently effective for white and red wines, if in the case of the latter the must is pumped over the head.

The adoption of the Toutée system is therefore indicated for a cellar with limited water supply, but it would be too expensive to establish in a cellar already furnished with vats.

When the water supply is limited, we must try to use the same water again, or develop surfaces large enough to act with air alone, or adopt a mixed system in which air and water act together, as in the Toutée vat covered with cloth.

Whatever be the ingenuity of apparatus utilizing water alone, its consumption will always be large, more than half the volume of wine cooled, but if the water supply is sufficient for one day's operation, the night cooling will be ample. With arrangements easily devised we may bring back the water to a suitable temperature, ready to be used again the next day.

But there are cases where the cooling of the water must be done at the same time as it is employed.

Dessoliers proposed to rapidly reduce the temperature of the heated water with a kind of refrigerator, submitting it to a great surface for evaporation, aided with a strong blast, and devised for that purpose an apparatus called *cheminée* *climagène* (Fig. 19), which consists of a chimney more or less high, according to the quantity of water to be treated, in

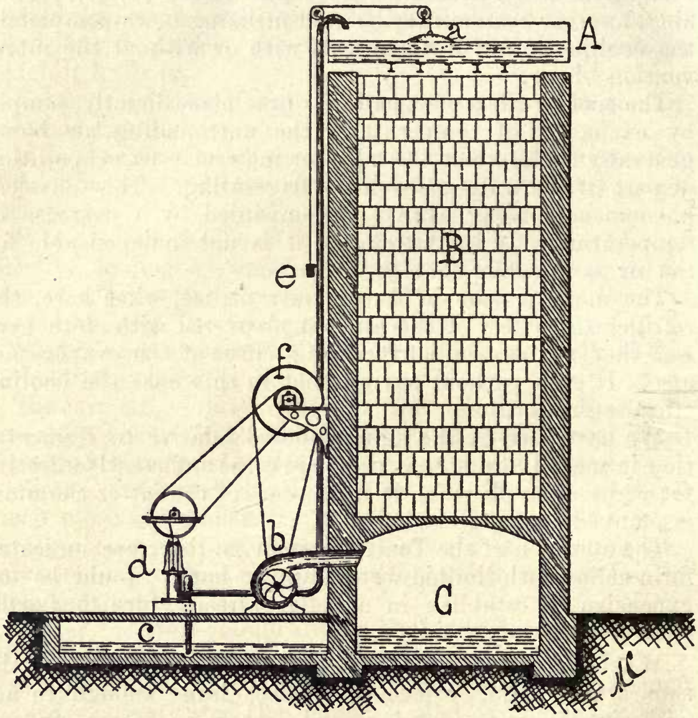


Fig. 19.--Climagene chimney of Dessoliers —A, Distributing tank for the hot water; B, cellular bricks; C, receiving tank for the cooled water; d, pump; b, ventilating fan; a, e, level indicator.

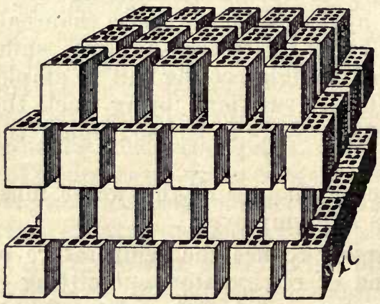


Fig. 20.—Climagene Chimney of Dessoliers—Arangement of the cellular bricks.

the centre of which cellular bricks are piled up to the top, overlapping each other. The water poured on the top descends to the bottom, spreading completely over the surfaces of the bricks (Fig. 20). A strong ventilating fan sends an air blast from bottom to top, creating active' evaporation, with consequent cooling of the water.

With the *cheminée climagène*, the results are excellent, but the same result can be reached without going to the expense of such a building.

There are different materials easily procurable everywhere, such as coke, already employed for similar purposes by other industries, which present a larger surface than cellular bricks. We feel certain that a cylinder made of double hogsheads, with the bottoms knocked out, and filled with coke, would afford a better solution of the problem than Dessolier's chimney.

It is rational to utilize evaporation, as it is so active in hot climates, but apparatus based on that principle only, that is to say, in which the outside surface is just maintained moist, cannot have a constant refrigerating action.

The refrigeration in this case depends on the hygrometric state of the air, and on the rapidity of the air current.

Theoretically, the cooling produced by evaporation is proportional to the difference existing between the maximum tension of water vapour at the temperature at which the work is being done, and the tension existing in the air at the same moment.

If we suppose the air to be completely dry the refrigerating power seems unlimited, for if the air is constantly renewed it will continuously vapourize the water, and therefore reduce the temperature. In reality, equilibrium takes place at the moment that the heat lost by the water by radiation and evaporation becomes exactly equal to that received from the surrounding air.

These states of equilibrium were experimentally determined by Gay-Lussac, who determined them for temperatures between 0° and 25° C. by the figures indicating the maximum decrease of temperature that can be obtained. The figures interesting to us are those corresponding to the temperatures of 15°, 20°, 25° C., and they are respectively 10·8, 12·7, and 14·7.

These experiments were repeated by Regnault, and appeared to him to be incomplete, as the influence of the rapidity of the current of air on the decrease of temperature was not studied. This decrease increases with the rate of movement of the air current, when it is higher than 8 metres per second, which corresponds to a strong wind, but is easily obtainable with a ventilating fan.

All the results apply to dry air, if the air is damp they will be lower, although remaining in the same proportion, and become nil if the air is saturated with moisture.

There are therefore in the utilization of evaporation two factors, one of which can be modified—the speed of the current of air; the other, which is not controllable, being the hygrometric state of the atmosphere; but the action of the latter is so pronounced that it would be imprudent to depend on a system based on evaporation alone, in certain regions where the hygrometric state is very variable.

The effect with such a machine would, however, never be nil, notwithstanding what has been said; even if working in a saturated atmosphere the effect will always be greater than we could have expected from the exact measurement of the quantity of water evaporated.

It seems at first sight that the decrease of temperature obtained can only be constituted by the sum of the calories given to the water, and that necessary to evaporate the weight of water which disappears during the experiment. If we represent by A the first of these numbers, by B the second, and by C the number of calories lost by the wine, it should be possible to write $A + B = C$. In practice this is not so. Not only is $A + B$ less than C, but experience proves that often $A + B$ is only half of C.

The heat lost cannot be equal to the heat gained, we must, therefore, conclude that there are undetermined elements in the calculation, which intervene to a large extent, and which cannot be measured directly. They are the exchanges with the surrounding air. These are so much the greater as the temperature of the wine varies from the surrounding air, assuming that the surface of evaporation is of constant conductivity.

We have experimented on a cooler constructed purposely with a view of utilizing the evaporation effect only. It gave insufficient results under rather good atmospheric conditions. The surface of evaporation acted upon was rather small, it is true. The apparatus consisted of six very flat lenses made of tinned copper, mounted horizontally on a vertical tube, and of a diameter of 40 centimetres. The decrease of temperature observed in wine at 38° to 40° C. was from 3·5° to 5·5° C., varying according to the strength of the current of air, the surrounding temperature, the hygrometric state of the air, and the rate of flow of the wine, which was between twelve and fifteen hectolitres per hour. Although not perfectly satisfactory, an improvement in the yield of alcohol resulted, which reached 4·7 per cent. more than that of the non-refrigerated wine (92 against 87·3, 100 being the normal yield).

No doubt larger decreases of temperature could be obtained by using larger surfaces, but there will always be an uncertainty of success in countries where the hygrometric state varies, as it does in the South of France, during the vintage time.

The problem of refrigerating musts is not very complex. There are no insurmountable difficulties, for it is not necessary to get a very low temperature as in the case of beer ; but only to reduce to 27° or 28° C. a vatful which has overreached 32° C.

It is advisable to go slowly and maintain an average temperature in the vat rather than to cool suddenly, for we imagine that a sudden large decrease of temperature can only be injurious to an organized plant such as yeast. If, on the second day after the start, the fermentation has not exceeded 28° C. we can without fear let it go on naturally. The temperature will not become excessive, for by that time the reaction producing the heat is almost all over.

STUDY OF VARIOUS MUST REFRIGERATORS.

The expense of refrigeration of the vintage consists of the sum representing the sinking fund of the machine—10 per cent. of its value—the labour necessary for pumping the water, which varies with local conditions, and the labour for pumping the wine.

The labour is, of course, proportional to the volume treated. It can, therefore, be expressed by a fixed sum per hectolitre. This is very small, but the sinking fund for the machine is so much the greater as the volume of wine treated is smaller.

Suppose, for instance, a cooler costing 1,500 francs (£62 10s.) applied to a vintage of 1,000 hectolitres (22,000 gallons) the operation will be over-estimated from the sinking fund by 15 centimes per hectolitre, while if the instrument is applied to a vintage of 10,000 hectolitres (220,000 gallons) the over-estimation will diminish to 1½ centimes per hectolitre.

In no case, however, will the expense reach the increased value acquired by the refrigerated wine. But it would always be better in dealing with small vintages to buy smaller machines, as these are less complicated and less expensive.

The apparatus of Müntz and Rousseaux is an excellent modification, for vinification, of a device used in other industries, and is actually adopted in many important cellars.*

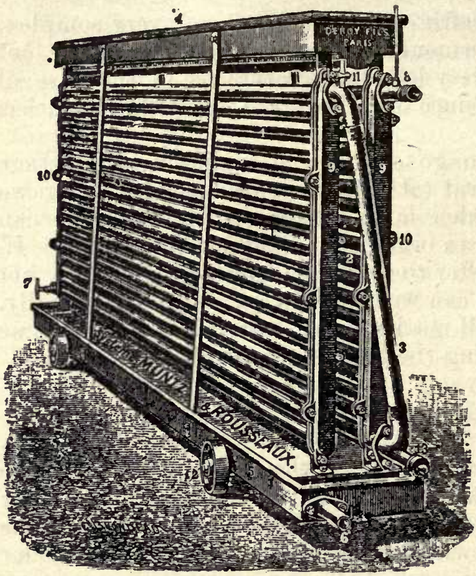


Fig. 21.—Müntz and Rousseaux Refrigerating Apparatus.

It is composed of two parallel series of nineteen tubes superposed. Fig. 21. Each tube is open at both ends and fixed to a vertical plate. A water-tight obturator is fixed on each plate in such a way as to be easily detachable. Communication is established between the tubes in such a manner that the liquid introduced at the bottom passes successively through all the tubes before reaching the top. A tube joins the top of one series to the bottom of the other. A trough with a row of small holes spreads water over the tubes, which are covered with canvas, the water drips over the tubes and falls to the bottom trough.

This apparatus successfully utilizes the cooling effect of the water, as the wine is exposed to a large surface before

* An important work by Müntz and Rousseaux, *Études sur la Vinification et sur la Refrigération des Mouts*, appeared in 1896, and was translated and distributed in pamphlet form amongst Victorian vine-growers in the same year by one of us.—(W.P.W.)

returning to the vat. Each tube measures 4 metres (13 feet) in length and has a diameter of 40 millimetres ($1\frac{1}{2}$ inches).

It is an expensive machine, which does not seem to be altogether suitable for small growers, but it is in its proper place in large cellars.

We made some experiments on other coolers which seem simpler in construction, and of more reasonable price, for the use of small and medium cellars. It goes without saying that we only considered machines capable of being easily cleaned, owing to their shape, and the facility with which they could be taken to pieces.

We tried three systems—one constructed by P. Paul on ideas we exchanged together ; one invented by Rouvière-Huc, and described in the *Progrès Agricole;* and the third simply composed of concentric communicating vessels, invented by P. Andrieu.

The machine designed by Paul and Roos is composed essentially of two concentric tubes, 4 metres in length, of 2 or 3 centimetres in diameter, plunging into a trough of small capacity. Each sheaf of concentric tubes forming an element of the system, the number of the elements varying according to requirements. Fig. 22.

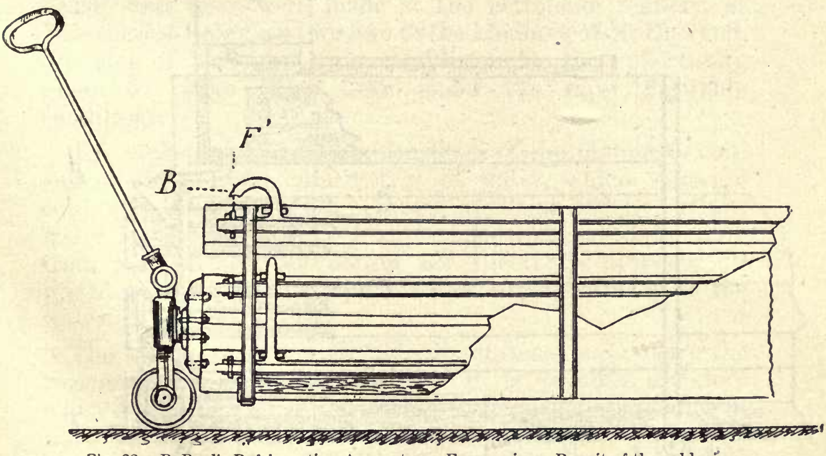


Fig. 22.—P. Paul's Refrigerating Apparatus.—Forecarriage, B, exit of the cold wine.

The wine circulates in the annular space between the inside surface of the outer tube and the outside surface of the inner tube. The water travels in an opposite direction to the wine, first of all passing in the inside tube, acting through the inside surface of the annular space, then in the trough continuing its action on the outside surface.

In a machine composed of several divisions the wine rises from one division to another, while the water descends from one trough to another to be emptied at the last one.

The interior tubes are fixed to the extremities of the exterior tubes by screened discs, fixed in the same way as an ordinary pipe coupling. Tightening the screws at one end of the tubes makes the whole system watertight by compression on rubber rings. The dismantling of the machine for cleaning purposes is simple, and the cleansing is very easily done, as the tubes are straight.

The annular spaces of the two divisions are joined together with flexible rubber hose and fixed by means of a coupling.

Finally, with the view of utilizing ice, which can now be obtained at very small cost, low enough to permit its use, the system has a box attached to the top to contain the ice, over which the heated water is spread and cooled before being used. Fig. 23 and Fig. 24.

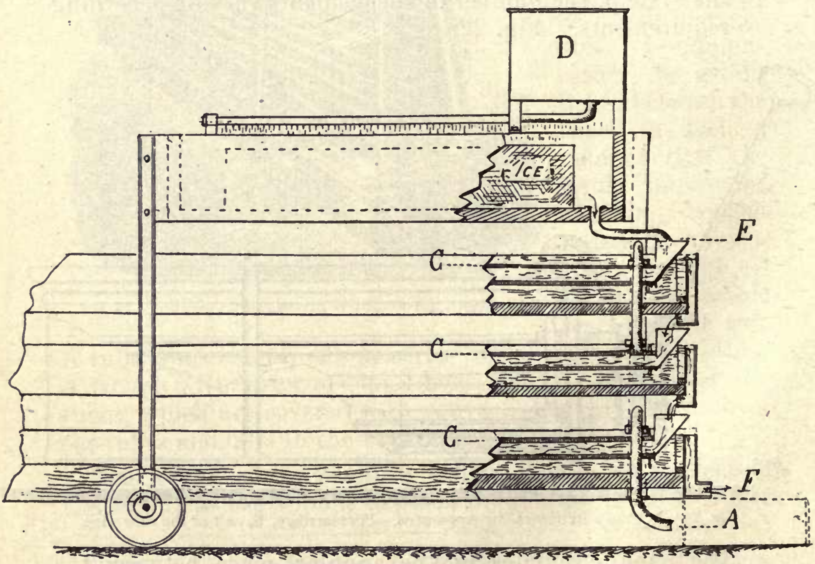


Fig. 23.—P. Paul's Refrigerating Apparatus. - A, entrance of wine to be treated; C, annular space in which the wine circulates; D, water supply; E, entrance of cold water; F, exit of warm water.

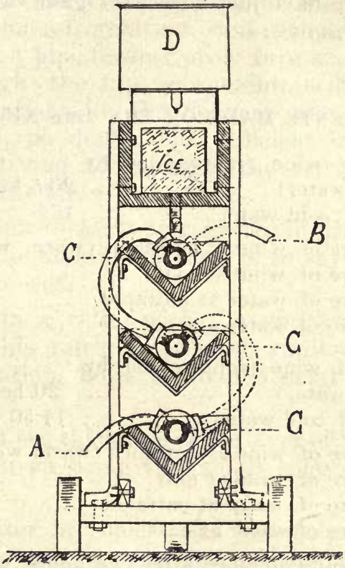


Fig. 24.—Paul's Refrigerating Apparatus.—Section view.

The first tests were made at the petroleum refinery, at Balaruc-les-Bains, and we owe to the kindness of M. Durrand, Director of this important establishment, the opportunity given to make these tests under the most desirable conditions.

The tanks used for the condensation of the petroleum consumed daily 1,000 cubicmetres of water, which, entering cold, flowed out at a temperature of about 50° C. If the water is carefully collected at various distances descending from the surface, we obtain all the temperatures comprised between the entering and exit temperatures of the water.

The tanks are of considerable dimensions, and receive the vapours from enormous boilers. It is possible therefore when distillation is in full swing to remove 20 or 25 hectolitres of water per hour during many hours without the temperature varying 0·5° C., if it is drawn from a constant depth.

These are very favorable conditions for a test of this kind.

The cooler we have just described gave, with water trials, the following results :—

EXPERIMENTS MADE ON THE 22ND AUGUST, 1896.

1. Quantity of wine (represented by warm water)	20·5 hectolitres per hour
Quantity of cold water... ...	15·0 ,, ,,
Temperature of wine at entrance (warm water)	35·9° C.
Temperature of wine at exit ,, ,,	28° C.
Temperature of water at entrance	19° C.
Temperature of water at exit	27° C.
2. Quantity of wine (represented by warm water)	20 hectolitres per hour
Quantity of cold water... ...	14·50 ,, ,,
Temperature of wine at entrance (warm water)	31·75° C.
Temperature of wine at exit ,, ,,	26·3° C.
Temperature of water at entrance	19·0° C.
Temperature of water at exit	25·3° C.

(Results obtained after two hours' work.)

A trial was made the following day, starting (as an experiment) with a higher temperature for the wine entering.

The quantity delivered was in one case 20·50 hectolitres for the wine and 14·50 hectolitres for the water.

1. Temperature of wine at entrance (warm water)	35·5° C.
Temperature of wine at exit	28·0° C.
Temperature of water at entrance	18·2° C.
Temperature of water at exit	28·2° C.
2. Temperature of wine at entrance (warm water)	39·5° C.
Temperature of wine at exit	31·0° C.
Temperature of water at entrance	18·5° C.
Temperature of water at exit	31·0° C.

(Results obtained after two hours' work.)

In all these trials the quantity of warm water used, representing the wine, was measured with great exactitude. The machine was fed from a tank the level of which was constant. The syphon supplying the refrigerator yielded less than the tank received.

It was, unfortunately, not possible to measure so exactly the water used for refrigerating, as it was drawn from a tap branching from a pipe feeding other taps at the same time, so that although the tap was maintained at a constant aperture, fluctuations in the delivery of water may have occurred, small, no doubt, but sufficient however to prevent us from trying to estimate the refrigerating action attributable to the air.

The measurements for water given in the above tables were made at the maximum, that is to say, when the pipe only fed the tap used.

When tried in a cellar with the vintage fermenting in wooden vats, this refrigerator gave similar results. We must draw attention, however, to a special feature of this machine.

On account of the thickness of the layer of wine circulating in the annular space being very small there is great danger of obstruction.

The refrigerator or cooler used had tubes, whose radius differed only by one centimetre. Although the machine worked well for a few hours we consider this difference is too small and should be doubled.

It is necessary to introduce into the cooler must free from solid suspended matters, such as skins, &c.

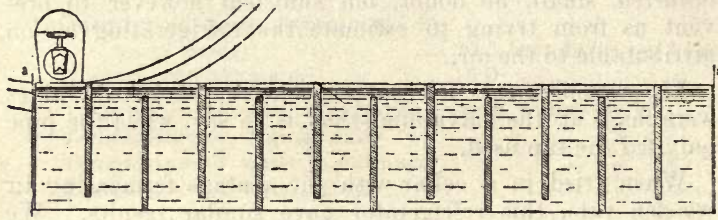
It should be used as follows :—

The must coming from the vat to be refrigerated, falls into a tub divided into two compartments by a vertical partition of wire gauze.

In the compartment opposite to that receiving the must from the vat, a tube is plunged connected with the bottom of the refrigerator, the suction tube of the pump being connected with the exit at the top of the refrigerator forcing the cool must into the vat again. Worked in this way no obstruction can take place, and the machine may work from 250 to 300 hectolitres of must without being cleaned.

The work done by this cooler is naturally a function of the number of divisions of which it consists. Six divisions will suffice for a delivery of 40 hectolitres per hour, with a decrease of temperature similar to that observed in the above experiments.

The second cooler experimented with is due to Rouvière Huc, a well-known vine-grower of the environs of Montpellier. It is especially suitable for small growers, is cheap, and may be constructed by any plumber. These are appreciable advantages.



Apparatus opened out.

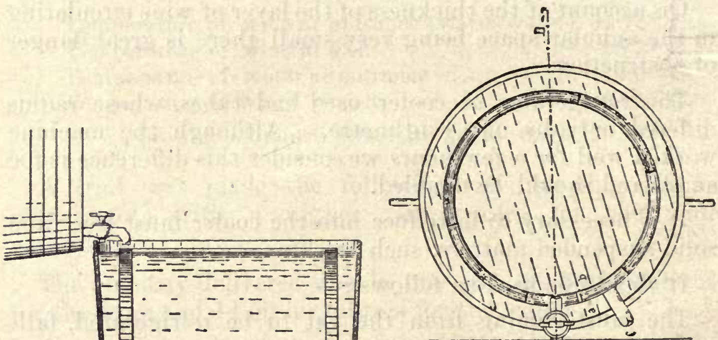


Fig. 25.—Rouvière-Huc's Refrigerating Apparatus.

The refrigeration is effected by forcing the wine through an annular space, limited by the metallic walls of two concentric cylinders. The whole system is immersed in a tank, traversed by a constantly circulating current of cold water.

The annular space is partitioned by projecting metallic plates, alternately overlapping, and forcing the wine to travel alternately from the top to the bottom of the machine.

The model tried at Balaruc-les-Bains did not give good results, the installation was defective, and did not allow an equitable judgment; however, the trial enabled us to point out a few weak points of the machine which enabled Rouvière-Huc to make additional improvements before the vintage. These, although imperfect, permitted him to carry on further trials in 1896.

He has been kind enough to communicate the figures obtained, which are very satisfactory.

1st hour	Temperature of wine entering	...	32·0° C.
	Temperature of wine at exit	...	25·0° C.
2nd hour	Temperature of wine entering	...	30·5° C.
	Temperature of wine at exit	...	25·0° C.
3rd hour	Temperature of wine entering	...	29·5° C.
	Temperature of wine at exit	...	24·5° C.
4th hour	Temperature of wine entering	...	28·5° C.
	Temperature of wine at exit	...	24·0° C.

These are for deliveries of wine and water respectively of 18 and 8 hectolitres only, operating on a fermenting vat of 150 hectolitres.

During the fifth hour, the must at entry being below 28° C., the operation was stopped.

The water pumped from a deep well, had a temperature of 15·5° C. at entrance, and an average of 24° C. at the exit.

Thirty-two hectolitres of water were used during the four hours, and absorbed about 27,000 calories from the wine in the vat.

The wine in the vat was reduced after the four hours' circulation to 28° C., which is a most satisfactory temperature.

These are very good results, and no doubt Rouvière's cooler will become a practical machine, when a few additional improvements in its construction render its working more convenient.

In spite of the results observed one should use the water in a more systematic way, as the working of the machine could only be improved thereby.

The third cooler experimented upon is due to Andrieu. The principle it is based on differs from the above in this, that it utilizes the refrigerating power of both air and water.

The machine has a surface of action much more considerable than the preceding. The wine circulates, as shown in Fig. 26, in an annular space, limited by two vertical cylindrical metallic walls, one in contact with water the other in contact with air.

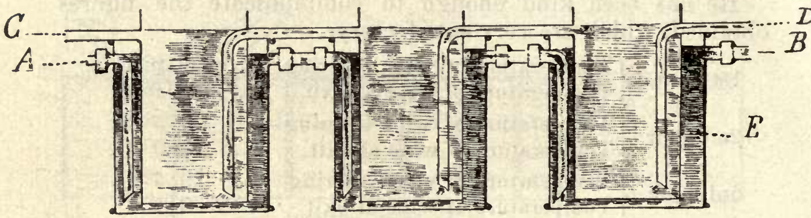


Fig. 26.—Andrieux Refrigerating Apparatus.—A, entrance of wine to be treated; B, exit of cold wine; D, entrance of cold water; C, exit of warm water; E, annular space in which the wine circulates.

It is composed of concentric vats similar to the Toutée metallic vats, the inside vat containing water, and that on the outside the wine to be cooled. The circulation of the liquids is in opposite directions both from bottom to top.

In this particular instance the outside vats were made of sheet iron covered inside with a varnish unaffected by the wine. They measured 1·18 metres in height and 0·82 metres in diameter; the inside tank was made of tin, 1·20 metre high and 0·63 metre diameter.

The inside vessel is arranged in such a way that its surface is at a constant distance of 9½ centimetres from that of the outside vessel, both at the sides and bottom.

It is evident that this machine has a very large surface for action, for each division has about 3½ square metres of available cooling surface, or 16½ square metres for the three divisions, while the three divisions of Paul's cooler have only 3½ square metres. Again, one should add, to Andrieu's machine, the surfaces at the bottom which also bring their contingent of cooling effect.

The results obtained with this device were very satisfactory. The decreases of temperature observed were confined between 4° and 10° C., according to the initial temperature of the wine entering (between 28° and 37° C.) for deliveries of wine and water comparable to those of Paul's cooler, that is to say, 1½ hectolitres of water for 2 hectolitres of wine.

Here are the figures relating to the two experiments—

1.	Quantity of wine	16·6 hectolitres per hour.	
	Quantity of water ...	13·6 ,, ,,	
	Temperature of wine at entrance	28·2° C.	Temperature of the air during the experiment, 20° C.
	Temperature of wine at exit	23·7° C.	
	Temperature of water at entrance	18·2° C.	
	Temperature of water at exit	22 0° C.	
2.	Quantity of wine	13·5 hectolitres per hour.	
	Quantity of water ...	8·64 ,, ,,	
	Temperature of wine at entrance	38·8° C.	Temperature of the air during the experiment, 20° C.
	Temperature of wine at exit	28·0° C.	
	Temperature of water at entrance	18·5° C.	
	Temperature of water at exit	28·5° C.	

(Results obtained after two hours' work.)

Considering the dimensions of the machine the delivery is small. We would have preferred making experiments with larger quantities, but this was not possible, as the section of the exit tubes did not allow a delivery exceeding 16 or 17 hectolitres.

The results are excellent, the only drawback being that the machine is cumbersome.

It has the advantage of not being liable to become obstructed, and the divisions or tanks may be used when the vintage is over in various useful ways—storage of wine, &c.

The outside vessels hold about 600 litres, the inside ones about 360 litres.

Vine-growers, therefore, are only embarrassed in choosing a cooler, for apart from those we have described, rather at length, there are a great many others in existence which might prove useful in a number of special cases. *Vine-growers should convince themselves of the fact, uncontrovertible at present, that the maintenance of fermentation at a temperature near* 30° *C. is a powerful factor in improving the quality of the resulting wines, and they must, therefore, make every effort to attain that desirable result.*

METHOD OF TAKING THE TEMPERATURE OF A FERMENTING VAT.

With or without refrigeration, it is always of great interest to the wine-maker, to know the temperature of the vats during fermentation, even if only to follow it and make the wine systematically. This is done by the use of thermometers, arranged in a more or less convenient manner.

It is well to know, to start with, that the temperature varies in different parts of the vat when it is full of vintage in fermentation. It is generally low at the bottom and high at the top, the average temperature being found towards the middle of the liquid zone, below the head or mass of floating marc. It is, therefore, at that point that the temperature should be taken if we desire to know the average.

The simplest way is to use an ordinary hand thermometer, graduated on the stem, placed in a groove made at the end of a piece of wood pointed at the end. The piece of wood with the attached thermometer is pushed below the marc to the required depth, and kept submerged in the liquid for a length of time sufficient to allow the thermometer to reach the temperature of the surrounding liquid.

This method is simple, but the observations are difficult, and not very exact. When an ordinary thermometer, arranged as described above, is used, and the thermometer is drawn out, it passes through cooler surroundings, which reduce the reading on the thermometer too quickly to allow an accurate reading being obtained.

It is preferable, when an ordinary thermometer is used, to choose one not too sensitive, that is to say, with a large bulb and large bore. It will be necessary to leave it for some time in contact with the liquid to attain its temperature, but it will keep that temperature longer after removal and facilitate the reading.

Alcohol thermometers are, all things being equal, better than mercurial thermometers for this operation.

Maximum thermometers, that is to say, those recording the indication of the highest temperature to which they have been submitted, are preferable. Very accurate and sensitive thermometers of this kind are made of the same shape as an ordinary thermometer.

A process much in vogue, allowing the use of any thermometer, consists in drawing from the vat a bucketful of the must to be examined; the temperature remains constant long enough to allow an accurate reading to be taken. This would be an excellent method if the liquid was taken from the centre of the vat, but being drawn from the bottom, it more often than not indicates too low a temperature. Thermometers with stems bent at right angles may be found in commerce; the bulb is introduced into the the vat or cask at the required height, the stem standing vertically against the outside wall. Fig. 27. The indications are good in this case if the bulb penetrates far enough into the vat. Unfortunately, the bulb does not generally protrude very far into the vat, so as to provide against breakage, likely to occur through the mass of marc moving suddenly under the influence of the liberated carbonic acid gas.

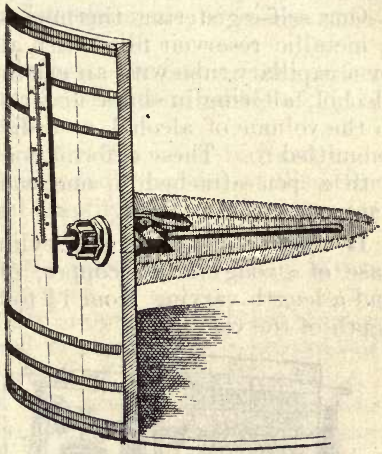


Fig. 27.

However, the taking of the temperature in any case is a very delicate operation, and for this reason Houdaille and myself have invented an instrument which is easy to use, and automatically registers the results.

Self-registering Thermometer of Houdaille and Roos.— In devising, in conjunction with Houdaille, the self-registering thermometer, which we will now describe, we aimed at placing in the hands of wine-makers an instrument for observation and control, which dispenses with the taking of temperatures, and gives for each fermentation a record, the importance of which will soon be appreciated.

The object is to have an instrument recording automatically, at any hour of the day or night, exact indications in a convenient form for observation. It should be of sufficiently strong construction to be handled by workmen in the cellar without danger of breaking, and capable of being introduced or removed from the vat without difficulty; of simple manipulation, and requiring no special knowledge; not inconveniencing the operations connected with wine-making; and, finally, not too costly.

To our knowledge, no thermometers answering all these conditions were in existence previously, and we think that our invention will give satisfaction in each of these respects.

Our self-registering thermometer consists essentially of a metallic reservoir filled with alcohol and communicating by a capillary tube with an elastic reservoir filled also with alcohol, altering in shape under the influence of the change in the volume of alcohol, according to the temperature it is submitted to. These deformations are amplified by a lever with a pen attached to one end, used for registering the temperatures.

It consists of a projecting cylindrical tube, with a conical base of strong tinned copper, of a diameter of 30 m.m., and a length varying from 1½ to 2 metres, according to the depth of the vat.*

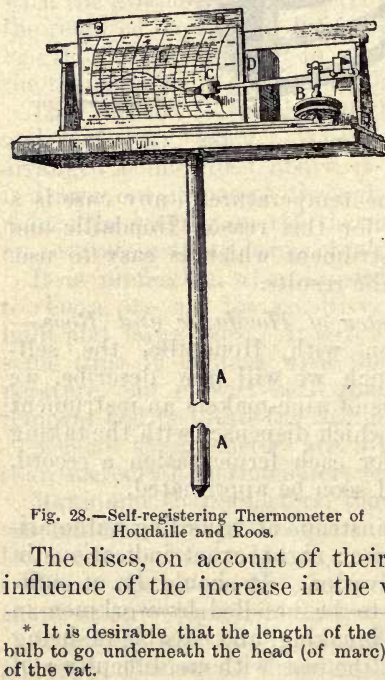


Fig. 28.—Self-registering Thermometer of Houdaille and Roos.

This protecting tube can be dismounted in two parts, joined by a coupling to facilitate cleaning; it contains the bulb and capillary tube joining it to the receiver (Fig. 28), fixed on a solid wooden support. The receiver is composed of two discs with concentric undulations, soldered on their outside edge, slightly dished, and communicating with the thermometer bulb through the capillary tube.

The whole system is filled with alcohol, air or gas being carefully excluded.

The discs, on account of their elasticity, swell under the influence of the increase in the volume of alcohol when the

* It is desirable that the length of the thermometer be such as to allow the bulb to go underneath the head (of marc), that is to say, about half the depth of the vat.

temperature rises, and contract when the temperature falls, on account of their own elasticity as well as the atmospheric pressure.

The cylindrical thermometer bulb is made of thin copper, and contains about 200 cubic centimetres of alcohol. Its length is 60 centimetres; it presents, therefore, a sufficiently large surface for exchange of temperature, to insure sensitiveness.

The *sine quâ non* of effectiveness consists in the perfect filling of the instrument, as the slightest bubble of air or gas would falsify the indications.

Near the receiver a support for the lever is fixed, connected by one end to the discs, and provided at the other with a pen for registering and amplifying the expansions or contractions of the discs.

The registration is made on a sheet *ad hoc*, which is displaced before the pen by clock-work.

Contrary to what is generally adopted in self-registering instruments, we have preferred to register the indications of the instrument on a plane, instead of a cylindrical surface.

This arrangement allows the reading of the complete record to be made at a glance, and facilitates the changing of the recording sheets. We have simply transformed the circular movement of a pinion to a rectilinear movement, by engaging it with a toothed rack, instead of a cog-wheel.

This toothed rack is fixed in the front part of the brass plate supporting the recording sheet.

The clock-work is sufficient for one week's continuous record, and insures, therefore, the working of the apparatus during the whole time of an ordinary fermentation. The anchor, or cylindrical escapement, allows its working in any position, and does not necessitate the apparatus being fixed vertically.

The instrument, as above described, is easily handled, and transportable. It has been carried great distances without special care, and without damage. It may be carried on the shoulder (like a gun), but weighs much less.

We have no doubt that this instrument will render great service to those who desire to follow or supervise their fermentations, and keep them between recognised limits.

The form of the curve will show at a glance if the temperature rises too quickly, and if it is necessary to refrigerate. The reading of the curve recorded during the hours when direct supervising might have been defective, will give the course of fermentation during that time, and the proprietor may readily control with it the execution of his orders, and by ultimately comparing the records of each vat, and the wines resulting from them, get valuable documents on the influence of temperature on fermentations and qualities of wines.

This self-registering thermometer, although very recently invented, has been improved in many details, rendering it stronger and more symmetrical.

FERMENTING HOUSE.

The vintage coming from the crusher reaches directly, after travelling a variable distance, the vessels where fermentation is to be effected.

The building in which the fermentation is effected is called the fermenting house. There is nowadays a great tendency to isolate the fermenting house from the storage or maturing cellar. This arrangement exists in all newly-built cellars, but is not an indispensable condition for success.

Contrary to general opinion, the fermenting house must be very well ventilated, open freely to all winds, and constantly swept by draughts.

Many think that it is better to use underground cellars for fermenting because they are always cool during hot days.

This is an error pointed out by Toutée, the inventor of the metallic vat, in the following humorous story—

"I saw the cellar of a large grower, in a hot climate, in course of construction. This grower desired to neglect nothing in order to make it a success, addressing an architect in the following way:—'I want to make wine in ——— where the temperature is rather troublesome, how can I protect the vats from that temperature?' 'Very simply,' answered the architect; 'begin by sheltering the ground against the solar rays by means of a shed, then excavate the shaded ground, and cover the excavation with masonry vaults, one metre thick, throw over the arches two metres thick of soil, and I guarantee the interior will remain unaffected by exterior temperatures. My charge is so much per square metre excavation, and so much per cubic metre masonry.'"

"The question is put in the same terms and solved in quite as smart a way by the vat maker, who says—'To shelter your musts against the sun and hot wind, isolate them in a non-conducting envelope.'

"Walls of oak (heart wood) 7 to 9 centimetres thick, that is how I make vats, they are sold by weight.

"Premises and vessels cost the bagatelle of £50,000.

"Well, imagine the stupefaction of our friend, when, entering his cellar with me, he noticed that the average temperature in Algeria being 29° C. on the 1st of September the thermometer showed 41° C. in his cellar.

"And I say *in his cellar*, for his musts were at a much higher temperature. When the poor man made up his mind to take the temperature of his musts by an original method, he found the testing glass in the laboratory recorded 49° C. after ten minutes waiting and various transversations which had made it lose some 4° or 5°.

"It is that the source of the greater heat is not at the exterior of the cellar, but rather in the interior of the vats, and he had obtained a result all the more worthy of compassion, inasmuch as he had taken every precaution to prevent all exchange of temperature between the interior and the exterior. Thanks to the £50,000 spent, the must was keeping all the heat developed by the fermentation."

Under this pleasant form the above account shows perfectly the inconvenience and dangers of a badly ventilated fermenting house. We advise, therefore, especially small growers, having cellars in town or village, too frequently poorly ventilated, to give up fermenting in cellars. Let the musts ferment outside under a tree or shed, just sufficient to protect the vat from the direct rays of the sun. Let them try only, and the results obtained will convince them better than any argument of the benefit they will gain by adopting this modification.

FERMENTING VESSELS.

The vinous fermentation, already briefly described in the first part of this work, is a complex phenomenon capable of being influenced by numerous causes. Some even assert that

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* Hipp. Lecq. *De la Fermentation des mouts de Vin à Temperature basse par l'Emploi des Cuves Metalliques.* Alger. Imprimerie Orientale, Pierre Fontana et Cie, 29 rue d'Orleans, 1894.

it is influenced by the shape of the vessel or the nature of the materials the vessels are made of.

In fact, this influence as well as that of the mass is rather indirect. There are a number of conditions to be realized for fermentation to start well and continue in a satisfactory manner, guarded against alterations liable to occur from parasitic fermentations; but, those conditions once realized, it is unimportant whether it takes place in wood, stone, brick, cement, wrought or cast iron.

The vessels usually used for fermenting are—

Wooden vats, conic frustrum shape, open or not at the top.

Stone vats, generally cubic in shape, open or not, coated or otherwise, with varnish or glazed tiles.

Brick vats, generally cylindrical in shape, much used in Algeria under the name of amphoræ.

The vats recently devised, but already much used, of sidero-cement; that is to say, built of a network of interlacing round iron, about $\frac{1}{4}$ inch in diameter, with a mesh of about 2 inches, sunk into a thickness of 2 or 3 inches of cement. They vary greatly in shape.

Toutée strongly advocates the use of iron vats, usually cylindrical, for hot regions.

Finally, ordinary casks used generally in all viticultural regions for storage.

The capacity of the fermenting vessels varies considerably.

Whatever their shape is, and whatever material they are made of, the vat will suit for fermenting purposes, provided its interior surface be inert, or incapable of producing alterations in the taste or chemical composition of the must.

The vats of masonry or sidero-cement cannot be used without preliminary preparation, but must be purified, with the object of preventing the possibility of their acting on the must.

The various lime compounds, which always exist in mortar or cement, have an unfavorable influence on wine, and must therefore be eliminated.

This result is easily attained by washing the inside walls with a solution of sulphuric acid, followed by a coating of silicate of potash, which,* when once dry, is quite unattacked by wine, and has the advantage also of rendering the walls impermeable.

* Sulphuric acid of 10 per cent. strength and two coatings of a 25 or 30 per cent. solution of silicate of potash.

The iron, too, remaining in contact with the wine would give it a styptic very disagreeable taste, and even modify the wine so much as to render its conservation impossible. It is absolutely necessary that the whole of the internal surface of the vats should be covered with an impervious coating without action on the wine.

FERMENTATION.

If we assume that the physical and chemical conditions of the vintage are suitable, those remaining to be fulfilled for fermentation to take place under good conditions and for the wine to possess its maximum of quality are :—

First—Management of the vintage so that the marc be not submitted to alterations through contact with the air.

Second—The drainage of the solid parts of the berry and the marc, obtained by special distribution of the marc in the midst of the liquid or by its lixiviation.

If fermentation is left to itself without preliminary precautions, the stalks and skins forming the marc, although at first sunk in the midst of the liquid, agglomerate little by little, and being lifted by the carbonic acid gas rise to the surface.

It is this agglomeration of the solid parts of the grapes which constitutes the *head*, and a fermentation is said to have a *floating head* when no special arrangement is made to maintain the marc below the surface, and is said to have a *submerged head* in the opposite case. They are called *multiple submerged heads* when the marc is subdivided into several parts.

Generally speaking, the floating head is inferior to the submerged head method, the reasons for the superiority of the latter are of two kinds—the marc of submerged head fermentations is always perfectly protected from contact with the atmosphere, and by its arrangement becomes thoroughly extracted by the liquid, while that of a floating head fermentation is, so to speak, completely in contact with the air in open vats, and is only partly exhausted by the liquid.

The action of air on the marc is injurious, even if a quantity of carbonic acid is present. In fermentations where the marc is not at all in contact with the air, volatile acids, especially acetic acid, which characterize defective fermentation, are never produced, while they are always found in the opposite case.

Pollacci determined these facts by experiments, which consisted in following day by day, and hour by hour, two fermentations conducted side by side, according to each method. To strengthen what has been already said we will quote the results of Pollacci's experiments.

POLLACCI'S EXPERIMENTS.

Fermentations made in glass cylindrical vessels, closed by means of a glass plate, slightly lifted by a cardboard band supported on the edge of the vessels.

Fermentation with floating head.	*Fermentation with submerged head.*
Second Day—Evening.	
Fermentation has begun, the space above the head still contains air, for a candle burns in it. The head shows a few moulds, and smell of acetic acid is noticeable.	Fermentation in full activity. No trace of moulds or acetic acid.
Third Day—Morning.	
Lighted candle still burns. More moulds, and acetic acid smell more pronounced.	A lighted candle extinguished when placed in space above head. No moulds, no acetic acid.
Third Day—Evening.	
Lighted candle extinguished. Moulds still increasing. Acetic acid can be detected by analysis in the liquid surrounding the marc. The head was rammed down.	Candle still becomes extinguished. No moulds, no acetic acid.
Fourth Day.	
Same as last. The liquid still contains 140 grammes of sugar per litre. Acetic acid smell not noticed after ramming the head.	Same as last. The liquid contains only 40 grammes of sugar per litre.

Fifth Day.

Same as last. Head rammed.	Fermentation continues active.

Sixth Day.

Same as last.	Fermentation diminishing.

Seventh Day.

Same as last.	Fermentation almost finished.

Eighth Day.

Fermentation continues. The liquid still contains 35 grammes of sugar per litre.	Fermentation ended. The liquid is clear, cold, and only contains 0·80 grammes of sugar per litre.

As has been already mentioned, the opening at the top of the glass vessel was very small. It was, however, sufficient to allow the access of air in such proportion as to permit the development of germs, such as *mycoderma aceti*.

With the method of keeping the marc out of direct contact with the air, the fermentation is healthier, quicker, and more complete. With a submerged head, even with the must in contact with the air, the moulds and *mycoderma aceti* germs do not develop, as they do not find a suitable resting place, or because the movements of the liquid constantly wet them, and prevent the direct action of the air.

Is there not an evident benefit in submerging the head? For, as has been already said, the suppression of secondary fermentation corresponds to the improvement of the vinous fermentation.

The interference of the air is not always injurious, being sometimes very useful; but, as far as the marc is concerned, it is always dangerous, except, however, before the start of the fermentation after crushing.

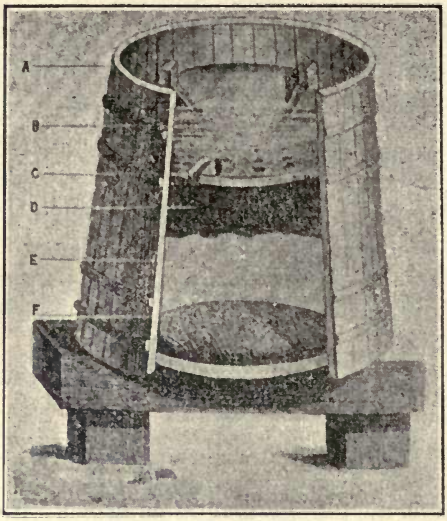

Fig. 29.—Fermentation with Submerged Head.

The distinction is therefore well established in favour of fermentations in which the marc is completely out of contact with the air.

The immersion, or submersion of the marc, in single or multiple heads is obtained by simple devices, the following (Figs. 29 and 30) show plainly how the problem can be solved. The arrangement of multiple heads as proposed by Michel Perret dispenses with the racking of the must for the establishment of the false head, but the results given are not better than those obtained with a single head. The application of the Perret method is very tedious. It is necessary to place several false heads in position, and the waste of time is greater than the simple racking as in the previous case.

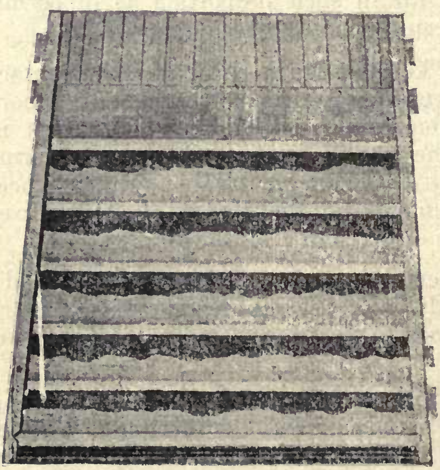

Fig. 30.—Fermentation with Multiple Submerged Heads.

We will quote as an ingenious modification of the submerged head system that devised by Coste-Floret, which consists of two vertical partitions dividing the vat. Fig. 31 very clearly and intelligibly shows it, and dispenses with a detailed description.

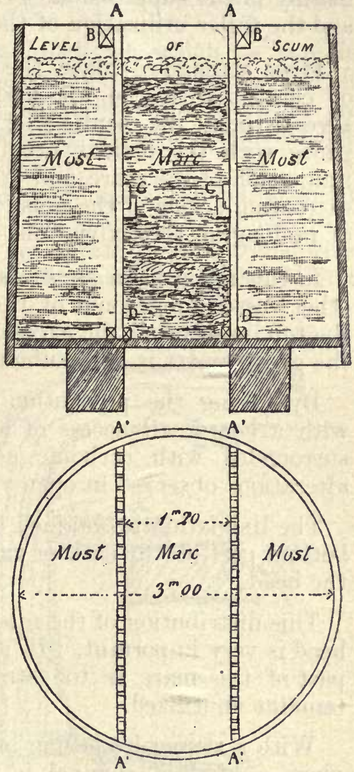

Fig. 31.—Coste-Floret's arrangement.

With the Coste-Floret method important advantages are evident, but we also notice some slight defects—the marc will always rise up a little and float, and will always be, though on a very small surface, in contact with the air. This is a defect, but it may easily be remedied by fixing a small false head horizontally of the same size as the marc chamber, preventing the marc from rising above the liquid.

We do not agree with Coste-Floret, that lixiviation of the marc results from forcing the must to pass through from one compartment to the other.

In fact, even if the marc can be prevented from rising, it is not possible to prevent a certain free space forming between the marc and the bottom of the vat. Therefore, when the must is made to pass from one side to the other, the liquid will naturally travel along the line of least resistance, and consequently pass below the marc without percolating through it.

We do not see the necessity for lixiviation in the case of submerged fermentation, and *a fortiori* in the Coste-Floret system. In both cases the surfaces of contact of the must and marc are quite sufficient to allow the latter to give to the wine all the useful principles it contains.

The advantages of submerged head fermentation lie mainly in the suppression of the injurious action of the air, and the fuller utilization of the solid parts of the grape.

If we manage to place the marc (although floating) out of contact with the air, and lixiviate it with the must several times, the results will be quite as good, and will dispense with the tedious manipulations connected with the immersion of the marc, and we will always be able to stop the extracting action of the must when necessary, by shortening or prolonging the lixiviation.

In this respect the use of large casks is preferable to any other vessel, on account of their special shape, narrower on the top, preventing the excessive rising of the marc, so that the greater part is kept submerged.

By taking the precaution of covering the top opening with a board, all access of air is prevented, and the marc surrounded with carbonic acid gas is not liable to the alterations observed in open vats.

The lixiviation is obtained by pumping the must from the bottom part of the cask or vat to the top, spreading it over the head.

This distribution of the must over the whole surface of the head is very important. If it is not done carefully a small part of the marc is too strongly extracted, while the rest remains unutilized.

With a strong jet falling on the head always in the same place, a kind of channel is formed in the marc, through which the must reaches the bottom of the head without distributing through it, and therefore without exerting a solvent action in its passage.

The proper distribution of the must is easily effected by the use of several little devices, amongst which may be mentioned the hydraulic swivel, and the break jet, which are now used by many wine-makers.

The hydraulic swivel consists of a box around which tubes are arranged horizontally like the spokes of a wheel, and bent almost to right angles in the same direction. The box revolves on a pivot when filled with liquid, on account of the hydrostatic thrust exerted by the jets of liquid. The adaption of the swivel to the distribution of the must presented several difficulties. These have been successfully overcome by P. Paul.

Much more simple is the break jet, which we have invented for use with a machine automatically distributing the must over the head, and which will be described later on; although simple, it works perfectly, without inconveniences of any kind.

The principle consists in placing under the jet, normally to it, and at a small distance from the opening of the tap a disc (Fig. 32) on which the jet breaks, and is transformed into a circle of a diameter varying according to the form of the jet.

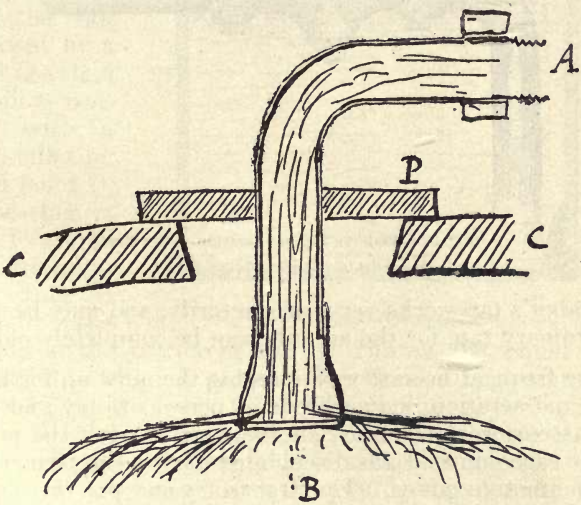

Fig. 32.—Break Jet.

The jet from a pump is not quite continuous, or does not possess the same force constantly, whatever pump is used. The result is, that the breaking of the vertical jet on the horizontal disc will spread in a very large rose while the pump is forcing, and in a small one when the pump is sucking, and therefore the whole of the marc will be sprayed.

The operation of spreading the must over the head is generally done with a pump—any pump may be used—coupled on the valve of the cask, if it is not desired to aerate at the same time. If it is considered necessary to aerate the must before pumping it over the head, it is necessary to allow it to fall into a tub placed under the vat, so that it comes in contact with the air.

To facilitate the aeration Trabut invented a tap (Fig. 33) by which air is introduced into the liquid jet in any quantity required.

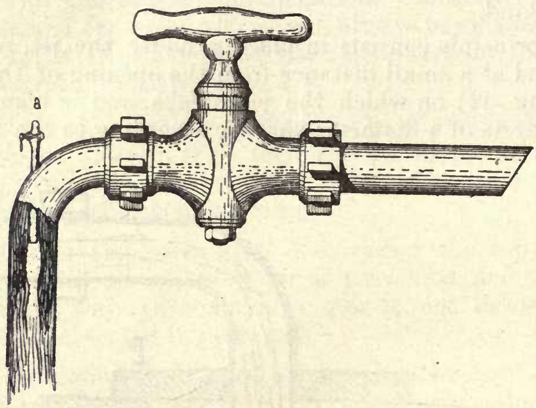

Fig. 33.—Trabut's Tap for Aeration of the Must.
a.—Tube to regulate admission of air.

Trabut's tap works very satisfactorily, and may be used as an ordinary tap, for the air tube can be completely closed.

The frequent necessity of pumping the must up for lixiviation and aeration, induced several persons to try and obtain the ascension of the must automatically, using the pressure of the carbonic acid gas disengaged during the fermentation for the motive power. The first to try and put the idea into practice was Victor Cambon. The machine he devised has been described in the *Progrès Agricole*,* from which we take the following extract:—

"The machine invented avoids the inconveniences of floating head fermentation.

"It may be arranged in various ways, but the vat requires to be hermetically closed.

"In the top a manhole is placed for the introduction of the vintage, which should be easily closed hermetically.

* *Progrès Agricole et Viticole.* 2nd August, 1891.

"This being arranged, the following is one of the methods that may be adopted :—

"On the top of the vat (Fig. 34) is placed a small wooden tank R of a capacity of about one-twentieth that of the vat. A tube T is placed in the bottom of the tank, communicating with the top of the vat, and closed by a valve S, the stem of which is connected with a lever oscillating round a point O; and bearing a floater F at the other extremity. A long tube U starting from the bung-hole at the bottom of the vat throws the liquid into the tank R, a sieve P prevents any skins, &c., getting into the tube U, the vat being filled with the vintage through the manhole H. It is then closed, and fermentation starts, the carbonic acid gas not being able to escape compresses upon the must and marc and forces it upwards through the tube V into the tank R. When the liquid reaches the height of the floater F the floater lifts the valve S, the must in the tank falls into the vat, and the carbonic acid gas escapes and bubbles through it. At the same time the tube U ceases to run, the floater sinks and closes the valve, and the same operation goes on again."

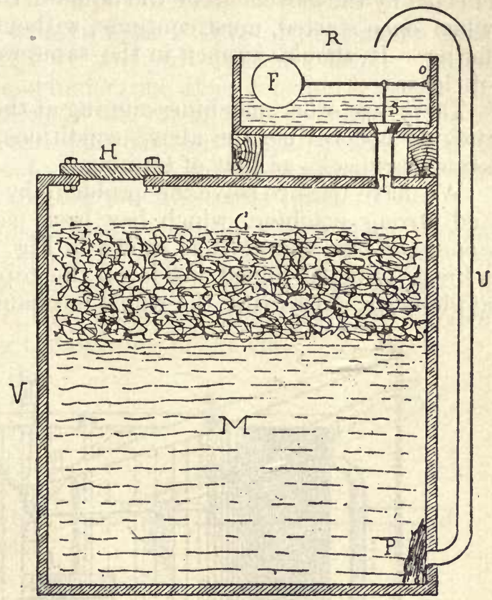

Fig. 34.—Cambon's Arrangement.

Cambon obtained good results with this apparatus, but it has several defects which we have tried to overcome and will now point out.

In such a machine the orifice through which the gas is liberated should be independent of that through which the liquid enters the vat. We must also determine a sudden and complete opening of the two orifices, which should be effected by the movement of the liquid in the tank, but which, when once started, must continue, without the liquid interfering. It should happen in the same way for the closing of the valve.

There are other machines aiming at the same object, but they do not realize the above conditions, and present the same drawbacks as that of Cambon.

We have tried to solve the problem by means of a simple and strong machine, which has been named *fermentation auto-regulator*, arranged as shown in Fig. 35. It consists of a brass cylinder tinned inside, on the top of which rest two angle-irons, supporting the whole mechanism.

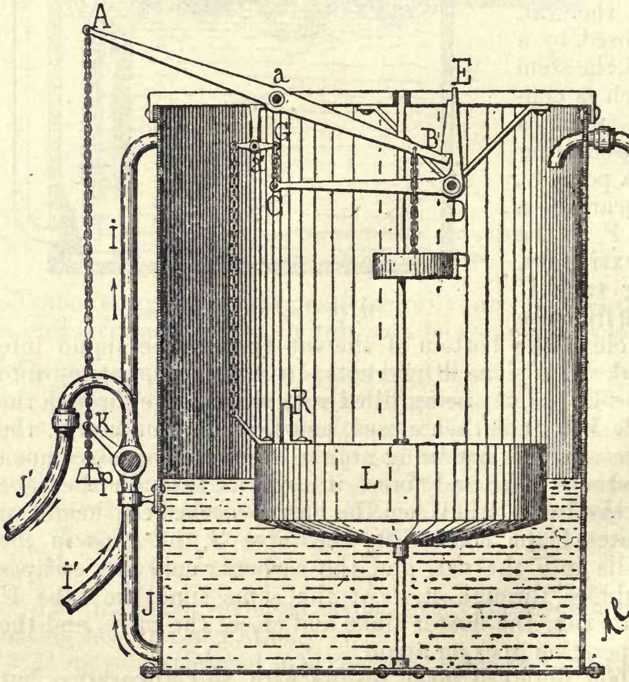

Fig. 35.—Fermentation Auto-regulator.

This simple mechanism consists of—

First—A straight lever A B, which is called the principal lever, revolving round a horizontal axis A.

Second—A lever bent at a right angle C D E, revolving round a horizontal axle D and having two notches, on the vertical arm D E, we will call this piece double catch.

Third—A small straight lever F G revolving round a horizontal axis A which we will call auxiliary lever. Three tubes open into the cylinder, one H is constantly open. It starts from the bottom of the vat and opens into the top of the cylinder. This tube may have any shape—that of a worm surrounded with cold water, or of any other system of cooler if it is desired to refrigerate at the same time.

The other two tubes provided with taps start one I I^1 from the top of the cylinder, the other J J^1 from the bottom. To reach one directly, the other after forming an elbow, the opening of the vat U. They are adjusted in the wooden door, tightly fitting the opening of the vat.

Fig. 36 shows the arrangement of the three tubes and the machine on the platform above the vat. The tube H being too long has been passed around a hogshead.

A glance at the two figures will enable us to see readily the working of the machine.

The principal lever is connected at its extremity A, by means of chains to the taps K, and a weight P, sufficient to overcome the resistance of the opening. At the other extremity B, of the lever, is a counterpoise P, calculated to overcome at the right moment double the resistance of the weight suspended to the taps, and the friction. All the different parts of the machine are worked at definite intervals by the displacement of a floater L, along a vertical rod, in the following manner :—

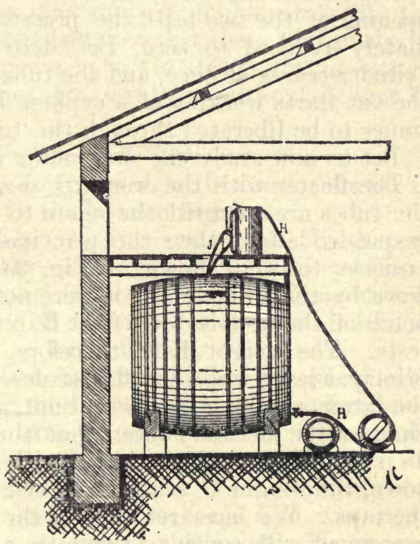

Fig. 36.—Arrangement of Auto-regulator on the Vat.

The machine being placed over a vat, as shown in Fig. 35, and the vat being hermetically closed, except at the bottom tap, which is always kept open, the pressure of the carbonic acid gas forces the must through the tube into the cylinder. The result of this effusion of must is to raise the floater L. As follows from Fig. 34, when the floater reaches the weight P it will stop a moment, and as it has an upward pressure greater than the weight P the floater continues to rise until equilibrium is established, releasing the principal lever from the weight P.

However, the lever will not move for it is kept in position by the lower notch of the double lever C D E.

The ascent of the floater and the weight P continues till the release R touches the horizontal bar C D of the double lever, displacing it around its axis D, freeing the principal lever, which rocks and is drawn down by the weight P suspended to the taps.

The result of this rocking is the complete and simultaneous opening of the two taps, the pressure in the vat is immediately reduced to zero, the delivery of liquid into the cylinder ceases at once, and the tube returning the liquid to the vat starts working as a syphon J J^1, while the gas continues to be liberated through the tube I I^1.

Let us now study the descending movement of the floater.

The floater with the weight P descends from the moment the tubes are open till the chain to which the weight P is suspended is taut, then the principal lever is in an inverse position to that shown in Fig. 34, and would be drawn down by the weight P if it were not held up by the upper notch of the double lever C D E, on which its extremity B rests. The weight P is, therefore, only suspended to the principal lever while the floater descends. It is only when the latter, reaching its lowest limit, acts by its weight on the chain of the auxiliary lever, that the notch will move from its position, releasing the principal lever, which is then drawn down, the weight P assumes its original position and closes the taps. We have returned to the starting point, and the movement will continue regularly as above described until the end of the fermentation.

We may add, to complete this description, that the special break-jet which spreads the must in a circular sheet at the end of the return tube may also, if rendered movable, act as a valve, preventing the carbonic acid gas from escaping through the return tube when the taps are open, as the escape of carbonic acid gas bubbling through the must might cause a loss of liquid.

The circulation resulting from the use of this machine renders the mass homogeneous in temperature and composition. It allows the use of refrigeration by interposing a cooler between the vat and the auto-regulator. As for aeration, it may be done by spreading the must delivered in the cylinder, and may be easily suppressed by simply covering the cylinder. The carbonic acid gas remains in it on account of its density.

The *fermentation auto-regulator* works very satisfactorily. It is excellent if used for cement vats, but we do not advise its use with wooden vats without previously ascertaining the resistance of the vat to the pressure required.

The increase of pressure brought about is not very great, depending on the height of the auto-regulator above the level of the liquid in the must. But wooden vats often do not stand even that slight increase in pressure. When well built of solid wood, they may support double or treble the pressure required, but it is better to test them previously.

Masonry, or sidero-cement vats, are always strong enough to allow the use of the auto-regulator without danger of bursting.

DURATION OF VATTING.

This means the time during which the must remains in contact with the marc in the fermenting vats.

It is impossible, *a priori*, to fix a stated time for this, as it varies according to the nature of the wine it is proposed to make, to the *cépage* used, to the method of fermentation adopted, the temperature of the vat, and the manipulations the must undergoes during fermentation.

If fermentation is studied, three distinct phases will be observed, corresponding to the activity of the ferments. The first phase, without external manifestation, corresponds to the multiplication of the ferments. During this period, which is always very short, the sugar is only slightly decomposed, and the production of carbonic acid gas is so small that it remains in solution in the liquid. The second phase, called tumultuous fermentation, corresponds to the maximum activity of the ferments. The decomposition of the sugar is rapid, and the disengagement of carbonic acid gas gives rise to violent bubbling of the liquid.

The elevation of temperature, which is a function of the quantity of sugar transformed in a unit of time, takes place suddenly, alcohol accumulates rapidly in the liquid, which gradually becomes less favorable to the work of the yeast. This brings about the third phase characterized by still active but relatively quiet fermentation.

Each of these phases is of greater or less duration, according to the state in which the grapes arrive at the cellar, and the perfection of the crushing and aeration of the vintage before being placed in the vat.

As a general principle, the must should be racked and separated from the marc, when the total sugar has been transformed into alcohol. This corresponds approximately to the zero degree of the mustimetre. It is then only that the wine has extracted from the marc all the useful matters, and acquired its maximum quality. This is only true, if all the conditions of fermentation, and especially that of temperature are suitable.

We may lay down, as a rule, that the higher the temperature is the shorter should be the time in the vat.

Up to 35° C., and for wines of an alcoholic strength not exceeding 10 per cent. by volume, the fermentation starts quickly and is soon finished. If the temperature exceeds 35° C., or even if it does not exceed 35° in the case of wines containing 12 per cent. and over of alcohol, the fermentation becomes retarded, and even stops altogether if the temperature exceeds 35° C. Under these circumstances, if the means are not at hand for reducing the temperature of the fermentation to 30°, it is necessary to rack, whatever degree is indicated by the mustimetre or sweetness remains in the wine.

Fermentations between 32° and 35° C. are only possible in the case of light wines. These are the only kinds that are not much damaged, because the fermentation goes quickly for two or three days at most, and during the short maceration, the marc cannot affect the surrounding liquid prejudicially.

In any case, directly the fermentation exceeds 35° C., if refrigeration cannot be effected, the wine must be racked. No doubt poor wines result from the latter procedure. They are superior, however, to those obtained by leaving them longer in contact with the marc. They will yield as much alcohol, and have the same freshness and *finesse*, and will, after all, command a higher price than the heavy astringent wines of abnormal taste always resulting from prolonged contact with the marc at a high temperature.

The wines called maceration wines are only made successfully in cold countries. The wine may acquire by prolonged contact with the marc at a normal temperature certain qualities demanded by the trade, but at high temperatures it only acquires defects. In the South of France the duration of vatting is generally three or four days, but lasts eight days when the temperature does not exceed 30° C. In the latter case the wine is coarser, the dry extract is higher, and the wine produced is richer in colour. The qualities of the colour remain good, without any leaden yellow, depressed, undefinable shades of colour, which always create a bad impression when examined in the *tasse*.* (Fig. 38.) An eight days' vatting, if well conducted gives with Aramon (even if grown on flat land) a wine which many expert tasters would not believe to have been made from Aramon exclusively.

Fig. 38.—Tasse.

We will not deal at length with the wines called one-night wine. By this expression is meant wines of very short vatting. They have generally more *finesse*, and are richer in alcohol than the longer fermented wines, but are after all only intermediate between red and white.

VARIOUS ADDITIONS TO THE VAT.

ACIDIFICATION.

We have seen (page 47) the importance attached to the acidity of the vintage, and have shown the amount desirable —completed if necessary by means of tartaric acid—in order to obtain fine solid wines of good *robe* (colour, &c.)

The necessary or useful quantity of tartaric acid to add is calculated from a few determinations of the acidity of the must, and it is placed with the grapes in the crusher, or spread over the vat while it is being filled. *Tartaric acid* is the only acid that can be recommended for practical use, as it is the only acid capable of fixing the excess of potash as an insoluble combination and liberating the normal acids of the grape neutralized by the potash.

* A shallow silver or electro-plate cup, the interior bossed in opposite directions, always used by wine judges in examining the colour of wine.—See Fig. 38.

PLASTERING

Is an indirect means of acidifying the vintage, and consists in spreading over the grapes in the crusher ordinary plaster of Paris (calcium sulphate). This is a very unreliable means of increasing the acidity. The plaster acts on the bitartrate of potash in the must, liberating half the tartaric acid in combination; but generally the plaster is calcareous, that is to say, containing frequently a large amount of calcium carbonate which partly, if not entirely, neutralizes the excess of acid resulting from the reaction.

The reactions of plaster in wine are rather complex. We have shown, in conjunction with Eug. Thomas, that in presence of bitartrate of potash, the plaster (calcium sulphate) forms calcium tartrate and acid sulphate of potash, and that, contrary to what is generally admitted, the acid sulphate of potash does not remain as such in the wine. In turn it reacts on the different organo-potassic compounds which always exist in wine side by side with the bitartrate of potash, and transforms them into neutral sulphates, liberating a part of the acids previously combined as organo-potassic compounds.

Plastering hastens the clearing of wine, and increases its brightness and keeping qualities; but unfortunately this does not take place without the liquid acquiring a special roughness due to the presence of sulphate of potash in solution.

For plastering to be efficacious it should be done freely. The maximum limit allowed by law (in France), 2 grammes of sulphate of potash per litre, is not sufficient to enable the method to give decided advantages; it is extremely difficult to fix *a priori* the quantity of plaster to be used for the resulting wine to conform to the legal limits.

It is better to completely reject this method condemned by law, and all the more reasonably, as in commerce plastered wine is regarded unfavorably.

PHOSPHATING.

This practice, due to Hugounenq, is free from some of the adverse criticisms applied to plastering.

No law prohibits its use. It is recommended by many œnologists, and, as a matter of fact, does not destroy the *finesse* of the wine.

Phosphating consists in adding to the vintage pure di-basic calcium phosphate.

The chemical reactions taking place after phosphating are of the same class as those occurring in the case of plastering. Tartrate of calcium is formed by the action of the phosphate of calcium on the acid tartrate of potash contained in the must, but it is not yet known which phosphate of potash remains in solution; however, it cannot be injurious, and the phosphoric acid it contains cannot but have a favorable action on the fermentation.

The effects of phosphating are the same as those of plastering, with the difference already noted that phosphated wines retain their *finesse*, and the phosphate of potash in solution does not affect the taste of the wine to the same extent as sulphate of potash.

The colour, however, does not seem to be influenced to the same extent in phosphating as in plastering.

SELECTED YEASTS.

The addition to the vat of selected yeasts, that is to say, yeasts taken from the lees from *grand crus*, is nowadays practised by a large number of wine-makers.

The technical science of micro-biology enables us now to take a single cell of good yeast, to cultivate it, guarded from all possible means of contamination, and by using culture mediums specially adapted to their development, to get in a very small volume a number of active cells, infinitely greater than are contained in a large bulk of vintage.

The object is to insure the rapid predominance of a *special* vinous fermentation, which will more or less check the work of the ferments natural to the vintage.

It is the substitution of the work of a special yeast in place of that of the natural yeast.

The advocates of selected yeasts have greatly exaggerated the advantages resulting from their use, still their use presents some real advantages.

In fact, well-conducted fermentation with selected yeasts generally gives a slightly superior wine to that obtained from a spontaneous fermentation with the same grapes conducted under the same conditions. This is generally admitted, and is certainly important.

This superiority, however, is only observed in the case of a well-conducted fermentation, especially as far as temperature is concerned.

In short, a more regular and rapid fermentation is obtained, a quicker clearing of the wine, and more highly developed qualities of preservation. These are results granted by observers to follow from the use of well-selected yeasts. But there is another point, their influence on the bouquet of the wine, which is much debated.

Many authors, who have studied the question of the use of selected yeasts, have pointed out the action on the bouquet, which is regarded by them as the principal effect. It is presumably even so real, and so developed, that one of them has not been afraid to assert that wort fermented with Chablis yeast had been taken by wine judges for true Chablis.

We need not point out the evident exaggeration of such a statement.

The aroma or bouquet of wine must be regarded as the product of numerous factors of two classes.

The first cannot be modified for a given vintage. They are the *cépage*, the soil, the subsoil, and the climate. The others depend, perhaps, on the variety of yeast, but more positively on the care and attention given to the vintage, and ultimately to the wine. These may be modified.

The perfect cleanliness of all the wine-making material, well conducted fermentations, and, later on, opportune rackings have more effect than is generally credited on the final bouquet of wine.

The study of the action of the different races of wine yeasts is much more complex than that of the various races of beer yeasts. In the latter case we work on musts, which may always be reproduced identically, and even by sterilization cleared from any organisms which might disturb the result of the fermentation. These conditions cannot be realized in vinification. We grant that the variations existing between different vintages are slight, but they exist, and in the actual state of our knowledge, however slight these variations may be, no one can say if it is not to them that should be imputed the great dissimiliarity observed between the products of their fermentation.

If we introduce into the must one of the factors influencing the bouquet, as already explained, we will improve it slightly, but that is all. By using yeast of a particular *cru*, we certainly make a slight advance, but the advance made will be so much the greater as the grapes used more closely resemble those of that particular *cru*. This is quite sufficient, we consider, to show that it must not be thought possible to make Bourgogne wine with Aramon grapes.

We are inclined to think that cultivated yeasts, develop in the wines they produce, an aroma peculiar to each of them, and which certainly enters in part into the constitution of the bouquet of the wines, issued from the same *crus* as the yeasts ; but, we emphasize, the aroma given by the yeasts is more often than not a very poor reflection of the bouquet of the *grand crus*.

The Champagne yeasts, however, have in this respect a decided effect, the characteristic flavour of champagne (the sugar excepted) is met with in the white wines made in districts remote from Champagne, but fermented with yeasts originating there. There is in this case an undeniable action with regard to the specific flavour which the yeast may communicate to the wine, and it is to be presumed that Champagne yeast is not an exception, but that all yeasts, to a greater or less extent, act in the same way.

Whatever this action may be, when it is desired to make wines for immediate consumption (like ours in the South of France), it is not of much importance whether the yeast modifies the future attitude to acquire bouquet or not.

Selected yeasts seem to furnish straighter, finer wines, of good keeping qualities, and this is quite sufficient to justify their judicious use.

The study of wine yeasts and of the advantages that may be derived from their application to the different methods of vinification is far from being exhausted. Kayser, Director of the Œnological Station at Nimes, has tried for a long time to throw light on this obscure question alone or in collaboration with Barba. He has already obtained results important enough to justify the hope that by means of selected yeasts (the conditions of life of each race being fixed) still better results than those given to-day may be obtained.

DE-VATTING (DECUVAGE).

This operation consists in separating the fermented wine from the marc.

The de-vatting is very easily done, when the casks are not too far apart, by placing the cask to be racked in connexion with the empty cask, and letting the liquid run in by gravitation until it is at the same level in both, and then finishing the operation by pumping.

The casks which are to receive the newly fermented wine must be thoroughly clean, and washed with an abundance of water, till quite freed from lees. They should not be sulphured, or if they have been, sulphurous fumes should be completely removed by a current of air.

The new wine after racking still continues fermenting for a few days, and this must not be checked in any way. The sulphurous fumes act as a decided check on the fermentation, and this is so much the greater as the liquid is impoverished as regards its ability to nourish the ferment.

Contrary to what is usually done, the newly racked wine must not remain more than a week or fortnight in the vessel it has been racked into. After that time, when the fermentation has been well conducted, the wines have deposited, and are ready to be racked into another cask, which should be slightly sulphured.

It is a common prejudice that sulphuring should not intervene in the fermentation of red wine. This will be discussed later on, but we will state now that this prejudice is without foundation. The practice of sulphuring cannot but have advantages in the case of both red and white wines. It is simply a question of the quantity used.

EXHAUSTION OF THE MARC.

The de-vatting leaves in the vat the marc from the vintage it contained.

The marc still contains after natural drainage a considerable quantity of wine which should not be lost. It is submitted to pressure. This drains it more or less, and furnishes what is known as "press wine," as compared with the other racked portion known as "taste wine."

PRESSES.

The machines used for the extraction of the wine contained in the marc are called presses. They are intermittent and continuous, depending on the method of feeding adopted.

INTERMITTENT PRESSES.

In ancient times planks and heavy stones were all that was used, but a very insufficient pressure was the result. It is mainly in the direction of presses that mechanical skill has been directed during centuries in the cellar, and the ancient type, with a few modifications, in detail, is still the most widely used.

The press actually used consists essentially of three parts. A vertical screw, a horizontal table or base supporting the screw in the centre, and a nut travelling on the screw constituting the compressing part. (Fig. 39.)

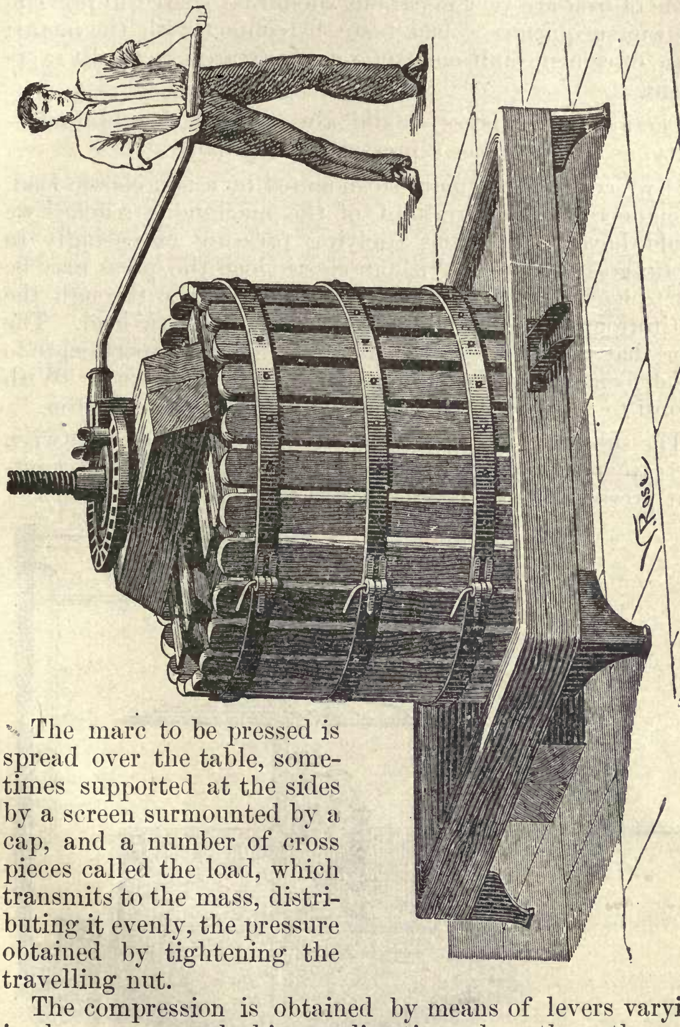

Fig 39.—Intermittent Press.

The marc to be pressed is spread over the table, sometimes supported at the sides by a screen surmounted by a cap, and a number of cross pieces called the load, which transmits to the mass, distributing it evenly, the pressure obtained by tightening the travelling nut.

The compression is obtained by means of levers varying in shape, some worked in one direction only; others, the most commonly used, worked with an alternating movement, but forcing the travelling nut to revolve always in one direction by means of a ratchet reversing the movement.

The table is made of wood, iron, or cement.

Those made of wood would be excellent if it were not rather difficult to make them staunch and impervious. Those made of iron are very good, but should be coated to prevent the wine acquiring a bad taste by contact with the metal; those of cement built on strong concrete are practically everlasting.

The load of the press should always have a certain elasticity, as it constitutes a pressure accumulator.

If we consider the marc surmounted by a non-elastic load, when once the pressure limit of the machine is reached we would have to continue applying pressure unceasingly to obtain good results. With an elastic load the press may be left to itself, for the pressure continues to act through the restitution of the force accumulated in the elastic load. The time that the press can be left to act alone is proportionate to the deformation of the load under the given pressure. With regard to this, wooden loads are superior to those of iron.

The substitution of powerful steel springs placed between the cap and the nut is a decided improvement in intermittent presses, this suggestion is due to Crassous (Fig. 40).*

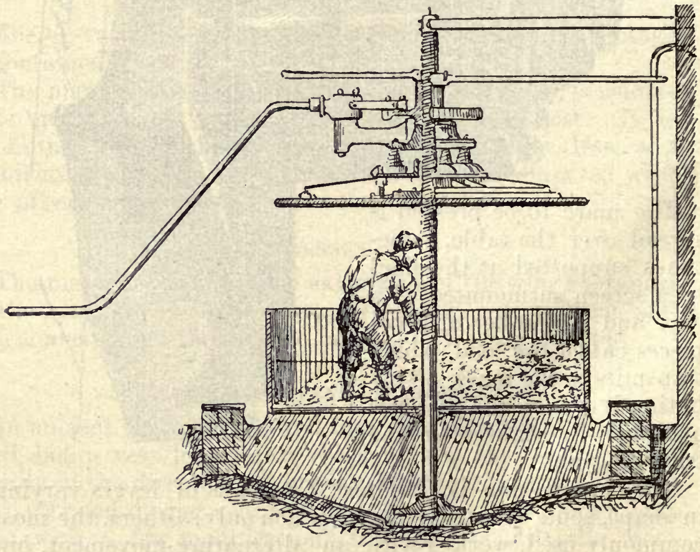

Fig. 40. – Press with spring load.—Crassous Arrangement.

* This idea was first realized in practice by P. Paul, who manufactures these presses.

The load is dispensed with but not its useful effect, which on the contrary is amplified; the cap is fastened to the bolt by a very simple device and they travel together. This greatly simplifies the working. But where the main advantage comes in, is in the action of the springs. These are of the same type as those used for railway-carriage buffers. Their normal limit of compression is 20,000 kilos. for a 14 or 15 centimetre stroke.

The height of the marc on the table diminishes under the pressure till its resistance equals the compressing resistance of the springs, if from that moment the tightening is continued the pressure is accumulated in the springs, which become more and more compressed, and is restituted by them when the tightening ceases, the cap continuing to descend till the springs have expanded to their normal length.

The stroke is about 14 or 15 centimetres, and this allows a long enough interval for workmen to attend to other operations in the cellar.

While an ordinary press with a wooden load requires retightening every quarter of an hour, presses fitted with accumulating springs continue acting from two to six hours, according to the pressure and the state of the marc.

The number of springs varies with the surface to be pressed, and the surface itself varies according to the pressure we desire to obtain.

Generally the marc is cut afresh at the sides to a distance of about 30 or 40 centimetres in from the circumference, as the case may be, and thrown over the cake again, and the pressing continued. The pressure is the same, but as it is distributed on a small surface it is much greater per unit of surface.

All presses dry the marc to about the same extent, the perfection of work depends much more on the way it is done than on the type of press employed.

The opinions of many specialists have led wine-makers to try and obtain unnecessarily high pressures.

The yield of juice from a given quantity of marc depends on two factors—the pressure and the time during which it acts. The second of these factors can in no way be substituted for the first. It is better to leave the marc longer in the press, submitting it to a moderate pressure, than submitting it to a powerful pressure for a short time.

This method of operating requires the use of a number of small presses, or of a lesser number of presses capable of receiving a large volume of marc.

Both large and small presses have their advocates, the superiority of either type is far from being admitted; generally from comparative observations we consider that large surface presses are preferable. Their working is simpler and the marc quite as dry as that worked with machines of smaller surface. We know many cellars where the presses are large enough to receive the marc from a 450-hectolitre (9,900-gallon) vat, each dries that quantity of marc without cutting the cake in 24 hours. Therefore, without any work beyond the filling, tightening, and emptying, the draining of the marc is quite as satisfactory as that obtained in less time, with one or two cuttings.

CONTINUOUS PRESSES.

Ordinary presses, such as those above described, give medium results, even the best of them, that is if there are any better than others. The drainage of the marc is far from being complete, as it always retains at the end of the operation about 60 per cent. of liquid. Is it desirable to go to any further trouble, and will we not by an increase of pressure augment the yield at the expense of the wine? We do not think it is desirable, but the advocates of continuous presses are of this opinion, for they quote amongst the advantages of these machines a more perfect exhaustion or drainage of the marc.

In short, continuous presses have been invented with the objects—

First—To reduce labour.

Second—To reduce the stock of machinery by dispensing with the use of ordinary presses, which, to treat an equal quantity of vintage, are more numerous and expensive, and above all more cumbersome than continuous presses.

Third—To reduce the time of pressing.

Fourth—To increase the yield of press wine.

We must at once state that the increased yield aimed at is not yet proved to be attained. All the continuous presses known (with a few rare exceptions), although widely different in shape, depend on the same principle.

They are composed of two or more cylinders, worked as crushers if fresh vintage is to be treated, or as light compressors if fermented vintage is to be dealt with.

After passing through these cylinders the vintage is carried on by an Archimedean screw, accumulating it in a perforated horizontal cylinder, the diameter of which decreases towards the exit, and is terminated by an orifice small enough for the marc to form a compact cake or stopper, which can only be expelled under considerable pressure. A fresh quantity of marc replacing that expelled acts in turn as a stopper, and so on as long as the machine is fed. (Figs. 41 to 45.)

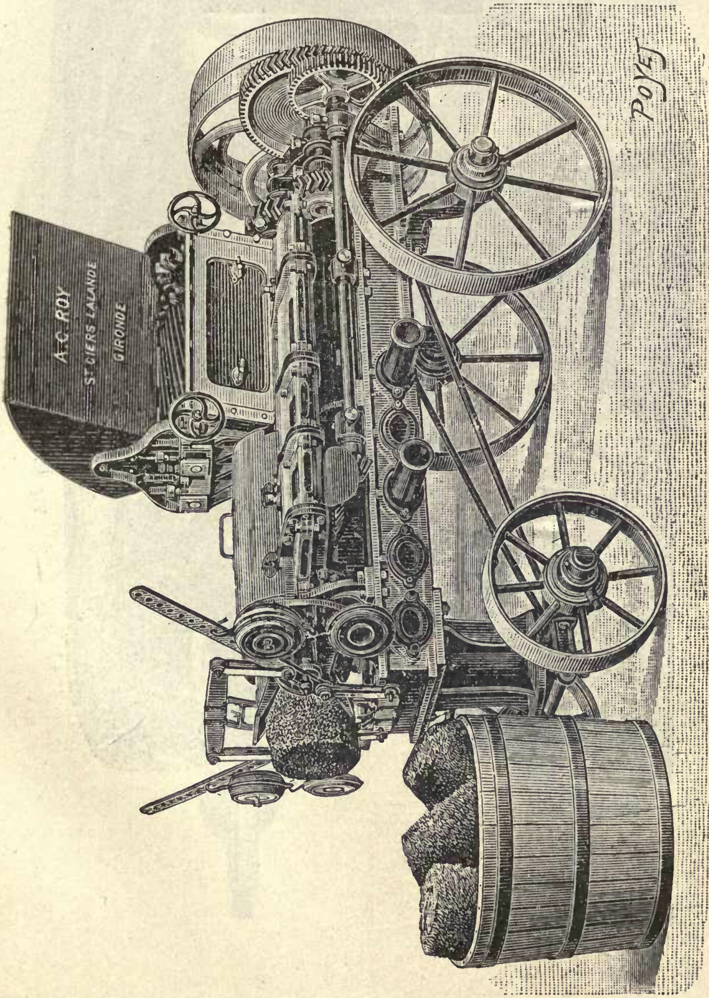

Fig. 41. – Roy's Continuous Press.

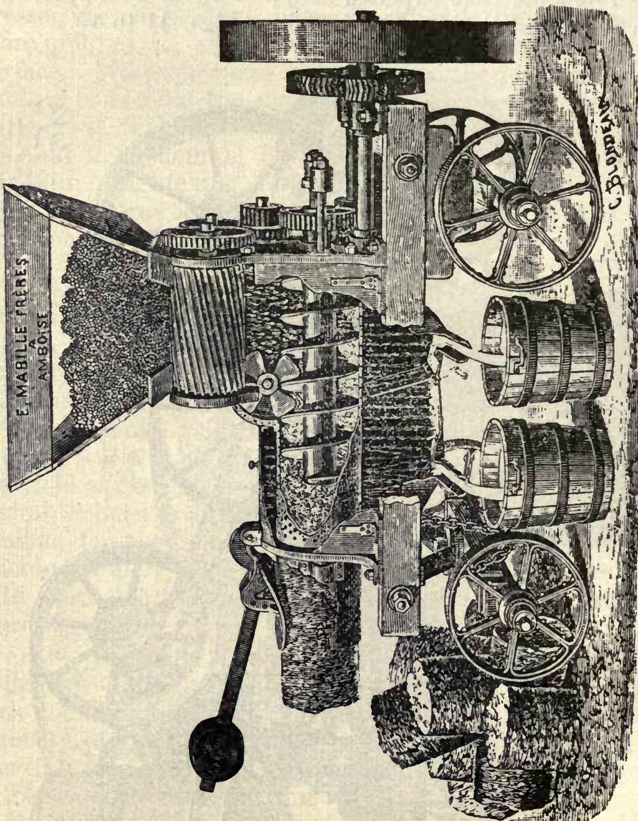

Fig. 42.—Mabille's Continuous Press.

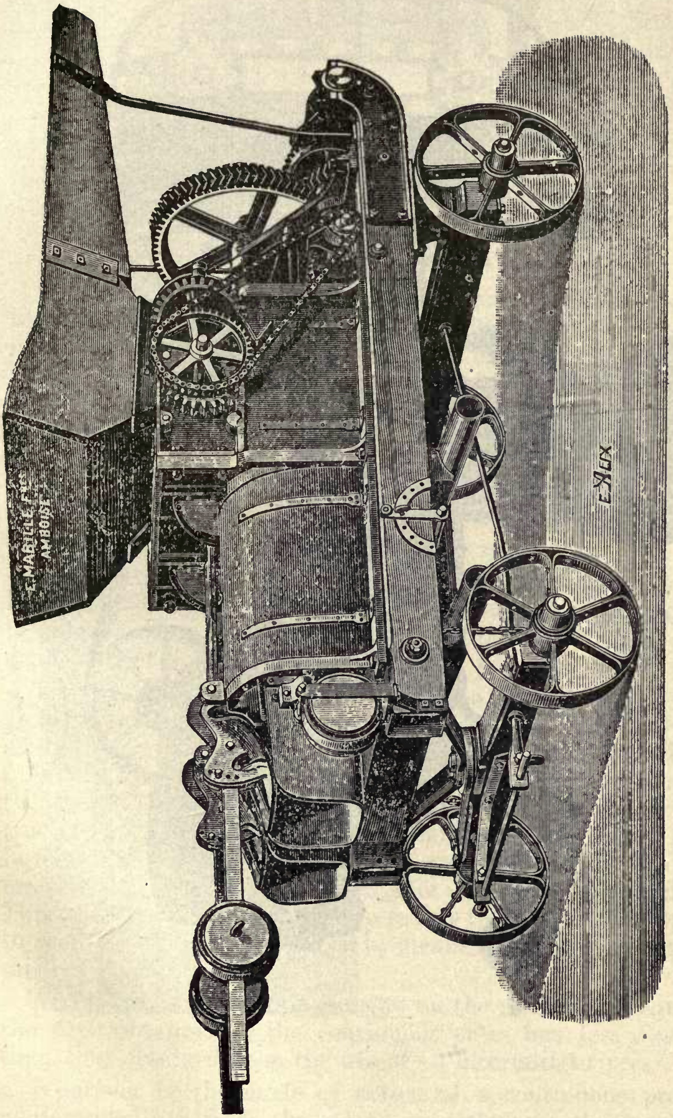

Fig. 43.—Mabille's Continuous Press, with twin screws.

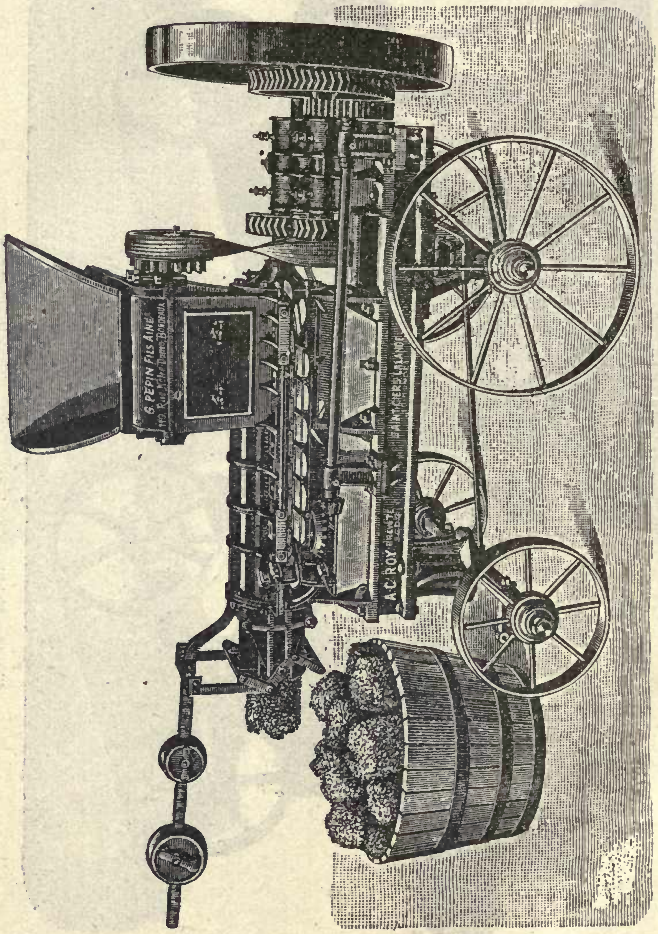

Fig. 44.—G. Pepin's Continuous Press.

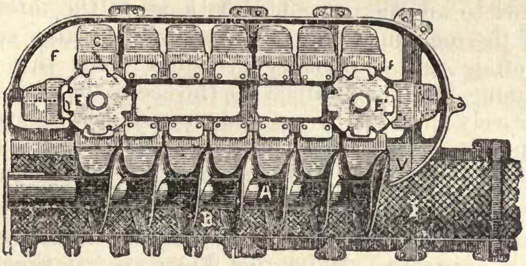

Fig. 45.—Self-acting Carrier of Pepin's Press.

The cylinder may be of conical shape and composed of steel blades, allowing the diameter of the exit from the cone to be increased or diminished by means of a movable iron collar, or it may be as in the Debonno press (the first invented) a tube of rectangular section, with the angles rounded off, closed at its extremity by an adjustable roller, the axis of which is horizontal and perpendicular to the axis of the Archimedean screw, rising under the pressure of the marc, and offering a resistance, which may be varied by means of weights carried on one or two levers connected with the roller.

The use of continuous presses is particularly tempting in the manufacture of white wine, for it is necessary in this case to obtain in the shortest time, a separation of the liquid and solid parts of the fruit, as completely as possible.

There is unfortunately in the working a notable defect—the yield in juice is apparently greater than that furnished by an ordinary intermittent press, but the must furnished is infinitely more turbid, owing to the greater disintegration of the vintage, to such an extent that if we want to know the true yield of grape juice, it is necessary to separate from the liquid obtained from the continuous press, a quantity of solid matters in suspension, which cannot be regarded as juice. This quantity is great enough to reduce the true yield of juice to even less than that obtained by means of an ordinary intermittent press.

And what is more, the pressure on the marc being equal, the wine obtained by the continuous press has less *finesse* than that obtained from the use of an intermittent press.

Whatever be the mode of action of a continuous press, while travelling from the entrance to the exit the marc is submitted to an energetic friction against the internal surfaces of the machine; disintegration of the stalks, seeds, and skins, often very pronounced, results from this friction. The organic juices contained in the cells of those organs pass entirely into the wine, and, as we have shown when describing the crushers, it is important to leave two elements of the grapes (stalk and seeds) intact. The continuous presses at present known do not overcome these inconveniences.

If we are dealing with white wine, this inconvenience is still more apparent. We do not know any continuous press capable of extracting from red grapes a quantity of white must equal to that obtained by an ordinary crushing, followed by the usual pressing, without the must in the former case being more coloured than the latter. This fact is quite unexpected, for it is generally admitted that the most important factor of the non-colouration of the must depends on the rapidity with which the grapes are treated.

It is a factor, it is true, but not the only one to be considered. It is generally admitted that the colouring matter of the berry is only soluble in concentrated or diluted alcohol, and that if we avoid fermentation the colouring will not occur. The colouring matter contained in the cells does not pass through the membrane while they are surrounded by non-alcoholic must, but if we place in the white must broken cells full of colouring matter, the colouring matter, although completely insoluble in the must, will diffuse through it in very minute particles, which it will be impossible to separate; but, what is more, if the insolubility of the colouring matter is admitted as long as it is protected by the cellular membrane, it is not so when the colouring matter is bare and exposed to the action of the must. Duclaux has established, by a few experiments, that the colouring matter cannot be considered as insoluble in the must, but that this liquid has not got the power of dissolving it through the cellular envelope.

These various inconveniences delay the general adoption of continuous presses in the viticultural industry. We hope that constructors will be able in the future to overcome them. Continuous presses will then, and only then, become machines for general use, owing to their advantages, henceforth irrefutable.

EXHAUSTION OF THE MARC WITHOUT PRESSES.

Presses are far from giving every satisfaction, and the marc treated by them has to be submitted to new manipulations to make piquettes, or marc spirit, if it is desired to utilize the wine they still contain.

We studied in collaboration with M. Semichon, Director of the Œnological Station of the Aude, various means of increasing the yield of pure wine from fermented marc, and cannot do better than quote the following extract summarizing our researches on this subject:—

"Under ordinary conditions, in the vinification of red wine, the marc remaining in the vat after the racking of the wine, is placed in the press and submitted to a more or less greater pressure, during a varying period.

"It is thought that by this operation, all, or at least a greater part of the wine contained in the marc is extracted.

"Pressure, however, does not give as complete an extraction as is generally thought, for if we determine the quantity of the wine left in the marc after the operation as conducted under ordinary circumstances we always find a minimum of 50 per cent. of the weight of the marc. Distillers know that they generally extract from 100 kilos. of compressed marc a number of litres of alcohol equal to a little more than half the alcoholic degree of the wine furnished by that marc.

"It is therefore an important fraction of the total yield that might be used as wine, for if we admit that the production of one hectolitre corresponds to a quantity of 15 to 20 kilos. of compressed marc, it is (taking the minimum of 50 per cent. of wine remaining) a volume of 7 or 10 litres of wine which may be used for making piquette or marc spirit.

"This is an important loss, which shows that presses are not perfect instruments as far as yield is concerned. They are not perfect either with regard to the quality of the wine they yield. Every wine-maker knows the defects of press wines in regard to their organoleptic value and keeping qualities.

"The improvements made in recent years in the manufacture of piquettes induced us to apply to the exhaustion of unpressed marc the method which actually gives the best results for piquettes, and which consists in methodically displacing the liquid impregnating the marc by an ascending current of water.

"By causing the liquid piston of ascending water to displace the wine, we thought that the yield would be greater than that of any press.

"An almost integral mechanical displacement is possible, and can be demonstrated by a simple laboratory experiment.

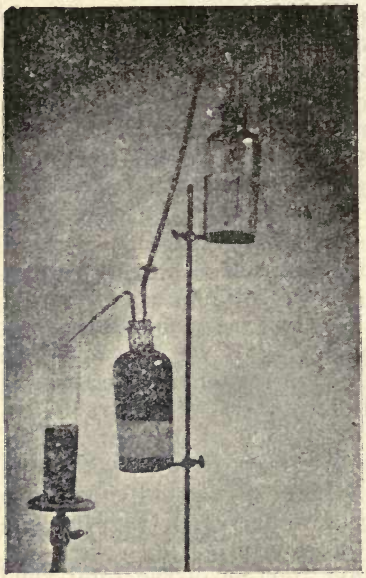

Fig. 46.

"If in a flask full of wine we allow a current of water to slowly flow in to the lowest part, the wine is lifted by the water, while the line of demarcation of the two liquids remains sharply defined if the experiment does not last too long. If the wine is collected, we notice that the diffusion zone is very narrow, and that the alcoholic strength of the liquid experimented upon becomes only appreciably lower in the last portion collected. In an experiment made with a flask of three litres capacity (Fig. 46) filled with wine of 10·4 per cent. alcohol, we gathered :—

1 litre,	containing	10·4	per cent. of alcohol.
1 ,,	,,	10·5	,, ,,
500 c.c.	,,	10·3	,, ,,
300 ,,	,,	10·05	,, ,,
400 ,,	,,	3·51	per cent., average of eight trials of 50 c.c. each.

"The three litres of wine experimented upon contained 312 c.c. of pure alcohol, and the displacement gave—

104	c.c. of	pure alcohol	with the	1st litre.
105	,,	,,	,,	2nd ,,
51·5	,,	,,	,,	500 c.c. following.
31·5	,,	,,	,,	300 ,, ,,
14·04	,,	,,	,,	400 ,, ,,

"A total of 306·05 c.c., which shows a loss of 2 per cent. only.

"95·5 per cent. of the alcohol has been extracted in the shape of pure wine equal to that experimented upon, that is to say, of 10·4 per cent. alcohol.

"It will be noticed that in this experiment the second litre is of higher alcoholic strength. This difference is small enough to be attributed to an error of determination. We do not believe it, however, for we have always noticed this slight increase of the strength in the numerous experiments made. We are unable to explain this constant fact, and can only record it, pointing out that its constancy cannot be explained as a mere coincidence.

"This shows, when dealing with liquids alone, that it is possible to displace, without mixing, and without any other help than water, more than 95 per cent. of the wine contained in the vessel. Will the experiment be as simple if the wine to be displaced impregnates a spongy more or less continuous mass such as marc ?

"Evidently not, for new factors come into play. We must differentiate between the wine simply wetting the exterior of the tissues, and that contained in the tissues.

"The former is displaced almost as easily as in the case of liquids, the latter can only slowly come out of the tissue by a kind of dialysis through the membrane of the cells, or even through the skins, if we have to deal with badly-crushed vintage.

"We made several displacement experiments with solid matters, porous or otherwise, such as broken glass, cotton, sponge, pumice stone, &c., saturated with wine, which showed very quickly that we could not hope for as good results as in the case of liquids alone.

"We merely quote the results of these experiments as references, and did not stop to study them completely, as the marc alone interested us.

"The causes which prevent us obtaining an integral yield in the displacement method applied to grape marc, are—

1st. The diffusion or mixing of the wine and water.

2nd. The difficulty the wine encounters in traversing the walls of the tissues by a kind of dialysis.

"We determined by numerous experiments, under varying conditions, the rapidity of the diffusion of wine in water. We will not insist on the results obtained, but draw the two following conclusions:—

1st. There is an advantage in having a rapid displacement, that is to say, an ascensional rapidity of the liquid piston amounting from 8 to 10 centimetres per hour.

2nd. There is an advantage in operating on the marc of well-crushed vintage.

"In the laboratory we obtained, on small quantities of marc it is true, a yield of pure wine notably higher than that given by the presses.

"In current practice, however, the marc cannot be treated with the same care that is possible in a laboratory experiment, but by modifying the arrangement, and by increasing the number of displacement tanks and arranging them in batteries as is already done for the diffusers in certain industries, we may expect a satisfactory enough yield for the process to remain applicable.

"The experiments were made on a large scale, but not, however, large enough,* and it will not be possible to do this till next vintage.

"With four displacing tanks, each holding 100 kilos. of marc, we obtained results comparable with those of the presses. (44·4 litres of pure wine per 100 kilos. of drained marc, while 45 litres were obtained with the presses, that is to say, about 65 per cent. of the wine contained in the marc.)

"We think that these results would already be advantageous, for they dispense with the labour of pressing, and give an equal yield; but the course of the operation enables us to foresee that by doubling the number of tanks, or even by taking six only, the yield in pure wine would be increased, and reach that of the laboratory experiments made on the marc, that is to say, about 85 per cent. of the total wine contained in the marc.

"We must add that the quality of the wine so obtained is superior to that of press wine. It has not the same

* With a sufficient number of tanks (eight or ten) we might greatly increase the ascensional speed of the water.

harshness resulting from the crushing of the organic tissues, neither its defects of preservation resulting from the impurities in suspension in the liquid.

"The quantity of wine to be utilized in the shape of piquette or spirit, will be reduced to 3 per cent. in place of 7 or 10 per cent.

"We used in our experiments the following arrangement:—Four tanks made from casks with the heads knocked out, of about 120 litres capacity, provided with a screen forming a false bottom, were placed in communication in such a way that the liquid entering in the bottom and centre of the first one, overflowed by a side aperture in the upper part, to pass into the second tank, where it penetrates into the middle of the bottom, and so on.

"The four tanks so arranged were charged with marc, and the displacing commences; at the third we might have already drawn pure wine, but we only did this at the fourth at the rate of 45 litres per 100 kilos. of vintage. The first tank is then considered as exhausted, the slightly pink-coloured water it contains is racked and sent back to the water tank, while the feeding is made directly on the second tank, which now becomes the first; charged with fresh marc the vat we have just finished with becomes the fourth, and so on, each cask becoming in turn the first and last of the system.

"The limited quantity of water which remains at the end of the operation in the shape of piquette may serve to extract the wine from an unlimited quantity of marc.

"We consider that a battery of eight tanks would give much better results, the working would be the same as that described; it might be facilitated, however, by adding a ninth tank, for the charging and discharging to be made without stopping the displacement operations.

"The zone of diffusion of wine and water is spread over the first two or three tanks, and is preceded by a volume of pure wine, sufficiently extended to allow it to be collected without any admixture of water.

"This diffusion zone is so much the greater as the vintage is less crushed, we even think that this factor (perfection of crushing) is so important that the method would be inapplicable in the case of an uncrushed vintage.

"We tried to obtain a more rapid and better displacement by the use of a liquid denser than water, and with that object worked with solutions of common salt of strength varying between 1 and 10 per cent. The yield in wine is not increased, and it has the inconvenience of leaving tails, that is to say, portions of piquette too salty to be of any use.

"We do not pretend to have made conclusive experiments on the subject, and we propose to complete them during next vintage, but such as they are they enable us to lay down the principles of a method of exhaustion of marcs more satisfactory than that depending on compression."

Since the publication of this work, M. Semichon and myself have secured the co-operation of several vine-growers desirous of experimenting with a method which, while dispensing with the work of the presses, would give a better result in yield of pure wine. We hope after the next vintage (1898) to be able to definitely establish the superiority of diffusion over pressing by the figures obtained in operating on large quantities.

CHAPTER V.

VINIFICATION OF WHITE WINE.

The vinification of white wine differs essentially from that of red wine, in the fact that the transformation of the must into wine takes place without contact with the solid parts of the grape.

There are two cases to be considered—

Vinification of the grapes of white *cépages.*

Vinification of the grapes of coloured *cépages.*

The white *cépages*, most commonly cultivated for the manufacture of white wine in the south of France, are the Picpoul, Terret-Bourret, and Clairette.

All red grapes are eligible for making white wine, excepting the Tinto varieties and Bouschet hybrids (having red coloured juices).

VINIFICATION OF WHITE VARIETIES.

Is much simpler than the vinification of red *cépages.* It consists in crushing the grapes, draining them, placing the drained marc in the press, and leaving the juice from both the above operations to ferment. However, there are certain operations that may improve the *finesse* and keeping qualities of the wine, and therefore increase its value. One of these operations is the *débourbage* (settling).

This consists in separating the suspended impurities. Various methods have been proposed for the *débourbage*—simple filtration, the application of which is much too expensive, the must offering great resistance to filtration; centrifugating, the effectiveness of which has not yet been sufficiently proved; and the simple separation by deposition and consecutive rackings, the best, most practical, and least expensive of all.

It is necessary, in order to obtain complete deposition, to maintain the liquid perfectly still during a sufficient time, that is to say, to prevent the liquid from starting to ferment.

Low temperature would be a good means of resolving this question or problem, but would be rather costly. E. Thomas and myself studied a scheme applicable to a daily quantity of 500 hectolitres, and we arrived at the conclusion that the required result could only be obtained at an extra expense of 2 francs per hectolitre, evidently incompatible with the value of the product to be made.

There is fortunately an excellent and cheap means of suspending the fermentation during the required time. This is by sulphuring.

The gas produced by the combustion of sulphur (sulphurous anhydride, SO_2) is very soluble in water and must, and has the property of arresting the reproduction of the yeast and rendering it inactive during a certain time without killing it, if the amount used is not too great.

It is the exact gauging of the sulphurous acid absorbed which is the important point in the application of the *débourbage*.

We must use sufficient sulphurous acid for the deposition to be complete, and yet a small enough amount for the inactivity of the yeast to cease directly the separation of the lees has taken place.

Experiments have shown that an amount of sulphurous acid corresponding to 0·01 per litre of must does not greatly retard the commencement of fermentation. A quantity of 0·03 retards the fermentation for 10 or 12 hours. With 0·05 it is retarded for 18 to 24 hours, and with 0·075 it is retarded from 48 to 60 hours. With 0·10 the fermentation only starts five or six days after treatment. We can, therefore, retard at will the start of the fermentation by simply introducing into the must the above-mentioned quantities.

It is not very easy to gauge the absorption of the exact quantity of sulphurous acid resulting from the combustion of sulphur. This is why we are often liable when using imperfect apparatus to sulphur too strongly, which retards the fermentation indefinitely, and therefore the selling of the wine, or not enough, in which case the fermentation starts before the *débourbage* is completed. One or other of these defects is frequently observed when the operation is simply performed in a previously sulphured cask.

We studied some years ago the application of various definite compounds to replace sulphuring—the alkaline sulphites, the alkaline earthy sulphites capable of being decomposed by the must, and yielding for a given weight, a constant quantity of sulphurous acid. The results were excellent, but it is difficult to obtain in commerce at reasonable cost, sufficiently pure chemicals to be used in vinification, and in practice the homogeneous admixture of a small quantity of matter with large quantities of liquid is always difficult to realize.

Sulphurous acid diffuses more easily in the must than the solid sulphites, therefore we have preferred to use it and to find practical means of charging the liquid with the desired quantity only.

The application of sulphurous acid to the must is called *mutage* (numbing), a name originating from the effect it produces, rendering the must *muet* (numb).

The machines used for this operation are called *muteuses*, *mutoises*, *mutoirs*.

The *mutage*, in view of obtaining dry white wines, is only temporary, and requires much less sulphurous acid than in the case of the must being required to remain sweet, for making ultimately concentrated must, grape syrup, or ports.

The ordinary *muteuse* consists of a vessel in which the must travels in one direction, and air charged with sulphurous acid in the opposite direction.

Such for instance is the *muteuse* of Coste-Floret (Fig. 47). The must arrives by the tube a, falling in a spray in the muteuse C, through the perforated plates A B, and absorbs during its passage the vapours generated by the stove E.

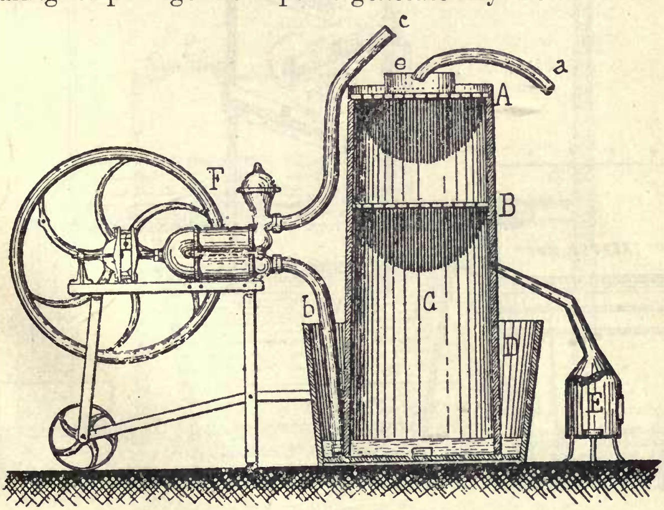

Fig. 47.—Coste-Floret's Muteuse.

The must itself forms a liquid joint in the bottom of the tub D, it is then taken by the suction tub b of the pump F, and pumped back by the tube c (b.e.).

The *muteuse* of P. Paul shown in Fig. 48 is almost as simple. It consists of a box 1 metre 30 c.m. high and 40 c.m. wide. The must arrives at the upper part and falls on oblique superposed partitions. It is therefore exposed on a large surface to contact with the vapours charged with sulphurous acid coming from the stove.

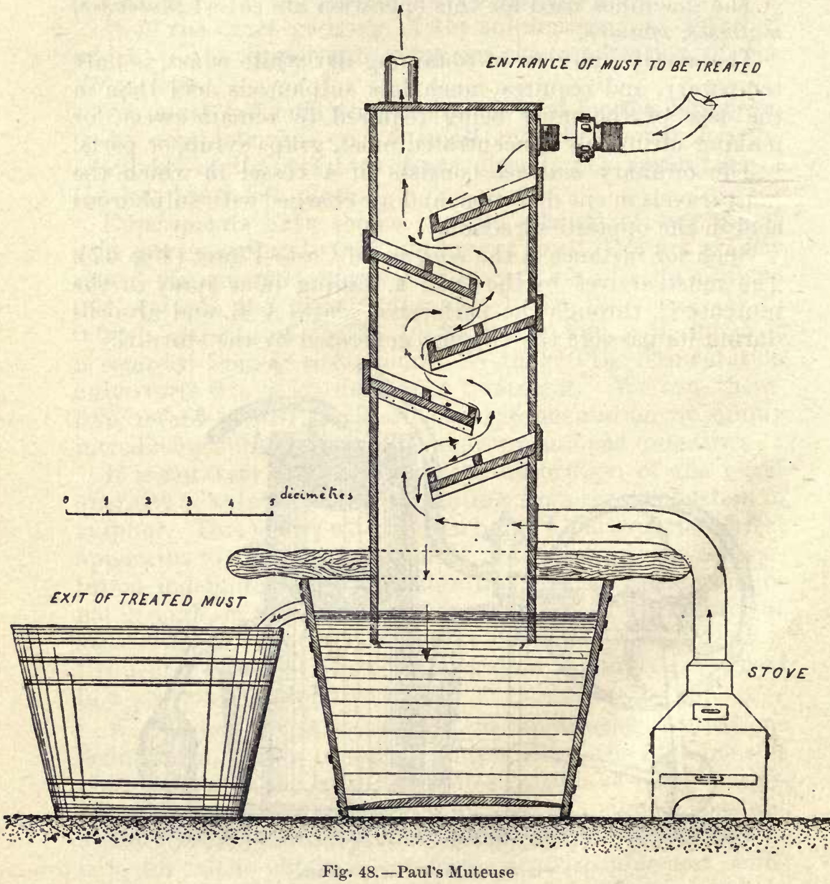

Fig. 48.—Paul's Muteuse

These two machines may insure the complete dissolution of the sulphurous acid furnished by them, but cannot be considered as capable of gauging the absorption of the sulphurous acid with precision, for it is very difficult, not to say impossible, to furnish them with exactly the required quantity of sulphurous acid.

The weight of sulphur burnt in a given time is a function of the speed of the current of air, and the speed for the same aperture of the valve varies greatly from one operation to another, even at different times during one operation.

The sulphuring cylinders used at Villeroy by the Compagnie des Salins du Midi, which work in a similar way to the two *muteuses* described above, have the same defects. At their vineyards at Bosquet the Compagnie des Salins du Midi use a different apparatus allowing more exact measurement.

The *muteuse* used at Bosquet consists of a sidero-cement chamber d (Fig. 49) in which the necessary weight of

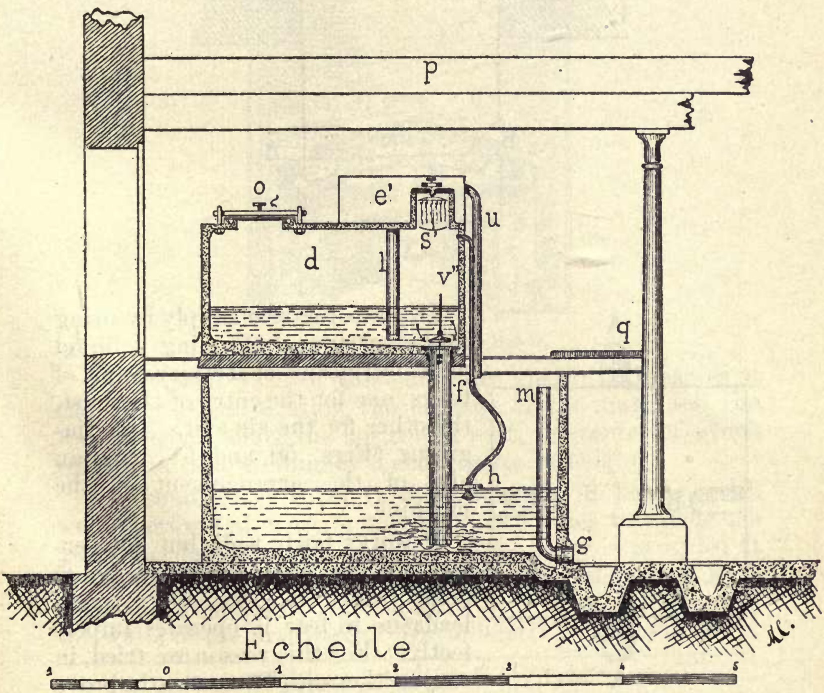

Fig. 49.—Bosquet's Muteuse.

sulphur is burnt (half the weight of the sulphurous acid required) in the shape of sulphured cloth suspended to the cloth carrier S, which can be raised or lowered. The chamber is then filled with must, and when the gas is absorbed the valve V is lifted and allows the must to flow into the *débourbage* tank below.

With this apparatus fairly accurate measurement and absorption can be effected, but it is very complicated.

With the exception of the Bosquet *muteuse*, which cannot be used in small cellars, the machines above described only give an illusory measurement.

Eugene Thomas attempted to substitute an apparatus allowing the measurement and absorption, by direct sulphuring of the vat to be filled with must, the idea being to prevent the air which is driven out when filling the vat from carrying away with it any sulphurous acid.

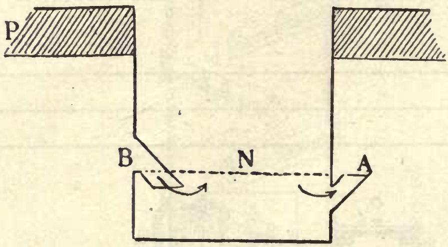

Fig. 50.

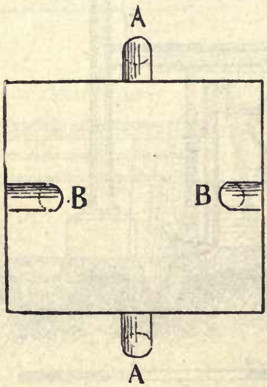

Fig. 51.

This was realized simply by using a kind of funnel, forming a liquid joint by means of two systems of tubes, one for the entry of the must, the other for the air exit. The diagrams (Figs. 50 and 51) give an idea of the arrangement of the machine.

It works fairly well, but not perfectly. The washing of the gas is done rather spasmodically, which leads us to fear it operates imperfectly. For this reason we tried, in conjunction with Thomas, to improve the apparatus.

The modified apparatus consists of three parts, capable of being dismounted and fitting together (see Fig. 52).* It consists of—

A. A cylindrical vessel of the same diameter as the manhole; the cylinder carries at its top a horizontal flange resting on the edge of the manhole, to which it is luted with plaster. The annular part at the bottom has a space of 8 to 10 centimetres between the concentric rings.

B. A cylindrical cover B, the sides of which drop in the annular space, about 14 to 16 centimetres high.

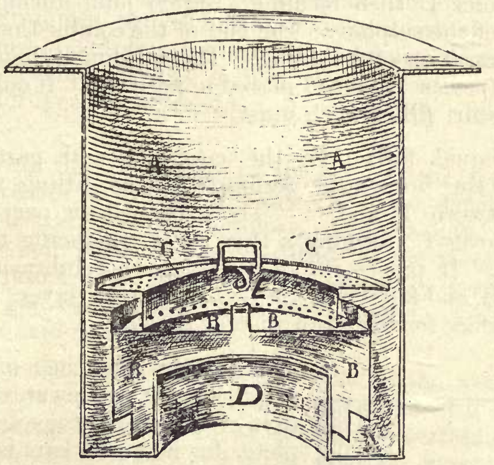

Fig. 52.—Thomas and Roos Mutoir.

The vertical walls of this cover are cut in embrasures at the lower edge, to allow the passage of the must, and rise 2 centimetres above the horizontal part, the centre of which carries an escape chimney 3 centimetres in height.

A second lid or cover C, 4 centimetres in height, with walls perforated with numerous small holes to divide the gases and facilitate the washing. This cover is provided at the upper part with a handle, and inside with a hook E to suspend the sulphur cloths from. This cover extends over the walls of the first cover. The diameter of the cylinder C,

* This apparatus is constructed by Vidal.

should be 1 centimetre greater than that of the cylinder D, and 1 or 2 centimetres less than that of the cylinder B.

The total depth of the apparatus may vary. We have adopted 50 centimetres, which is sufficient to prevent the must from splashing out, even during rapid filling.

The following is the method of operating :—The apparatus is placed in the manhole and the upper flange carefully luted. It is then filled with must till it overflows inside over D. The required quantity of sulphur is then suspended to the hook E in the shape of sulphured cloth, or sticks, placed in a suitable recipient. The sulphur is lighted and introduced into the vat through D, the cone C resting over the cylinder D then forming a liquid joint during the combustion of the sulphur. The end of the combustion is shown by the cessation of bubbling. The sulphur is then removed, and the pieces B and C placed in position. It only remains then to start filling with must.

The liquid falls over the cover C, and partly passes through the horizontal perforated parts, filling the liquid joint between D and C. The excess flows over the sides of the cover C, forming a thin sheet conducing to effective washing. It passes into D through the embrasures at the base of B, and falls into the vat in a thin layer, offering a large surface for the absorption of the gases.

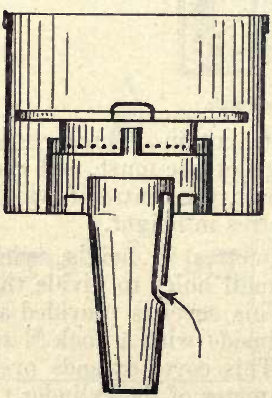

Fig. 53.—Arrangement for Bung-hole.

Whatever be the quantity of sulphur burnt in the vat, the absorption of the sulphurous acid is complete, for no smell can be detected above the apparatus. The same arrangement may be used for bung-holes. In this case the piece A is modified, as shown in Fig. 53. It is prolonged by a conical tube, in the side of which a small tube is placed for the exit of the gas evolved during the filling.

It goes without saying that in this case, unless the cask be small, the introduction and combustion of the sulphur must be done through the bottom manhole.

Through the fact that the sulphurous fumes contained in the vessel are completely absorbed by the must, this apparatus may be considered as a measuring and absorption apparatus.

We know that when sulphur is burnt it produces double of its weight in gas ; if, therefore, we wish to charge the must with η grammes of sulphurous acid per hectolitre we must burn before filling $\frac{\eta}{2}$ grammes of sulphur, the air contained in the vessel is more than sufficient to produce the required quantity of sulphurous acid.

Under ordinary conditions of temperature air contains at least 20 grammes per hectolitre of oxygen, which can burn 20 grammes of sulphur to form 40 grammes of sulphurous anhydride. This quantity is four times greater than that required for perfect *débourbage*, if completely absorbed by the liquid.

But during the combustion of the sulphur the gas in the vessel increases in volume through the heat developed by the combustion. It is, therefore, necessary, in order to avoid loss and preserve the exactitude of the measurement and absorption, that the vessel be closed in such a way that the gas can only escape after having yielded the sulphurous acid to the must.

At M. Thomas' cellar the arrangement of the vats facilitates the introduction of a cast-iron pot filled with sulphur, which is suspended to the top of the vat at a certain distance from the manhole, in such a position that the must does not touch it.

The sulphur is lighted, the apparatus immediately placed in position, luted with plaster, and filled with must, taking care to fill up two or three times till the combustion is over. This is easily noticed by the cessation of bubbling, the filling of the vat then begins.

When it is necessary to deal with a large wooden cask we begin by fixing the apparatus. The sulphur is introduced and lighted at the bottom opening, when the combustion is finished and the equilibrium established for a column of 5 millimetres of water, the height of the liquid joint, it is possible without difficulty to open the bottom manhole and remove the sulphur recipient, and close the opening. If this operation is done quickly the loss of gas is negligible.

At this moment the difference of pressure between the gas in the vat, and the atmosphere, is sufficiently small to be out of consideration.

To avoid luting with plaster, F. Crassous, Director of the Compagnie des Salins du Midi, proposed placing under the flange of the apparatus an india-rubber tube, which, when compressed by the weight of the apparatus, will insure an air-tight joint.

We think that the air chamber of the pneumatic bicycle tire would answer perfectly for this purpose. It could be inflated to the required amount, and the thin rubber they are made of would insure the exact adaptation of the tube to all the irregularities of the wood or masonry. We have not yet seen this idea applied in practice, and, therefore, can offer no positive advice about it; but it would certainly facilitate greatly the handling of the apparatus.*

To finish the various processes of the application of sulphur, we will describe a method called pump sulphuring. This idea is due to M. Sénac, Viticulturist of the Département of the Gard, which while allowing an exact measurement dispenses with the use of special apparatus.

The principle consists in forcing into the must by means of a pump all the gas produced by the combustion of a given weight of sulphur; in this particular case the pump not only serves to force the sulphurous fumes into the must, but also acts as a regulator of the introduction of air, in such a way that the combustion of the sulphur is proportional to the rate of pumping.

A 120-gallon cask with the head knocked out makes an excellent sulphur stove, by placing on the ground an iron pot containing the lighted sulphur, and covering the pot with the cask, the lower edge of which is slightly raised to allow the passage of air. The suction tube of the pump is fixed to the bung-hole, the forcing tube being connected with the vat

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* It would be, however, necessary for the rubber tube not to be placed in contact with the iron hoops, and to fit on the wood only. This case is rather exceptional, as the centre hoops pass very close to the top manhole.

(Fig. 54), the gas resulting from the combustion forced into the vat is *completely* absorbed by the must, during the operation no sulphurous smell can be detected around the stove, nor at

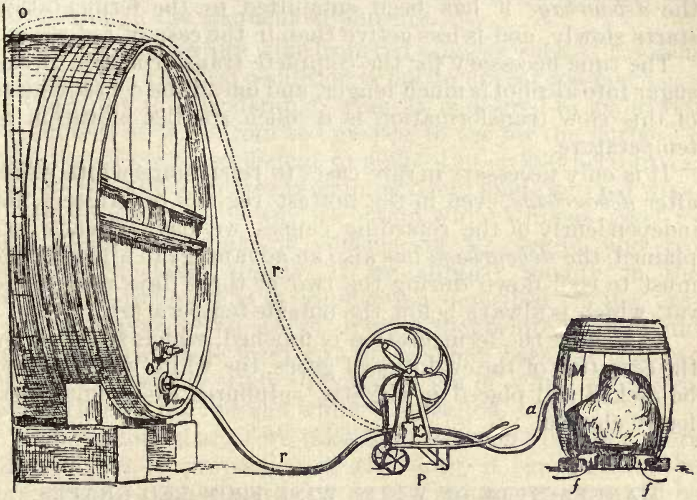

Fig. 54.—Pump Sulphuring.

the top hole of the vat. This is an evident proof of the complete absorption of the gas and of a rigorous measurement, for it suffices to weigh the sulphur to be burnt. To apply this method to the *débourbage* of white wine, we begin to force the gas when the vat contains a few hectolitres of must, the filling up and the sulphuring continuing simultaneously, the latter requiring less time than the former. The pump is stopped as soon as the vat is sufficiently full, and we can then as an extra precaution give a few strokes of the pump to complete the stirring of the mass, and insure the perfect mixing of the sulphured must with that added subsequently.

FERMENTATION.

When, after sufficient lapse of time the previously opaque must has become opalescent, the moment has arrived to separate it from the deposit, and to remove it to the vat where fermentation is to take place.

During this operation the must should be very energetically aerated to allow the last traces of sulphurous acid to be transformed by the oxygen of the air, and to enable the oxygen to remain in solution in the must, so as to assist the multiplication of the yeast. When placed in the fermenting vat the white must may be left to itself without any danger, through the *débourbage* it has been submitted to, the fermentation starts slowly, and is less active than in the case of red wines.

The time necessary for the complete transformation of the sugar into alcohol is much longer, and one of the consequences of this slow transformation is a much smaller elevation of temperature.

It is only necessary in rare cases to refrigerate white wines after *débourbage*, even in the hottest regions of Algeria, for independently of the retarding causes we have already explained, the *débourbage* has also an advantage in allowing the must to cool down during the two or three days rest in the vat, which is always below the outside temperature.

As soon as the fermentation is finished, which is shown by the cessation of the evolution of gases, the white wines should be racked and placed in slightly sulphured casks until perfectly cleared.

MANUFACTURE OF WHITE WINE FROM RED GRAPES.

The only difference resides in the precautions taken to insure the non-dissolution of the colour, it is essential:—

First—To avoid incipient fermentation before the separation of the must, carefully avoiding squashing the grapes before they are brought to the crusher, and proceeding rapidly with the operations of crushing and pressing.

Second—To crush the grapes without disintegrating the skins, so as not to liberate the colouring matter contained in their cells.

Third—To destroy as completely as possible the colouring matter which may have been dissolved in the must, and separate by *débourbage* the fragments of coloured skin in suspension.

Therefore, to make white wine from red grapes we must lightly crush the grapes, separate the juice by drainage, and then by pressing, reserving the juice to be fermented to red wine as soon as it becomes too strongly coloured, then proceed to the *débourbage*, and finally leave to ferment.

This is the process most generally used, but always furnishes wine too pink to be called white, and not enough coloured to be called red.

It is necessary after fermentation to sulphur strongly several times, to reduce the colour, and it is not possible to make really white wine without altering the character of the taste through the frequent sulphuring.

To obtain fine white wine from red *cépages*, such as Aramon for instance, the first condition is not to expect too much.

We think it is preferable, when it is desired to make 100 hectolitres of wine from red grapes, to use for the purpose a quantity of grapes sufficient to make 150 or 200 hectolitres, the 50 or 100 hectolitres remaining being made into red wine.

By working in this way we obtain white wine as good as it is possible to make it, considering its origin, and red wine of excellent quality, if we slightly modify in the latter case the method of vinification described in the preceding chapter. We are of opinion that white wine should not alone be made from red grapes, but both, so that we cannot exclusively study the vinification of white wine here, but rather mixed red and white vinification.

It is evident that, if we take from Aramon vintage a more or less greater proportion of the must it can furnish, the proportion of marc and juice in the remaining part will be very different to what it would have been normally. We should, therefore, apply to the remaining part a method only allowing in a lesser degree, the solution of the substances contained in the marc. By limiting the extraction to 40 per cent. we obtain from Aramon a colourless juice which may furnish a good type of white wine made from red grapes. There is no special rule for the vinification of this must, it is submitted to exactly the same operations as in the vinification of white grapes above described, and the same quantity of sulphur used for the *débourbage*.

In the vinification as red wine of the remainder of the juice, not used for making white wine, stemming plays an important part. We have seen already that the unfavorable action of the stalks is due to a greater extent to the physical part played by them in facilitating the penetration of the marc by the must, than to the substances yielded by them to the wine.

The solvent power of the must may be considered constant, but the quantity of soluble matters it extracts from the marc depends on the surface in contact and the time the contact lasts. It is evident that the surfaces in contact will be increased in this case, it is therefore necessary to render the

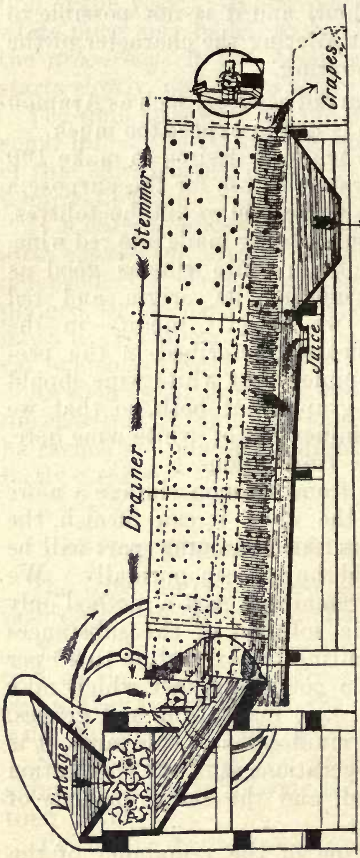

Fig. 55.—Blaquière's Combined Crusher, Drainer, and Stemmer (side view).

marc as impenetrable as possible, and to shorten by half the period of maceration. Blaquière's machine (Fig. 55), constructed for the manufacture of white wine from red grapes, crushes, drains, and stems at the same time. It does good work, but in our opinion the proportion of must separated is too great. Probably, by diminishing the length of the drainer so as to obtain only 40 per cent of white juice, the results would be better.

Fermentation starts very rapidly in marcs incompletely drained for white wines, the temperature rises quickly and reaches on the second day the limit above which the yeast works imperfectly.

This elevation of temperature is one of the principal causes of the failures in the manufacture of these wines, the inherent defects of high temperatures are still increased in this case by the greater quantity of marc in contact with the must. We cannot therefore expect to obtain red wine with fine colour, and clean taste, if we do not maintain the vat between the limits of temperature shown as most favorable, *i.e.*, 28° to 30° C.

This method of mixed vinification—the only one giving good bright wines up to the present time—might be replaced with advantage by that which L. Semichon,* Director of the Œnological Station of the Aude, studied and perfected last vintage.

* L. Semichon. *Revue de Viticulture*, 1897.

The experiments of Semichon on this subject possess an undeniable importance for the South of France. We will quote *in extenso* this communication, trusting it will be applied in practice by the viticulturists of the South.

NEW METHOD FOR THE VINIFICATION OF WHITE WINES.

"The consumption of white wines has greatly increased in latter years, raising as a consequence the market value of this product. For this reason viticulturists have tried to render practical the manufacture of white wine from red grapes; in this direction the efforts of all tended to obtain the greatest possible yield of pink must from a given quantity of vintage, but have invariably depended on the old process of manufacture based on decolouration with sulphurous fumes.

This process, however, is very defective, the enormous difference in the bouquet and flavour between pink and white wines made from the same grapes, already shows that the sulphurous acid deprives the wine of many of its qualities, and leaves a disagreeable taste. It acts as a reducing agent, and decomposes the colouring matters by removal of oxygen. When the wine comes in contact with air through the various manipulations it is submitted to, it absorbs oxygen, the colouring matter re-appears and the wine becomes pink.*

"If, therefore, the white wine made in this way is truly white and neutral in taste, we may assert that it is in a state of unstable equilibrium, between two situations equally defective, the excess of sulphurous acid which gives it a bad taste, and its inherent defect which renders it pink.

"These two defects are serious obstacles in commerce, and of such importance that many merchants have given up buying or making white wine from red grapes; we are almost obliged now to obtain good table wine to have recourse to wines made from white grapes.

* As far as the unfavorable action of the sulphurous acid is concerned, we do not share the opinion of our colleague, for here, as anywhere else, it is a question of exact measurement of the sulphur used. We have noticed that the sulphurous acid produced by the combustion of sulphured cloth remains more evident in the wine than that produced by the combustion of pure sulphur. This is caused, no doubt, by the formation of sulphuretted bodies, due to the combustion of the organic matter of the cloth.—L.R.

"In 1895, Martinand* studied a more rational method for the decoloration of must, which seems destined to have, in practice, a great future. It consists in oxidizing the colouring matter and precipitating it, instead of simply masking it by reduction.

"The method of vinification he advocates includes five different phases :—

1. Extraction of the must without taking the colour into account.
2. Cooling below 15° C. to prevent fermentation starting.
3. Aeration of the must and oxidation to precipitate the colouring matter.
4. Filtering under pressure.
5. Fermentation.

"This method presents, in practice, many difficulties—for instance, the refrigeration to below 15° C., which requires special machines, and is difficult to apply on a large scale; and the filtration under pressure, which is tedious and delicate, requiring expensive apparatus.

"We have been able to modify this method, so as to render it simpler and more advantageous than the sulphurous acid method. It suffices to dispense with refrigeration, and proceed to aerate rapidly by causing the must to fall in a shower in contact with the air, immediately after crushing or pressing.

"The colour changes to brown, through the oxidation of the colouring matter, which remains suspended in the liquid.

"The essential point is that the oxidation be sufficient for the colour to remain insoluble, in the mixture of water, alcohol, and acids, constituting the made wine ; the fermentation proceeds in the usual way, and when completed, the particles in suspension subside slowly. We may, however, increase the rate of subsidence by a slight fining, for the oxidized colouring matter plays the part of tannin.

"It is indispensable in Martinand's method to separate the colouring matter before any formation of alcohol, however slight, and that is why he advised the refrigeration of the musts so as to retard the fermentation, and to aerate and filter before it started.

* *Revue de Viticulture,* vol. iv., 1895, and *Comptes rendus de l'Academie des Sciences,* 1895.

"Experiments showed us that this is not indispensable, and that it is possible to aerate sufficiently before the production of alcohol be detectable.

"And, further, the separation of the oxidized colouring matter is useless.

"To ascertain the value of this method, we studied it under most favorable conditions, and made the following experiments at the Château du Pech, belonging to Mrs. de Rivière, with the assistance of the manager, Mr. Ritouret.

"On the 4th September, 1896, we started to fill, in the morning, a 300 hectolitre vat with Aramon vintage. After several hours, the vat being half full, we drew must by the bottom opening, and divided it into three casks.

"No. 1. A 120-gallon cask, with the head knocked out, through the contents of which air was forced for one hour.

"No. 2. A 120-gallon cask, strongly sulphured, to make wine by the old process.

"No. 3. A 120-gallon cask, in which the wine was left to ferment naturally, to make pink wine.

"The must drawn from the vat had a temperature of 18° C, and was decidedly pink in colour.

"The must, No. 1, after an hour's aeration, became brown coloured, the oxidized colouring matter remained in suspension in the state of fine particles, which pass through any filter; the next day, 5th of September, it was again aerated for one hour, the brown turbid must was then placed in a new cask and left to ferment.

"Ten days after No. 1 was still slightly fermenting, turbid, but white with slightly yellowish tint; it was racked, the colouring matter subsided gradually, and in February the liquid was of a bright yellow colour with a very slight turbidity.

"No. 2 presented the maximum of decoloration and limpidity on the evening of the filling up; ten days after it had not started to ferment. By error the sulphur had been used in excess, and we were obliged, in order to make the fermentation start, to rack it several times in contact with air; during this operation the sulphurous anhydride gave by oxidation sulphuric acid, which conduced to the re-appearance of the colouring matter; six weeks after the must was in tumultuous fermentation, and the colour re-appeared; now in February it still contains unfermented sugar, and is the most strongly coloured of the three.

"No. 3 was decidedly pink, and still slightly fermenting ten days after ; ten weeks after it was still pink, bright and dry, and retained these characters.

"The wine made by the aeration process only presents the difficulty of clarification, and we made several experiments on this subject.

"*First*—The filtration is infinitely easier and more rapid, as might be foreseen, with wine than with must.

Second—The addition of a small quantity of salt, by increasing the density of the particles in suspension, favours their subsidence; but we do not advocate this method, as it affects the taste of the wine.

"*Third*—A slight fining gives a still better result; with 10 grammes of isinglass per hectolitre we obtained a bright wine of fine yellowish colour.

"If a few drops of sulphuric or nitric acid be added to the wine before fining, it becomes pink, the colouring matter in suspension being dissolved by the acid; prolonged action of air never has this result. If the acid is added after fining, the wine retains its yellowish colour, whatever may be the quantity of acid added.

"It is, therefore, certain that it is the colouring matter in suspension which renders the wine turbid, and that it plays towards the finings the part of tannin, that the bright wine fined or filtered will never become pink again, as wine made by the sulphurous acid process does, for the colouring matter, instead of being simply masked, is completely separated.

"What degree of aeration is necessary and sufficient?

"We determined the influence of prolonged aeration, and obtained the same results as Martinand. We will now show that the aeration of the must in No. 1 was excessive. The following are the results of comparisons of the musts of three wines made in the cellar, taken the evening of the filling of the vat, and left in glass flasks to finish fermenting naturally, with five samples of the same must taken the same day from the bottom of the vat and submitted to aeration, varying in duration. The aeration was effected by means of a bellows connected with a glass tube, terminated in a finely-drawn-out point. These samples were afterwards left to ferment naturally.

" With regard to their colour and classification, they may be placed as follows :—

Description of Sample.	After One Month.	After Two Months.
Wine from No. 2, sulphured	Pink, in consequence of excess of sulphuring	Pink, in consequence of excess of sulphuring
Duplicate, not aerated	Pink, clear ...	Pink, clear
Aerated one-quarter of an hour	Colourless, very turbid	Colourless, very turbid
Wine from No. 3, pink*	Colourless, turbid ...	Colourless, slightly turbid
Aerated for half-an-hour	Slightly yellow, turbid	Flask broken
Aerated for three-quarters of an hour	Slightly more yellow, a little less turbid	Slightly more yellow, almost clear
Aerated one hour ...	Also as above ...	Also as above
Wine from No. 1 (aerated for one hour by pumping in a cask)	Yellowish, turbid ...	Also as above

" These comparisons show that the yellow coloration is due to a more complete oxidation of the must, and the clarification of the wine seems to be more rapid as the aeration is prolonged.

" The aeration made in the cellar on the evening of the first day was greater than that made in the flask in the laboratory; by accident the flask No. 3 was broken, and the must through this absorbed more air. This was sufficient to discharge its colour.

" It would appear, therefore, that in the first experiment in the cellar the aeration was excessive, and that white wines may be made from Aramon by slightly aerating the must with the pump, or by letting it fall in a shower through a perforated plate.

" It is our intention to try this on a large scale next vintage.

" It is easy to ascertain if the aeration has been sufficient to discharge all pink colour. The following process, which we adopted in the laboratory, should be used :—

> " A few cubic centimetres of the must is passed through filtering paper; when the liquid is nearly all through, a few cubic centimetres of an aqueous solution containing 10 per cent. of alcohol and 1 per cent.

* The flask broke, and the wine remained in contact with air during one hour. It was then decanted. These operations were sufficient to render it colourless.

tartaric acid is poured into the funnel. If the liquid passing through the filter is pink, the aeration is insufficient, and the pumping of air through the vessel must be continued. The solution used has a percentage of alcohol and acid equal to or greater than the wine to be made, so if the colour is not dissolved in this solution it follows that it will not be dissolved in the wine.

"What is the value of the wines made by this new method? They do not possess the defects of wines made by the use of sulphurous acid, and after comparing three wines made at Pech, the following results were obtained :—

"With regard to flavour, the aerated wine (No. 1) is green, *nerveux*, and fruity ; No. 2 still contains sugar, which prevents a fair comparison with the two others. It tastes of sulphur, and has no fruity flavour ; No. 3 is pink, has as much fruity flavour as No. 1, but is not so *nerveux*.

"It might be thought that aeration would alter the constitution of the wine. We point out, however, that the must does not contain any volatile matters liable to be dissipated by the current of air. Here is the result given by analysis of these three wines :—

	No. 1.	No. 2.	No. 3.
Alcohol, per cent., in vol. ...	10·1 ...	8·0 ...	10·1
Total acidity, per litre ...	5·76 ...	6·77 ...	5·34
Dry extract	15·95 ...	57·30 ...	16·90
Ash	1·75 ...	2·65 ...	2·30
Reducing sugar	— ...	37·39 ...	—

"These results show that the alcoholic strength is the same for the white and pink wines, whatever process of manufacture is used. The 37 grammes of sugar in No. 2, which had not yet fermented, would give about 2 degrees of alcohol, which would bring the figure for No. 2 to the same as the others.

"The total acidity is slightly higher in the aerated wines, but the difference is negligible. The high acidity in No. 2 is due to the sulphurous anhydride transformed into sulphuric acid.*

"The dry extract of No. 1 is less than that of the pink wine No. 3. This is due to the precipitation of the colouring

* The difference is such that it does not seem attributable to the sulphurous anhydride only ; for, if this were so, it would have required such a heavy dose that fermentation would have been rendered impossible.—L. R.

matter through oxidation. On the whole, the composition of wine made by this new process is practically the same as that of the corresponding pink wines.

"In conclusion, it is to be hoped that this new method of manufacturing white wines will prove advantageous to both wine manufacturers and merchants.

"1st. In vineyards where Aramon is in excess, and where the wine obtained from it is deficient in alcohol and colour, it will be possible to transform a portion of the vintage into white wine, and thus get a better return. On the other hand, the Aramon being in smaller proportion in the rest of the vintage the wine will gain in colour. In years of abundant vintage, where the grapes are large and give lighter wine, deficient in dry extract and colour, a part of the must may be drained from the bottom of the fermenting vat and made into white wine. The remainder, fermenting with a greater proportion of marc, will consequently be richer in dry extract and colour.

"2nd. The total extraction of the must by pressing, as advocated by Martinand, will dispense with the costly and complicated plant necessary to extract the limited possible quantity of slightly coloured must from red grapes.

"3rd. It is probable that this method will be applicable to other red *cépages*, such as Carignan, Grenache, and Cinsaut, &c., producing wines of higher value ; this will be tried during next vintage.

"4th. The trade will obtain white wines of clean taste, and good keeping qualities, able to be used for the same purposes as wines from white grapes, and not presenting the defects of wines made by the use of sulphurous acid."

CHAPTER VI.

UTILIZATION OF BY-PRODUCTS.

The by-products of wine manufacture are—the marc from the press, the lees, and the tartar. Each of these by-products has a definite value, and bears a certain proportion to the value of the total vintage.

Marc.

It is necessary to distinguish between marc from white and red wine.

The latter is usually utilized in the South of France for the production of piquettes, or the manufacture of spirit; the alcohol may be obtained by direct distillation or by the distillation of the piquettes.

Direct distillation is only possible in the case of red marc, and is not usually done by the vineyard proprietor, but by distillers working by contract.

The alcohol obtained from the distillation of marc is very much in request in the East of France for immediate consumption, but is not thought much of in the South. Its value is always less than that of wine-spirit (brandy); for this reason we do not advocate direct distillation, as distillation of piquettes gives a much finer product, and are of opinion that in our region the marc should only be used for the manufacture of good piquettes for immediate consumption or distillation, as the case may be.

The object in manufacturing piquette is to obtain in as small a volume as possible the total alcohol remaining in the marc.

Whatever may be thought about it, however well drained the marc may be, it always contains a large proportion of wine.

Analyses made by Boussingault, Barral, Marès, Degrully, Bouffard, &c., show that the pressed and drained marc generally contains 70 per cent. of liquid, or, to be more correct, of volatile matters; in other words, this means that 100 kilos. of drained marc contain 70 litres of wine.

With the new process this figure is decreased, but never falls below 55 to 60 per cent.

It is therefore absolutely necessary, if we do not extract this wine from the marc, to utilize the alcoholic contents in some way or other; the only really practical means is in the manufacture of piquette.

There are actually three methods of doing this, of very unequal practical value, as shown by Prof. Bouffard* :—

1st. Maceration ; 2nd. Sprinkling, or lixiviation ; 3rd. Methodical washing by displacement.

For these three methods the marc must be disintegrated and rammed into a suitable vessel.

To apply the maceration method, a certain quantity of water must be added to the rammed marc, and left in contact with it during a few hours; the water is then racked off, and replaced by a fresh quantity, and so on till the racked-off water does not extract any more wine.

This is a very defective method, furnishing very weak piquettes; it does not answer the desideratum contained in the definition given, which is to accumulate in the smallest possible volume the integral quantity of alcohol contained in the marc.

The second process, sprinkling or lixiviation of the marc, may be either intermittent or continuous, and is widely used in the South of France.

A vessel filled with rammed marc is provided with an open tap at the bottom, and the upper surface of the marc is sprinkled by means of different devices (like lawn

* *Progrès Agricole et Viticole.*

sprinklers) Fig. 55, amongst which we may note the Bourdil hydraulic sprinkler, and Paul's piquette sprayer.

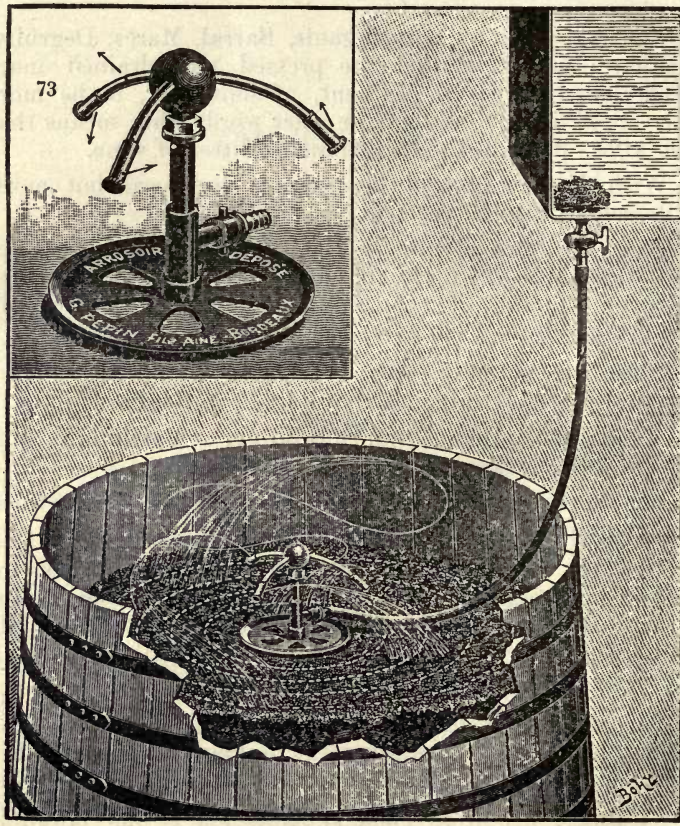

Fig. 55.—Hydraulic Sprinkler.

The water descending through the mass diffuses with the wine contained in it, carrying away the wine by the tap, yielding piquettes which become weaker as the operation is continued.

It is necessary in using this method to operate with great care, stopping the operation when the piquette falls below 2 per cent. of alcohol. On mixing all the fractions a mixture of half the alcoholic strength of the original wine should result.

There is in the lixiviation method a serious defect. This is the drawing downwards of an alcoholic liquid of less density than water, which has naturally a greater tendency to rise up. This drawing down is only obtained by establishing a rapid current of water, which is done at the expense of the alcoholic strength.

The third system—methodical washing by displacement—is easily done with suitable vessels, and is free from all the above criticisms. It exhausts the marc satisfactorily, and yields from the commencement till almost complete exhaustion, piquettes nearly as strong as the original wine, or, at any rate, by mixing all the fractions a liquid of average alcoholic strength very near that of the wine results. Figure 56 (p. 194) shows diagrammatically the arrangement to be adopted. It is easy to fix this up with any vessels or casks, varying in size according to the quantity of vintage to be treated.

In methodical washing done by displacement we aim more at forcing the wine upwards than at obtaining diffusion; theoretically the water acts only as a piston, adapting itself to the irregularities of surface, filling all the cavities, and pushing out the liquid, wetting those surfaces or imprisoned in the cavities.

In practice this does not happen, however, as diffusion takes place ; but, as we have already pointed out in speaking of the non-pressed marc, the diffusion zone only forms a layer of a certain thickness, so that we can almost always obtain pure wine at the end of the system. The essential point in methodical displacement (per ascensum)—that is to say, by means of a rising instead of a descending column of water—is to carefully regulate the rate of flow of the water. The ascensional speed should always be slow enough not to drown the marc, as this would simply place the process on the same level as that of maceration or lixiviation.

One of the conditions for success depends on the arrangement of the marc, which must be well disintegrated and evenly rammed.

The vats should be provided with false bottoms, under which the water enters. The first vat overflows into the second, the second into the third, and so on. Four vessels are sufficiently efficacious.

It is easy to explain the good results given by this method.

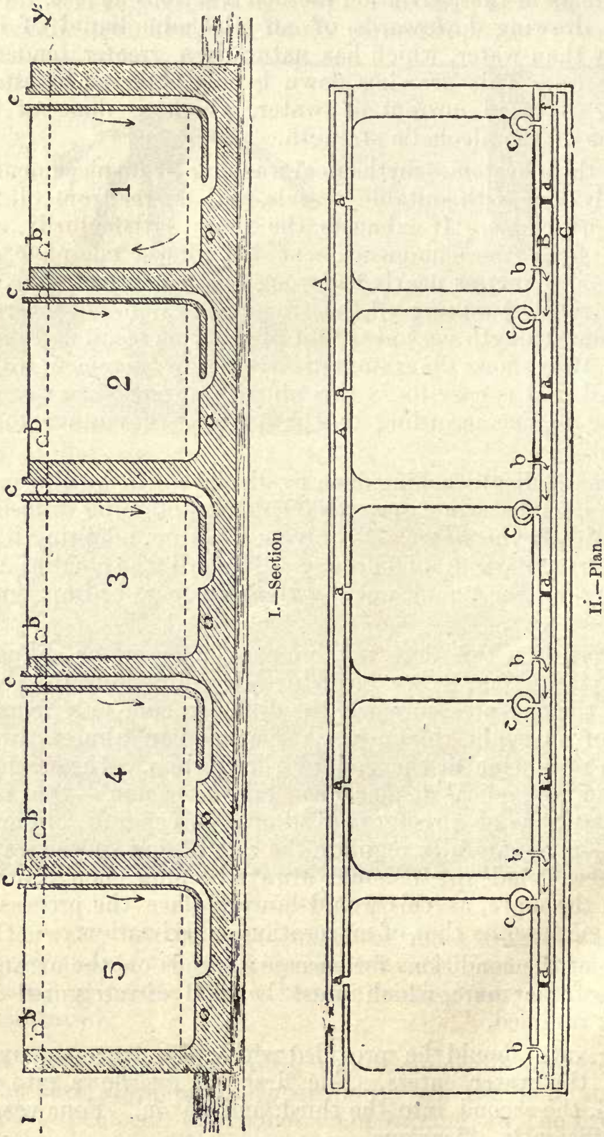

Fig. 56.—Arrangement for making Piquettes.

Instead of a continuous operation, let us consider the case of an intermittent one, and the four vessels full of marc, from wine giving 10 per cent. of alcohol.

If the marc contained 60 per cent. of wine, 100 kilos. would contain 60 litres. Let us wet or submerge the marc with as many times 60 litres of water as there are 100 kilos. of marc, and let it remain in contact. The diffusion takes place progressively, and, after a few hours, the vessel will contain for each 100 kilos. of marc 120 litres of liquid, the alcoholic strength of which will be half that of the original wine—that is to say, 5 per cent.

Let us now pass 60 litres of this liquid into the second vessel, also charged with marc containing 60 per cent. of wine; after contact the mixture will have an alcoholic strength not lying between 10 and 0, but between 10 and 5 —that is to say, 7·5 per cent.

Through the same procedure the third vessel charged with the liquid from the second will yield a piquette containing 8·75 per cent. of alcohol, and the fourth vessel charged with the liquid from the third will yield a piquette containing 9·5 per cent.

In a continuous operation the results are the same, or even better, for in a well-performed operation the liquid overflowing from the first vessel into the second would already have an alcoholic strength above half that of the wine.

In practice it is usual to stop washing the first vat when the liquid overflowing into the second has become poor in colour, and contains 1½ to 1 per cent. of alcohol. In a successful operation the alcoholic strength falls rapidly. In a few minutes to one hour, according to the size of the vessel, the piquettes fall from 5 or 6 per cent. to 1 per cent. The water delivery should then be directed into the second vessel, the first being disconnected, emptied, and recharged with fresh marc, and connected to the opposite end of the system.

It is, therefore, the methodical washing by displacement which seems to be most recommendable. We think it is the only method enabling rich piquettes to be obtained, of good keeping qualities, and also more easily and economically distilled. The alcohol obtained by distillation of well and soundly made piquettes has none of the defects of that extracted from the marc direct; on the contrary, it possesses all the qualities which give wine-spirit a higher value.

With regard to marc from white wines, we must operate differently; the problem here is reversed, for it is must, a liquid denser than water, that has to be extracted from the marc.

Sometimes the white marc is left to ferment as it comes out of the press, and is later on converted into piquette, or distilled directly; in both cases the result is very unsatisfactory, the fermentations taking place in pressed marc are always bad. The piquettes obtained from it are execrable and cannot be used for consumption, and the alcohol resulting from their distillation does not repay the cost of production.

The direct distillation of fermented white marc does not give better results.

It is therefore necessary to treat the marc directly it leaves the press, to accumulate its sugar contents in water, and leave the saccharine solution to ferment, distilling it ultimately.

The operations are performed in the same vessels as in the case of red marc, but in this instance we must use the lixiviation method, spraying over the second vessel the liquid gathered from the first, and so on.

The leaching of the first vat is stopped when the liquid leaving it does not taste sweet.

It is imperative in this operation to act quickly, to avoid, as far as possible, too active fermentation in the mass.

As in the case of the treatment of red marc, the exhausted vessels are emptied, charged again, and placed at the other end of the system, while the second vessel becomes in its turn the first. The marc exhausted in the manufacture of piquette cannot yield anything more, but constitutes a good food for cattle, and if not used for that purpose may be used for manure.

The preservation of washed marc for cattle food is more difficult than that of marc simply taken from the press, for, in the latter case, the wine or alcohol it contains protects it in a certain measure against alterations.

It is necessary to take more care for the preservation of washed marc.

The best method consists in stratifying the marc with salt in the proportion of 2 to 3 per cent. in vats or silos compressed tightly, which is easily done by placing a lid weighted with full hogsheads on top, at the rate of 500 kilos. per square metre of surface. Under this small but continuous pressure the height diminishes considerably, and a great quantity of water escapes from the bottom of the vat or silo, the mass becomes very compact, and only the first few centimetres become affected by fungi.

The marc from white wines may be treated in a similar manner, the residues from the distillation of piquette contain a great quantity of tartar, but we cannot think of extracting it. It has, however, a fertilizing value on account of the potash it contains, and should be thrown in the manure pit. It is indispensable to mix it with manure, for in the state it leaves the still it cannot be applied directly to the soil, as it would destroy the roots and kill the plants with which it came in contact, unless used in small quantity or treated with lime to first neutralize the acids.

The direct distillation of marc assures the recovery of an important part of the tartar it contains, but this slight advantage does not counterbalance the other imperfections of the method.

Lees and Tartar.—The lees deposited by both red and white wines, during the time which elapses between the fermentation and the second racking, have considerable value, on account of the bitartrate of potash they contain. The lees from the *débourbage* (sedimentation) of white wines are only fit for manure.

The lees should be treated to extract the wine they contain before being sold for tartar.

However thick they may be, they contain, when leaving the cask or vat, more than 75 per cent. of their weight of wine. The simplest method to extract the wine consists in filling strong cloth bags with the lees, piling them in the press, and submitting them to slight but continuous pressure.

The wines gathered in this manner are not of much value, but may be used for the still. However, submitted to judicious treatment they improve, and may be used for consumption.

The pressed lees should be treated for their tartar by the wine-maker. This is a simple and remunerative operation, for the tartar obtained has always a higher value than that of the lees, and what is more, we retain in addition the residues from the treatment, which are first-class for manuring purposes. The value of tartar per unit is always less in the lees than in cream of tartar.

Good lees in a dry state do not contain much more than 25 per cent. of tartar, and the 25 kilos. of tartar is the only substance paid for by the buyer when fixing the price of 100 kilos. The remaining 75 kilos. contain about 4 per cent. of nitrogen, which at the market price of 1·50 fr. per unit brings the value of the 75 kilos. to 4·50 fr. per unit.

The wine-maker should, therefore, try and extract the tartar from the lees for two reasons—first, because the tartar easily obtained at 80 per cent. strength can be sold at 1·40 fr. per unit, while only 1 fr. or 1·10 fr. would be paid for the tartar in the lees. Secondly, because it retains on the property an excellent manure, which costs nothing.

It goes without saying, that it is not necessary to treat the lees every year. One may, after drying, store it, and treat it every other year according to the quantity.

The extraction of tartar from lees is very simple. It only requires a large boiler and casks.

The strength of the lees being known (we will see later on how it is ascertained), it is boiled with water, placing such a quantity of lees in the water as will represent about 7 kilos. of pure tartar per hectolitre of water.

With lees of 25 per cent., about 30 kilos. of lees should, therefore, be added to one hectolitre of water.

After a quarter of an hour's boiling, during which the mass is stirred, allow it to deposit for a few minutes; the liquid is then passed through a piece of canvas stretched over a tub, and the operation started again; on cooling the water previously boiled with the lees, almost the whole of the tartar in solution is deposited. Each hectolitre of water used should yield about 6·5 kilos. of tartar, while a half kilo. remains dissolved, but is not lost, for the same water may be used again four or five times.

If used a greater number of times it becomes rather viscous, preventing the rapid deposition of the tartar. It should, therefore, be renewed after four or five treatments.

The residues remaining on the canvas, and the water, are sent to the manure pit.

We can, even without much trouble, dispense with the filtration through canvas, and replace it by simple decantation; in this case the boiling must be stopped, the liquid allowed to remain undisturbed for ten minutes or a quarter of an hour, then racked and placed in the depositing vessel. The residue is then removed from the boiler and sent to the manure pit, or kept dry till required.

At the actual market value of tartar* 1·25 fr. per degree in cream of tartar, and 90 centimes in the lees. 1,000 kilos. of lees at 25 per per cent. would give by this treatment, deducting the possible loss:—

225 kilos. of tartar, at 1·25 fr.	281·25 fr.
775 kilos. residue for manure, at 4·50 fr. per 100 kilos.	34·85 fr.
Total ...	316·10 fr.

While the direct sale of the lees would only bring in 225 fr.

It is necessary to treat 1,000 kilos. of lees, to boil about 35 hectolitres of water, the fuel used for this operation represents a sum much smaller than the credit difference. The labour itself does not add greatly to the expenses, and the work may be done during bad weather, when the men cannot attend to the ordinary out-door work. The figures quoted are exact, assuming that the lees are paid for on the real percentage of tartar, but this is almost never done; more often than not the lees are sold without previously determining their strength, and are in fact frequently sold for almost nothing before the wine they contain has been separated, that is to say, in the form of a thick liquid containing 75 per cent. of wine. In this method of doing business everything is in favour of the buyer.†

The tartar obtained from the crust deposited in the casks cannot be submitted to any treatment by the wine-maker, as the increased value it would acquire by refining would not compensate for the extra cost involved. As for the complete refining, it is an operation which only pays on a very large scale.

The tartar deposited as a crust in the vats, and that extracted from the lees, should, therefore, only be sold on the percentage of bitartrate of potash contained ; but it is necessary for the wine-maker, who cannot wait for the

* July, 1897.

† The boilers used for the destruction of the pyrale (caterpillar) on the stumps of vines may be used to furnish the boiling water for the treatment of the lees. In this case a simple cask may be used for the dissolution of the tartar, taking care, however, to charge the water with a little less lees on account of the difference of temperature, which will always be less if the water is removed from the boiler.

result of a laboratory assay or accept that given by the buyer, to ascertain, at least approximately, the value of the tartar to be sold.

Determination of the percentage of bitartrate of potash in the crust or lees.

F. Chabert, Analyst at the Œnological Station of the Hérault, has tried to realize the conditions under which the acidimetric method generally used in laboratories may be placed in the hands of persons not accustomed to chemical manipulations ; and, in order not to increase the laboratory outfit of the cellar, to use for this purpose the apparatus generally employed for measuring the acidity of the must.

We require, as in the case of the acidimetre,

A burette graduated in tenths of a cubic centimetre.

A titrated alkaline solution of potash or soda.

A glass flask of one litre capacity.

An alcoholic solution of phenolphthalein.

Litmus paper.

Such is the material necessary for testing the tartar.

A thorough sampling is the first condition necessary for a reliable analysis.

If the tartar is contained in bags or placed in heaps, a handful is taken from different parts of every bag or heap. These are placed together, and will form a sample varying in size according to the bulk of the stock. This first sample should then be thoroughly crushed, well mixed, and divided into two parts. One-half is then replaced in the bags, the other half being re-submitted to the halving operation, and so on until a perfectly homogeneous mixture is obtained. An average sample is then drawn off, of four or five hundred grammes, which is powdered in a mortar, and serves for the analysis.

Analysts usually operate on very small quantities, but it is better for persons not conversant with operations of this class to work on a rather large weight—the possible errors are then only multiplied by a small figure, and do not notably influence the results calculated to 100.

By working on 5 grammes of tartar, fair accuracy is obtained. The indispensable weighing is a delicate part of the work, for it must be done with a balance turning to 1 or 2 centigrammes, and such balances are not often found in cellars.

Any pharmacist or chemist can perform the weighing; but we think that sufficient use might be found for a small balance to justify its purchase. The price, however, is a trifle, and does not exceed 20 francs (16s. 6d.).

The 5 grammes of tartar or lees are placed in the glass flask, 300 to 400 cubic centimetres of distilled water added, and the contents boiled. Four or five minutes' boiling is sufficient to insure the complete solution of the cream of tartar. An insoluble residue always remains, of varying quantity, according as the operation is made on lees or crust. It is not necessary to decant, for in this case we should be obliged to wash the residue two or three times with 50 cubic centimetres of boiling water. It is on the solution of tartar and in the flask itself that the determination is made. Add to the solution, after boiling, four or five drops of phenolphthalein, then while constantly agitating the contents of the flask add the alkaline solution from the burette till the red colour appears and indicates the end of the operation—the change of colour is readily detected after a few trials. With white tartars it is so decisive that one drop in excess of the alkaline solution is sufficient to cause the appearance of the colour. Its detection when working on red tartars is not so easy; but we may use a much surer although rather more tedious method, that is, by testing from time to time with litmus paper.

When the end of the reaction is almost reached the mixture becomes bronze coloured. The appearance of this colour is an indication that the reaction is almost finished. If from this moment, after each two or three drops of the alkaline solution added, we remove a drop of the mixture by means of a stirring rod and place it on a strip of litmus paper, the paper will change colour and finally become pure blue, instead of the red colour it had in the preceding case. This change of colour indicates the end of the operation. The analysis is now finished, and it only remains to translate the figures obtained into definite results.

To arrive at the change of colour of the liquid, we used a certain volume of alkaline solution, as determined by the reading of the burette. Let us suppose that the burette, filled to zero with the alkaline solution, reads at the end of the operation 15·6 c.c. This means that 15·6 c.c. were used to neutralize the acidity of the tartar ; this acidity is proportional to its content in tartar. It suffices, therefore, to know to what acidity 1 c.c. of the alkaline liquor corresponds, in order to ascertain by a very easy calculation the richness in tartar. Let us suppose, to make this quite clear, an alkaline liquor in which each cubic centimetre corresponds to 0·10 gramme of tartaric acid, the ratio between tartaric acid and cream of tartar is 2·506, which means that 1 of tartaric acid corresponds to 2·506 of cream of tartar. The alkaline liquor will, therefore, in this case be equivalent to 0·2506 per 1 c.c. used.

Therefore, as we have used for 5 grammes of the solution of tartar, 15·6 c.c. of the alkaline liquor, the 5 grammes contained—

$$0.2506 \times 15{\cdot}6 = 3{\cdot}909 \text{ gr.}$$

and, therefore, 100 grammes would contain—

$$3.909 \times 20 = 78{\cdot}18 \text{ gr.}$$

In this particular case the strength of the tartar is 78·18 per cent.

It is not indispensable for the alkaline liquor to be of the strength above mentioned. It may be of any strength, but if too weak, it becomes necessary to use large quantities and unnecessarily prolong the operation. If, on the contrary, the liquor is too strong, too small a volume is used, and the slightest error in reading the volume delivered would be an appreciable factor in the quantities used. If, for instance, in the above case we had used a liquor four times stronger, an error of reading of 0·1 c.c. would have caused an error of 2 per cent. in the final result, while, with the solution adopted above, the same error of reading would only cause a final error of 0·5 per cent.

The figure of 0·10 gr. of tartaric acid per c.c. used in the above example, allows a sufficiently close approximation, and we think it is well not to exceed it. The most convenient limits for the strength of the alkaline liquor correspond to from 0·05 to 0·10 of tartaric acid per c.c., if the alkaline solution varies between these limits it may be safely used. It will suffice in any case to multiply the known strength equivalent to tartaric acid, by the ratio 2·506 to obtain its equivalent in tartar.

If, as often happens, the strength of the alkaline liquor is only known expressed as sulphuric acid, it may be converted to tartaric acid by multiplying by 1·53, and into bitartrate of potash by multiplying the result of the last multiplication by 2·506.

Example.—Take for example the alkaline liquor known as normal, very frequently used by analysts, and which may be easily purchased from any chemical laboratory, its strength is 0·049 in sulphuric acid per cubic centimetre, that is to say, that 1 cubic centimetre neutralizes 0·049 of sulphuric acid, its equivalent in bitartrate of potash is from what we have seen above $0{\cdot}049 \times 1{\cdot}53 \times 2{\cdot}506 = 0{\cdot}188$ of bitartrate of potash. If 20·6 c.c. of this liquor were required to bring about the change of colour in a boiling solution of 5 grammes of crude tartar, it means that the sample contains in 5 grammes—0·188 gr. × 20·6 c.c. = 3·87 gr.
and for 100 gr.—3·87 gr. × 20 c.c. = 77·4 per cent.

It is evident from the above that the testing is a simple operation. We may even use the alkaline liquor used for the determination of the acidity of the must, for, excepting the weighing and solution of the tartar, the operation is similar in every respect. All those accustomed to the measurement of the acidity of must will be able to perform this operation, with exactitude without further teaching.

It is understood that we only determine by this method the bitartrate of potash present, and not the bitartrate of lime, but this is of no importance. The value is always based on the contents of bitartrate of potash.

We urge upon wine-makers, who usually sell their tartar without any previous examination, to use the process above described, that is, if they do not wish to send the sample to a laboratory. They will very soon see the advantage resulting from the exact knowledge of the value of the goods placed on the market. Through the sale of the tartar, and by the use of the residues from the lees as manure, the wine-grower will every year make a net profit of 40 centimes per hectolitre of wine produced.

If tartaric acid has been used for the vinification the figure must be increased. This increase will recuperate a great part of the expense entailed in the purchase of tartaric acid.

CHAPTER VII.

CARE TO BE GIVEN TO WINE. DEFECTS AND DISEASES.

Normally constituted wine only requires rackings made at opportune times, filling up the casks as often as considered necessary, in order to acquire perfect brightness and be preserved against the germs which always exist in every vintage.

The number of rackings to which wine must be submitted, cannot be fixed *a priori*, neither can the way in which the rackings should be done, that is, either with or without contact with air. This depends on the constitution and future destiny of the wine ; the rackings should be numerous, and the aeration more or less intense according to the rapidity with which we desire to mature the wine.

Racking is simply a kind of decantation or separation of the clear wine from the subsided lees.

The first racking, which should be done a fortnight after the de-vatting, separates the wine from a great quantity of solid matters (yeast cells, vegetable particles in suspension, various micro-organisms), but it does not usually furnish bright wine.

This is due to the wine being saturated with carbonic acid gas which is only slowly liberated. The fine bubbles during their disengagement keep the light particles of lees in suspension in the liquid. Frequently, where we have to deal with musts rich in sugar, and which still retain a small quantity of it after fermenting, a slow after fermentation continues during several weeks in the racked wine in such a way that the wine, always bright just after de-vatting, becomes turbid again in a few days.

The cold during the winter completely paralyses the work of the different ferments, and induces rapid sedimentation, and consequently rapid clearing of the wine.

It is therefore when the wine, after the more or less prolonged action of cold, has acquired complete brightness, that the second racking should be done.

In the South of France this generally corresponds to the middle of January.* If the wines still remain turbid it means that they are defective, and they will then have to be submitted to operations or manipulations somewhat more complex than simple racking.

The selection of the day on which to perform the racking is not a matter of indifference. We should, on the contrary, always select a day when the barometer is high. There is a saying, in the South of France, that wine should always be racked or bottled when the *mistral* wind is blowing. This custom is very judicious, because when the *mistral* is blowing, the atmospheric pressure is always high.

Wine always contains carbonic acid gas in solution, although a large quantity is liberated at the first racking; long after the wine is found almost saturated with it, because the lees disengage it slowly but constantly.

The solubility of gases in liquids is so much the greater as the pressure is higher, the temperature being equal, so that, if wine saturated with carbonic acid gas remains completely still and clear on a fine day, when the atmospheric pressure is high, it is not so when the weather is unsettled, corresponding to a low pressure, on such days we will observe a more or less rapid disengagement of gas, which does not take place without causing the liquid to become turbid.

We should therefore not only choose a fine day for racking, but, to do it under still better conditions, choose a bright day preceded by several fine days.

The wine, usually perfectly bright after the racking, almost always becomes slightly turbid a few days after. This is due to the fact that several solid matters only exist in solution in the wine in the presence of carbonic acid gas; and that the oxygen, when the racking is made in presence of the air, renders some of the matters in solution in the wine insoluble, however, the result aimed at by the racking, that is to say, the separation from yeast cells, is attained. The subsidence of the solid matters taking place in the wine after the racking occurs very quickly, and the lees resulting are not detrimental.

It goes without saying that racked wine should be placed in thoroughly cleansed casks, rendered wholesome by sulphuring. The cask should be left open for a few hours

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* In Victoria, in the Northern districts about the end of June; in the Southern districts, June to July (Trans.).

before filling, to allow the sulphurous acid to escape ; this operation is necessary, for sulphuring, when done to render the cask wholesome, must be done so heavily that it would be detrimental to the wine if it were allowed to absorb it. However, if we should not introduce into the wine a large quantity of sulphurous acid, it does not mean that we should not sulphur at all.

Sulphur always exerts a favorable action on both white and red wines, in spite of the opinions to the contrary with regard to the latter.

Although it is necessary to sweep out the sulphur fumes by a good draught before filling, we think it will always prove of advantage to burn, before filling, a small quantity of sulphur, which may be fixed at 1 gramme per hectolitre.

Treated in this way, the wines of the South of France are sufficiently armed to enable them to pull through the summer, the casks only require to be kept completely filled.

Whenever wine is not perfectly clear and bright after the January racking (in Victoria about June), it means that it is diseased. The disease must then be treated at once by proper methods, to enable the wine to become bright and clear.

DEFECTS AND DISEASES OF WINE.

It is necessary to distinguish between *defective* and *diseased* wine.

A modification in the taste and physical aspect of wine constitutes a defect, but not a disease. The defects, especially those of taste, have a tendency to become attenuated by maturing. In any case, they do not get worse, while the modifications due to diseases, almost undetectable to the senses at first, increase to the extent of completely altering the constitution of the liquid and render it undrinkable, it an energetic treatment does not arrest the further progress of the evil.

Wines are all the more liable to contract defects or diseases, as the vintage is less healthy, the vinification less carefully conducted, and the cellar material less thoroughly cleansed and looked after.

In this, as in any other case, it is better to foresee the disease than to have to cure it. The absolute cleanliness of the cellar material, vessels, crushers, presses, pumps, hoses, and even the cellar and its surroundings, will avoid a great many of the defects and diseases of wines, and to a greater extent than one might really think. A proper method of vinification will do the rest. The sight, smell, and taste, are all called upon to form an opinion of the wine.

The *tasse* (Fig. 38) is a marvellous little instrument for observing wine, the play of light in it is an admirable help.

The smell enables us to detect certain defects which, not interfering with the colour, would pass unnoticed by the eye.

The degustation or tasting, performed with care, completes the impressions upon which are based a judgment of the wine.

The whole mouth, tongue, palate, and even the throat, serve to define the indications of the smell. By drawing back the liquid in the rear of the mouth with a movement similar to that of deglutition, we sometimes notice in an exaggerated or increased manner characters previously detected by the smell, and may thus more exactly determine their nature and intensity.

A yellowish colour is a frequent defect, and is independent of the cellar material. It is generally due to the abuse of racking during the course of fermentation.

We know that a great quantity of air is necessary to the must before the start of the fermentations, but when it has once started a small quantity only is necessary.

The practice of pumping over the head, excellent in so far as it gives more body to the wine, is often a cause of the yellow colour, because it is almost always done in presence of air, with wines always too hot. Hence the yellow colour of hastily-matured wine, which depreciates its commercial value.

The pumping over the head during fermentation is often useful when the aeration is only necessary for a languishing fermentation, and when the yeast requires invigorating. The yellow colour will be avoided if care be taken not to aerate excessively.

When the harm is done there is no other remedy but blending with other wines of finer colour and appearance.

When the wine becomes of a bluish-red, more or less blackish colour, it is a sign of a true defect in constitution.

Insufficient acidity in the vintage furnishes such dull wine, known as leaden, but the same shades of colour are found in almost all wines attacked by diseases due to microbes.

We have shown two ways of guarding the vintage against deficiency of acidity, the use of the second crop, and tartaric acid.

In vintaging early the resulting wine will always be acid enough. The first wines made are never leaden; it is therefore necessary, when vintaging at normal maturity, to increase the percentage of acidity by the addition of tartaric acid.

The last wines obtained from acidified vintage are as bright, fruity, and *nerveux* as the first made, while they are more alcoholic.

For a made wine the remedy is still tartaric acid, provided the leaden appearance is due to a deficiency of acidity, and is not the first symptom of a serious disease. The leaden wines resulting from a deficiency of acidity do not present any peculiarity to the smell, which is not ordinarily the case with diseased wines, but they show to the taste more flabbiness, flatness, and rapidly lose their vinosity when mixed with water. The acidification by addition of tartaric acid is a lawful and efficacious means of remedying this defect, but the action of the remedy is incomparably more satisfactory when applied as a preventative, that is to say, before the fermentation.

To ameliorate this class of wines, we should proceed by preliminary trials, on a quantity, to which tartaric acid is added in fractions of one decigramme, until the eye and the taste are satisfied with the operation. As a result, we will soon arrive at the amount necessary to be added to the wine, which usually lies between 50 and 100 grammes per hectolitre.

An earthy taste or flavour is also a very frequent defect. This is detected by the smell and taste, and is rather difficult to define exactly. The name is of no assistance, for it leads us to suppose that the defect is due to the soil the wine originates from. This has always been the popular belief; it simply means that we have been mistaken for a long while.

"Of all the earthy tastes," writes an author, "the most peculiar are those which are met with in Algerian wines derived from newly-trenched land, which had, before, borne Pistacia lentiscus, Jujube, dwarf Jackal Palm (Chamærops humilis), &c. Such soil exhales fantastic odours, which are found again in the wine grown on it, not only smelling, but also tasting."

We do not believe much in the influence of newly-trenched soil, for the very simple reason that when the vine arrives at the productive state the soil is not newly-trenched, and has had time to get rid of all flavours that might have contaminated it.

Five or six years ago, wines with an earthy taste were the fashion in Algeria, and that whether they proceeded from old or young vines, from vines planted in ground cleared a great number of years before, or from newly-trenched ground. The wines produced from old ground had that defect even in a more accentuated degree, because they were more alcoholic.

This is not so any longer. Certain vineyards which during the last twenty years produced wines having an earthy taste, now make clean-tasting wines, *and this is simply due to the improved processes and methods of vinification.* Formerly, the crushed vintage was left to itself, and allowed to *ferment in a happy-go-lucky way*, only de-vatting when the wine seemed to contain no more sugar, which usually happened fifteen or eighteen days after the fermentation started. It is entirely to this prolonged maceration, taking place at an excessive temperature, that we must attribute the origin of the earthy taste, and not to the earth itself. Since the application of the system of refrigerating musts, which enables regular and short fermentations to be made, the *earthy taste* due to newly-trenched ground has disappeared.

In the South of France, the same causes produce the same effects, but only to a slight extent. The means of avoiding the *earthy taste* are very simple, only ferment for five or six days, and prevent the heating of the vat. If there are no means at disposal for cooling, and the vat becomes too hot, de-vat as soon as possible, even at the expense of the colour, for we believe that it is better to make wine of clean taste, and free from earthy taste, than wine rich in colour, and possessing an earthy taste.

The remedy for the evil is almost useless. It consists in repeated rackings and heavy finings, which only result in attenuating the evil, without causing it to disappear, and in turn exhausting the wine ; the practice of blending is better than anything else.

Wines sometimes develop a putrid smell, similar to that of sulphuretted hydrogen, caused by the presence of a very small quantity of sulphur remaining from the sulphuring during the summer, or, to the condition of the vat in which the fermentation was conducted. In the first case it is due to sulphuretted hydrogen, in the second case it is the result of more complex sulphuretted compounds, and then the defect is more tenacious. A very frequent cause of the putrid smell is the use of compounds for luting the vats, into the composition of which blood enters. The blood is generally thought to be more effective when putrefied. It is needless to state that this idea is without foundation. The sulphuretted taste is difficult to remove from the wine. We may, however, arrive at it by strongly sulphuring again, that is to say, by making the wine absorb sulphurous anhydride*, although it seems incredible at first. In reality the sulphuretted hydrogen is destroyed by the sulphurous anhydride, and the wine contracts the smell of the latter, which is very different from the former, and possesses the advantage of disappearing in time.

To remove all other abnormal tastes, such as cask or mouldy taste, the use of olive oil is generally advocated.

The wine is roused with 1 per cent. of olive oil which suffices to fix to its benefit, or to be more precise, to its detriment, the foreign taste contaminating the wine.

We think it is only a second-rate method, the success of which is never complete. The olive oil used must be of the very best quality, which renders the method very expensive, anyhow, whatever be the quality of the oil used, the treatment always leaves in the wine, side by side with the more or less attenuated initial defect, a disagreeable oily character.

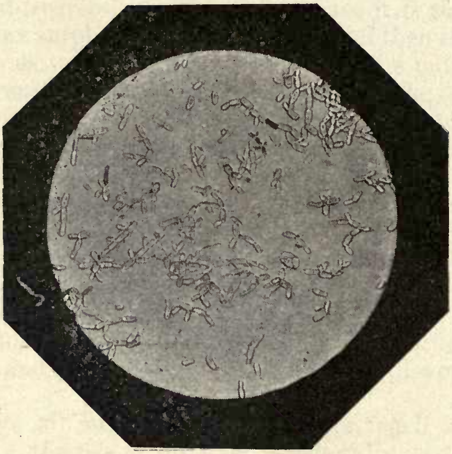
Mustard powder used in a quantity of 30 or 40 grammes per hectolitre, and stirred with the wine, gave us results, which, without being good, are, however, preferable to those obtained with oil, we may sometimes succeed in rendering by this treatment, the consumption of wine possible, which was otherwise undrinkable.

We have so far spoken of defects which do not lead to a gradual alteration of the wine. We will now describe the principal diseases which completely transform the wine if their evolution is complete.

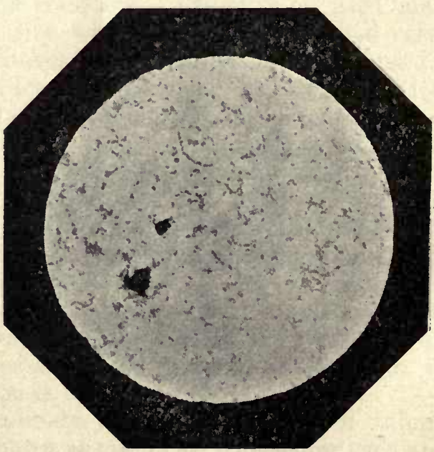
They are almost always the result of infinitely small organisms known as microbes, which play such an important

* This reaction proceeds according to the equation—
$2H_2S + SO_2 = 2H_2O + 2S$. (Trans.)

PLATE III.



Disease known as Flower, *Mycoderma vini.*



Vinegar Disease, *Mycoderma aceti.*

part in our life, although they are so small, and the rôle of which, unsuspected previous to Pasteur's classical researches, now becomes more apparent every day.

In œnology their importance is considerable. We know that they are the cause of the genesis of wine, that the marvellous transformation of sugar into alcohol is due to microbes, but these are salutary microbes. We are going to study now other microbes of noxious character, causing the destruction of the work of the first mentioned.

It is curious to study the old authors in their explanations of the diseases of wines. It is a succession of fantastical interpretations, which they probably did not understand themselves, and which are certainly unintelligible to laymen.

For instance, we read about "the intimate connexion of the spirituous parts with the saline and mucilaginous molecules," which is about equivalent to the "movement of the humours" advocated by the old doctors, in treating affections of which they were ignorant of the real cause.

The *fleur* (flower), Plate III., is the most common and benign of wine diseases.

It only attacks wine when in contact with air; the surface of the wine becomes covered with white spots, formed of a multitude of small organisms (microscopical fungi) which are termed *mycoderma vini*, which entangled together form a regular scum, becoming wrinkled when further developed.

This fungus is oval-shaped and reproduces by budding, affecting on a microscopical scale the shape of the branches of the common large oval-leaved cactus (*Opuntia*). It derives its nourishment from the wine, living principally at the expense of the alcohol, the alcohol being transformed into carbon dioxide and water, that is to say, consumed, and the alcoholic strength of the wine naturally diminishes.

However, for the action of the *mycoderma vini* to be appreciable, it requires to develop on a very large surface, compared with the volume of the wine, that is to say the ullage of the cask must be considerable. In ordinary cases where the flower only extends over a small surface of wine as in an almost filled cask, its action is quite insignificant. The case is the same in a bottle standing upright and badly corked. It is then only unsightly and does not injure the flavour in any way.

It is not so with acetification or *piqûre*, Plate III., which develops under exactly similar conditions, and in most cases follows the flower.

In the case of acetification the general characters are not so pronounced at the start, instead of a regular scum completely obscuring the surface of the liquid, it is a light transparent veil, a muslin instead of a thick blanket of flower. When acetification follows the flower, we observe rents in the blanket, rents which enlarge every day till the veil has replaced the blanket.

This light veil is formed of micro-organisms known as *mycoderma aceti* or *diplococcus aceti*, infinitely smaller than *mycoderma vini*, and which can only be detected under a very high magnifying power.

The cells appear to be shaped like two small balls, joined together in the form of the figure 8; when they take possession of the wine the small balls join together forming chaplets, when they become old, the chaplets dislocate and are replaced by new ones formed of younger cells, while the old cells fall inert to the bottom of the liquid, forming by their accumulation, a viscous mass known as mother of vinegar. A very characteristic property of the acetic ferment is its extreme rapidity of reproduction when the conditions are favorable. In 24 hours, according to Duclaux, an almost imperceptible quantity of *mycoderma aceti* will cover a surface square metre of liquid, producing, if we assume the layer to be composed of one thickness of cells, 300,000,000,000 cells in that short space of time.

The *mycoderma aceti* exerts an oxidizing action on alcohol, transforming it into acetic acid and water.

Directly this action commences, the wine assumes a sour or vinegar taste. This is a very serious disease, for all the extolled remedies are only insufficient palliatives, if the alteration is at all marked.

Acetification often results in wine, through the acetification of the marc during fermentation conducted with a floating head, and always takes place in casks which are left slightly ullaged, especially in cellars where the temperature is elevated.

Certain wines are more liable than others to become attacked by *mycoderma aceti;* such are wines in which sugar is left after incomplete fermentation, wines of low alcoholic strength, and wines worn out by age. Press wines are almost invariably slightly sour, and are very liable to become attacked by *mycoderma aceti*, if the casks are as already said not kept quite full.

The remedies proposed are only palliatives, for, if it is possible by destroying the cause of the evil through killing the micro-organisms to stop the progress of the disease, it does not, however, suppress the acid taste existing before the treatment.

To destroy the acetic acid formed, lime, carbonate of lime. or what is the same thing, powdered marble, have been recommended.

This is a bad remedy, and has the great disadvantage of introducing into the wine a substance (lime) foreign to the grape. The acid taste disappears, it is true, but its disappearance is not persistent for all time, and the wine contracts a strange taste which depreciates its value.

The saturation of the acetic acid by certain potash salts, and particularly by neutral tartrate of potash, answers much better; in this operation ordinary tartar (bitartrate of potash) which gradually subsides, and acetate of potash are formed. In this case the disappearance of the acid taste persists, under the conditions, however, that at the same time we stop or prevent the disease from continuing its development. There are to attain this end two means, apart from the general principle of sterilization; they are to fill completely and close the vessel airtight, or to burn a sulphur wick in the empty space over the wine, so as to surmount the wine with a layer of sulphurous anhydride instead of air. Under these conditions the development of the *mycoderma aceti* is completely arrested and the wine does not move, as long as there are traces of sulphurous fumes in the empty part of the cask, so that we may preserve the contaminated wine for any length of time by the simple additional precaution of renewing now and then the sulphurous anhydride.

Acetification is a common disease, but not so frequent, however, as the *tourne* (turning), Plate IV.

The *tourne*, or turning, attacks the tartaric acid, whether combined or otherwise, and transforms it into new compounds, imparting to the wine characters which entirely alter its nature. We have not to deal in this case, as in the two preceding, with organisms living on the surface of the liquid, and which may be removed by simply protecting the surface, but with organisms living in the midst of the wine, which therefore render it cloudy, directly they begin to multiply.

The *tourne* produces a special or peculiar cloudiness, which is a very definite symptom of this disease. If we examine by transmitted light, and in a thin layer, wine attacked by the *tourne*, and which has been slightly shaken, a shimmering appearance similar to the waves on watered silk is noticeable from the movements of the microbes it contains. This characteristic is very transient, for the wavy appearance soon stops after shaking, but it is sufficient to be acquainted with this appearance to readily recognise it.

The ferment of the *tourne* has a filamentary shape, very thin generally, and more or less curved according to its age. It occasions the decomposition of the tartaric acid, several different compounds resulting, such as tartronic, lactic, and acetic acids, and it ends by destroying not only all the tartar contained in the wine, but also that adhering to the wood or the vessel containing the wine.

The *tourne* ferment is a veritable de-tartrater of the casks, and this is a fact known long since, when wines did not come out of the cellar directly after they were made, but were often eventually submitted to the distiller.

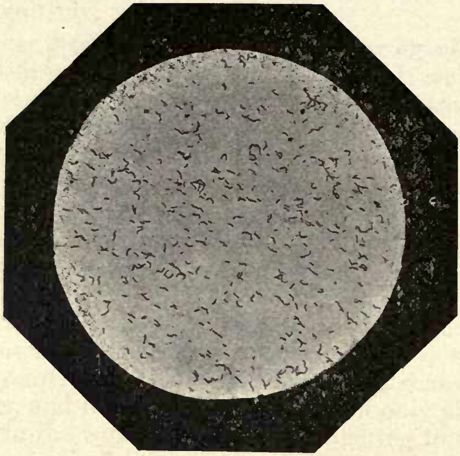
Nowadays the disease is more rare, and it very seldom becomes sufficiently developed to enable us to notice the complete destruction of the tartar in wine.

The *tourne* attacks all wines of low alcoholic strength. After the first invasion of mildew, the wines from mildewed vines were attacked, even in viticultural regions where *tourne* was previously unknown, by an alteration or disease which was for a long time regarded as altogether different. Gayon established by experiments and definite analyses that mildewed wines were simply attacked by *tourne*.

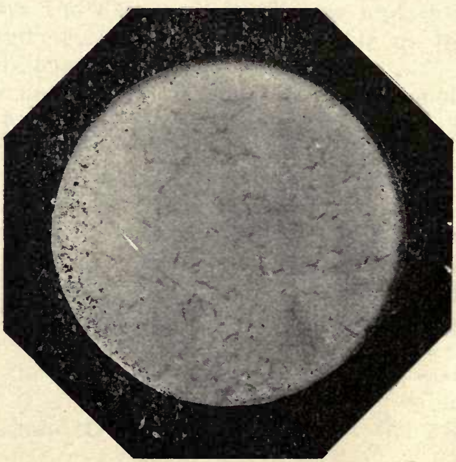
When the disease is so far advanced that the taste of the wine is sensibly modified, nothing can be done. In past days the evil was not very great, because the still enabled us to turn the diseased wine into fair spirit, easily saleable, but to-day it is a disaster, for the market value depending on the alcoholic strength is so low that the loss is almost total.

If the disease has not made much progress, and if the wine is still drinkable, the evil can fortunately be stopped

PLATE IV.

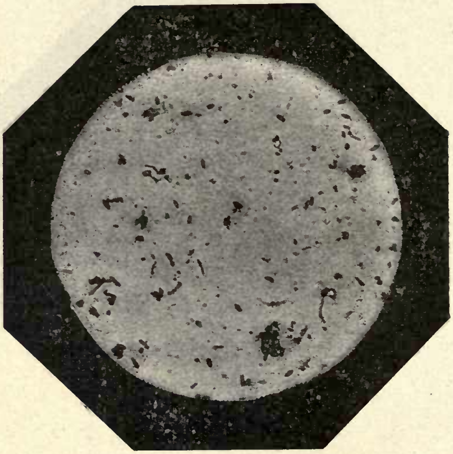


Disease known as "*Tourne.*"

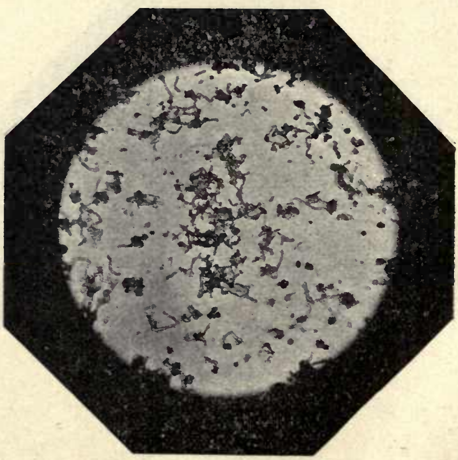


Disease known as "*Pousse.*"

PLATE V.



Disease known as "*Amertume*" (Bitter) (Young).



The same (Old).

by the general system of treatment of diseases due to micro-organisms, which will be briefly described later on.

Pousse (pushing), Plate IV., is the sister disease of *tourne*, but is less frequent, and only differs from it in this, that amongst the products of the destruction of the tartar, propionic acid and carbon dioxide are formed. Carbon dioxide is a gas, the same which is liberated during vinous fermentation, and can only be dissolved in wine in limited proportion. If we consider a well-bunged cask filled with wine attacked by *pousse*, that is to say by a disease constituting a veritable source of carbon dioxide, pressure will be developed inside the cask, the result of which will be the pushing of the heads outwards, hence the name *pousse* (pushing). The pressure becomes so high sometimes that it results in the bursting of the cask.

Pousse is due to a filamentary microbe, similar in form to that of *tourne*, but shorter, thicker, and straighter, while that of *tourne* is always more of less curved. If the disease has not progressed too far it may be cured by the same means as those used for *tourne*.

The disease known as *amertume* (bitter), Plate V., is very uncommon in the South of France. This is not due, as is generally supposed, to the fact that the disease is special to wines of *grand crus*, but simply that it requires a longer time to develop and acquire all its characters, therefore it can only be observed in old wines, and the wines of the South of France never get old enough to give the disease time to develop. As a matter of fact, the wines in the South of France are more liable to get this disease than any other, for the conditions of preservation and maturing are always more unfavorable in a warm climate than in a cold one.

According to the researches of Pasteur and Duclaux, *amertume* progressively destroys the glycerine in the wine, forming volatile acids, amongst which acetic and butyric predominate. It is probable that these are not the only bodies formed, for, if this were the case, it would be difficult to explain the bitterness, sometimes very intense, which characterizes this disease.

Amertume is due to a filamentary microbe, longer and thicker than those of either *pousse* or *tourne*, and which differs from them by its ramified appearance, which is similar to the branching of a tree.

When the disease is starting, the ferment is more or less isolated, relatively short and thick, and not ramified. It is when ageing that it becomes ramified and encrusted with colouring matter, which renders its detection more difficult, but at the same time gives it a more distinguishing character. *Amertume* is a disease to be feared in wines destined to be laid down, but it has no importance in the case of wines that are to be consumed young.

Graisse (fat) is a disease more peculiar to white wines, and need not be much dreaded. It cannot be very common, if we judge by the difficulty we find in procuring wine characteristically attacked. Under its influence white wines assume a viscous condition, and flow like oil from the tap, and even, if more developed, like white of egg.

Scientists do not know exactly under the influence of what decomposition this effect is produced. We can detect under the microscope chaplets of little balls similar to those of the *mycoderma aceti*, but rather larger, and surrounded by a kind of mucilaginous matter, but that is all. A violent stirring of the wine renders it quite fluid, and the addition of tannin acts as a temporary cure, as was shown by François very long ago.

The definite cure of this disease, like that of any other disease caused by microbes, is easy to effect.

A few years ago a new wine disease (but very old, no doubt) was discovered. It is known as *mannitic fermentation*, Fig. 57. P. Carles, of Bordeaux, had in 1891 pointed out the presence of *mannite* in certain wines. After a few experiments, he came to the conclusion that mannite was only found in wines made from figs. According to him the presence of mannite in wine indicated adulteration, the substitution or at least the admixture of grapes with figs.

Fig. 57.—Mannitic Ferment.

Having had an opportunity of finding and characterizing mannite in wines, which we knew were made exclusively from grapes, we were induced to study its origin, and were able to show that we had to deal with a disease due to the action of micro-organisms attacking not only fig wines, but also the pure juice of the grape.* The same year we were able during a trip to Algeria to extend and define our observations on the subject, but were not able to isolate the living organism which produced among other bodies, that which characterized the disease, mannite.†

Gayon and Dubourg studied the subject again in 1894, and thoroughly determined its evolution. They reproduced it in healthy wine, by inoculating it with the microbes they had succeeded in isolating.

Mannitic wines usually contain an excess of sugar, and the total acidity is very great. The dry extract is very high, not only through the presence of sugar, but even after the sugar has been deducted. The bitartrate of potash does not seem to be attacked, if the wine is only invaded by the mannitic ferment, but it frequently happens that the disease develops concurrently with *tourne*, which destroys the tartar.

The ferment appears in the shape of short and very small rods, immobile, which, instead of remaining independent and disseminated in the liquid, gather together in great numbers, forming colonies rather difficult to disintegrate. It only develops in wine containing sugar, for it is from its decomposition that mannite is formed. This disease is therefore only to be feared in the case of wines containing sugar, or musts. It may develop during the alcoholic fermentation, and seriously alters the wine when the transformation of the alcohol through some cause or other lasts too long, as happens when the temperature of the vat exceeds the limit which wine yeast can support.

The conditions favorable to mannitic fermentation of musts are naturally found in hot climates, and it was in Algeria and Spain that this disease was first noticed. Mannite only appears in French wines in exceptionally hot years. Contrary to the opinion of certain authors, mannitic fermentation is not a variety of *tourne* peculiar

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* *Memoires de la Société des sciences phy. et nat. de Bordeaux.* 28th July, 1892

† L. Roos. *Journal de pharm. et de chimie.* 1893.

to sweet wines; the differences are in fact numerous. The following are those given by Gayon and Dubourg:—

1st. The mannitic ferment differs in shape, dimensions, and mode of grouping of the cells.

2nd. It does not develop in wines free from sugar where the *tourne* ferment develops easily.

3rd. The latter does not develop in sweet liquids, especially in liquids artificially sweetened which are so favorable to the former.

4th. The volatile acids produced during *pure mannitic* fermentation are exclusively composed of acetic acid, while if this acid exists in *tourne* wine there is side by side with it, and in greater proportion, other volatile acids.

5th. While the tartar disappears in *tourne* wines it remains unattacked in *mannitic* wines.

In fact, it is a disease which exists from the commencement, and it is this which renders it so difficult to obviate. It can only be avoided by attentively watching the temperature of the vat.*

There is a disease which has attracted considerable attention in recent years, known as *casse* (breakage), but the origin of which does not seem to be due to microbes.

Prof. Bouffard † drew attention to this disease, which he noticed was common in the 1893 wines, upon which he made his first studies.

"The wine of a bright and clear colour in the cask becomes turbid when aerated for three or four hours, and a brown-red precipitate forms. If the wine is in a bottle kept still, the decolouration commences on the surface, where a small iridescent pellicle of colouring matter is formed which gradually affects the lower layers of wine, the sides of the glass become covered with an adherent deposit, and the wine becomes almost entirely decolourized, assuming a characteristic yellow-madeira colour. All these deposits consist of colouring matter, insoluble even in concentrated tartaric acid solutions.

"The wine does not disengage any gas, as happens in other diseases. Its taste does not recall in any way *pousse* or

* *Comptes rendus de l'Academie des Sciences.* 9th April, 1894.

† Sterilization of the must previous to fermentation, and the use of pure cultivated yeasts afterwards, is a means of avoiding the disease. (Trans.)

tourne. The taste may be compared to that of wines called rancid or madeirized, which are the characteristic of very old age."

Prof. Bouffard concluded that the idea of the action of a microbe must be set aside, an opinion which has been accepted since the publication of his work. He was also able to indicate at the same time that sulphurous anhydride and heating were efficacious remedies.

After Bouffard, various investigators studied this subject.

Gouirand, of the Viticultural Station of Cognac, has shown that wine subject to *casse* (breakage) contains a soluble ferment,* a diastase of the same nature as that recently isolated by Bertrand and called oxydase, the characteristic property of which is to fix the oxygen of the air on the oxidizable matters with which the ferment is in contact. The mechanism of *casse* will then be an indirect oxidation of the colouring matter, resulting in it becoming insoluble and therefore precipitating.

Laborde, of the Agronomic Station of the Gironde, pointed out one of the possible sources of the diastase,† namely, the products of elimination of the *Botrytis cinerea*, the special mould of the grapes which plays such an important part in the vinification of Sauterne and Rhine wines. The diastasic cause of the *casse* would seem to be admitted by every one; but Legatu, Professor of the Agricultural School at Montpellier, has just given a new interpretation based on the rôle of iron‡ which has already gained a number of followers.

According to Legatu, *casse* is not due to a pure and simple oxidation of the colouring matter, but to the oxidation of a *ferrous* salt, which in that state is incapable of forming an insoluble combination with the colouring matter, but which acquires that property by changing to the ferric state.

"This new interpretation, according to him, is not contradictory to the actually admitted influence of an oxydase, but in the case studied, the part played by this diastase (if it exists) has not consisted in rendering the colouring matter insoluble, but in favouring the phenomena of oxidation which always takes place in diluted solutions of ferrous salts. The insolubility of the colouring matter follows in consequence of the formation of a new ferric compound.

* *Comptes rendus.* April, 1895.
† *Comptes rendus.* 1896.
‡ *Comptes rendus.* June, 1897.

Legatu and myself tried to give this theory experimental verification. Our researches are condensed in the following note, abstracted from the *Progrès agricole et viticole:*—

"It is clear that the above note brings a new element of discussion to the scientific study of *casse* in wines, but does not establish upon sufficient experimental basis the part played by that element.

"It answers the question, it indicates a very plausible theory, but does not solve the problem or establish that theory.

"We have endeavoured by experimental researches recently undertaken to gather facts which would throw some light on the action of iron in the *casse* of wines.

"At that time of the year the difficulty of procuring suitable samples of wines limited the extent of our researches. It is difficult to find wines of good character not containing any sulphurous acid, and it is not to wines liable to *casse*, but already cured, that we should have recourse in order to systematically reproduce the *casse*. On the other hand, the non-cured *casse* wines have already been submitted to treatment, to rackings at least, they are partially attacked and their primitive state cannot be determined. However, the few samples we obtained enabled us to observe facts which are in perfect accordance with the new interpretation.

"It seems actually established that there are two varieties of *casse*. First, blue *casse*, which is observed in rich wines of an intense colouration, the true type of which is met with in the Jacquez, vinified without the addition of tartaric acid; secondly, the brown *casse* characterized by the more or less brownish colour of the precipitate, and in the partial or total substitution of yellow for the original colour. As will be seen, this distinction does not seem fundamental.

"No wine susceptible to complete decolouration by exposure to the air was noticed, one only took a slightly madeira-red colour.

"It was found to be indispensable to study the precipitate resulting from *casse*.

"We were surprised to find in this precipitate so far considered as oxidized colouring matter a notable amount of mineral matters, amongst which iron was in considerable proportion.

"Examples.—A wine of Montauban attacked strongly by brown *casse*, but, however, not completely decolourized, was left for two days exposed to the action of the air.

"The precipitate formed, collected on a Chamberland candle, washed with distilled water till the washings were no longer coloured, dried in a vacuum and incinerated gave—

Mineral matters	...	...	17·3 per cent.
Iron ...	...	...	5·0 ,,

"Wine made from Jacquez *cépage*, originating in the Hérault, not easily turning blue under the action of the air, gave, however, for half a litre, 110 milligrames of dry bluish-black precipitate, in which we found 2 per cent. of iron together with silica. In this particular case, as with all Jacquez, the wine had thrown down already a deposit which was found to be rich in iron.*

"All the precipitates from blue *casse* have been found to be rich in iron.

"We therefore consider, as a constant and well-established fact that a wine which breaks throws out iron.

"Is it not probable that blue *casse* is due to formation of ferric tannate, while brown *casse* is due to the formation of œnolate of iron? The close relation between œnoline and tannin† adds more weight to the above hypothesis, consequently are we not naturally led to see the cause of the *casse* in an excessive amount of iron.

"One of the first confirmations of this hypothesis must be looked for in the comparison between the intensity of the *casse* and the amount of iron. Now, one of us has already established‡ by numerous analyses that the Jacquez wines, so predisposed to *casse*, are also in a general way remarkably rich in iron. This is a clue, but the exact determination of that element in the must and in the wine

* Prof. Bouffard (*Ann. de l'Ecole nat. d'Agriculture de Montpellier*, t. II. 1886) states—"From facts observed, one may admit that the violet matter (deposited by the Jacquez) is the result of oxidation, and perhaps, as we hope to prove, a combination with the iron contained in wine, as a kind of tannate of iron. The precipitation only takes place after the aeration through the staves of the cask has been sufficient." Is not this the way *casse* proceeds? Bouffard distinguishes, however, this special *casse* from that we are studying, while it is only regarded by Legatu and myself as a simple variation.—(L.R.)

† L. Hugounenq. *Recherches nouvelles sur les vins.* Imp. A. Storck, Lyon.

‡ L. Roos, Giraud and David. Analyse chimique des vins de l'Hérault Recolté. 1890. *Bull de la Soc. centrale d'agric. de l'Hérault.*

directly after de-vatting would present more interest. However, this co-relation has already been verified for the Jacquez, as also for other samples.

"As a second confirmation, a sound wine (but not charged with sulphurous acid) should break when we increase the percentage of iron, a fact already established in the above note and confirmed since by new trials with various ferrous salts.

"In the third place, the treatments indicated against the natural *casse*, must be of the same value in wines in which the *casse* has been induced artificially. Sulphurous acid is so active against artificial *casse* that it is impossible to obtain it even in wines which have simply been racked into a sulphured cask. Example : A wine upon which trials of artificial *casse* remained without results was subsequently found to contain 32 milligrammes of sulphurous acid per litre ; *re* the heating, we have only studied its effect in an incomplete way, and will only mention that the absolute efficacy of this cure has been disputed. However, from our first researches it is evident that wine acquires by heating the property of holding the iron in solution more perfectly. There is therefore in the above results a point strong enough for an interpretation of *casse* independent of any oxidizing diastase to which the disease is to-day attributed.*

"It is interesting to try and produce the phenomenon of the *casse* under conditions excluding the presence of diastase.

"To arrive at this, œnoline free from iron and even mineral matter was isolated by the Hugounenq process. The use of strong alcohol for dissolving the œnoline excludes any diastase. The product of this dissolution was used to colour an alcoholic solution of tartaric acid containing some iron introduced in the form of ferrous hydrate. The mixture became turbid a few hours afterwards, forming a reddish precipitate similar to that of brown *casse*. At the same time the liquid was covered with an iridescent pellicle, as observed in natural *casse*, and affected the reddish-yellow colouration so characteristic of *casse* wines. This fact leads us to think that the presence of an oxydase is not indispensable to the *casse*.

"However, the facts given above seem to have as much weight as those advanced in favour of the diastase theory.

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* **Theory of Gouirand, supported by numerous experimenters.**

"We may even produce artificial *casse*, absolutely similar to the natural *casse*, while the oxydases only furnish, according to certain authors, a near image.

"And, what is more, the knowledge of oxydases and of their mode of action was until recently very vague. During the course of our researches Bertrand * established that a close behaviour existed between the oxidizing action of those bodies and of manganese, in the form of manganous hydrated salts, as the only conveyer of oxygen in the phenomenon of oxydation observed. The intervention of manganese being proved indispensable to the action of the oxydases, did not surprise us much. We are in presence, as in our own argument, of a metallic oxide.

"The manganous and ferrous salts have very similar properties, from the point of view of the transformations brought about by oxygen. With regard to this, the ferrous salts have even a more marked activity.

"Manganese exists in wines, but in scarcely detectable quantities. We cannot define its action in *casse*, but may state that the precipitates obtained in the wines affected by *casse* naturally, are always free from it. Manganese only exists in the liquid.

"As we were able in our experiments to produce the *casse* in a liquid completely free from manganese, we do not consider for a moment that it is necessary to invoke that metal to explain the natural *casse*.

"In all cases the phenomenon of the precipitation remains a function of the iron.

"In short, in this particular case, we do not see the utility of manganese united or not to a diastase as an oxidizing agent; anyhow, it does not enter into the composition of the precipitate."

Soon after its publication, Legatu's paper was the object of a violent critique from Cazeneuve. This criticism, remarkable for its vivacity, does not adduce any serious argument against Legatu's theory, which we found, on the contrary, strongly supported by the works of various experimenters.

"Sometimes we lose sight of the fact," says Bourquelot,† "that the oxydases may be produced with oxydizing matters which cannot be looked upon as true oxidising ferments."

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* *Comptes rendus de l'Academie des Sciences.* 14th June, 1897.
† *Journal de Pharmacie et de Chemie.* May, 1897.

Villiers* shows that in a purely inorganic liquid, through the action of a manganous salt, very important oxidizing phenomena result, where the manganese can only be looked upon as an oxygen conveyer, considering the great quantities fixed through its action.

A. Livache* studied the action of different metallic oxides on the oxidation of linseed oil, and quotes manganese as the most active, but similar effects were obtained with other oxides, notably that of iron, which gave results of the same class, although taking longer to obtain. Bertrand, to whom is due the most interesting work on the oxidizing ferments, has just found a close co-relation between their action and the presence of manganese in their composition.*

Legatu's theory does not negative the existence of oxidases, it only establishes that the *casse* of wines may not be due to diastase, or at least admitting a *casse* due to diastase, there is another, quite similar, in which the oxidizing ferment plays no part.

The effect of heat in preventing *casse* is often advanced to strengthen the hypothesis of a diastase, as soluble ferments are always paralysed by heating. But we have seen that wine acquires through heating the property of retaining the iron compounds in solution. We also know that organic compounds exist, into the composition of which iron enters, and which do not give any reaction for that metal. Would not, in this particular case, the action of the heat be to fix the iron in a state unattackable by oxygen? Whatever it be, if we admit, and this is generally admitted even by the advocates of diastase, a *casse* special to the Jacquez, and closely related to the excessive quantity of iron those wines contain, why deny the existence and the theoretical interest of a similar affection in the wines of other *cépages*, the analyses of which show quantities of iron equal and even superior to that contained in Jacquez.

TREATMENT OF DISEASED WINES.

Heating.—Whether due to microbes or not (such as *casse*), the diseases above mentioned all give way to heating.

Observations conducted systematically have shown that no living being, neither any reproductive organ of a living being (seed, egg, spore) can resist a temperature of 120° C. At

* *Comptes rendus.* June, 1897.

that temperature, dry or moist, all life is suppressed; but if, instead of operating in air or water, we operate in another gas, vapour, or liquid, the temperature may be considerably lowered and still remain just as effective.

Thus, in the case of wine, which is, after all, a solution of alcohol and different acid substances, it is sufficient to raise it to a temperature of 60° C. (140° F.) for a few minutes to annihilate any living organism.

Heating is, therefore, a veritable sterilization based upon the destruction of all living organisms, and we see what can be expected from the application of such a process.

The description of the machines for the heating of wines, Pasteurizers, or Œnotherms, does not come within the scope of this work. The reader will find all desirable information in the study published by Prof. U. Gayon on these machines.*

We will simply give a condensed account of the conditions necessary for efficient pasteurization. The wine to be heated should be almost clear, for the solution of the matters in suspension, under the influence of heat, is to be feared—solution which is always accompanied by a defective taste. We should, therefore, if not filter at least rack, and avoid the passage of the turbid part through the Pasteurizer.

For the wine to preserve all its qualities, and not to lose any colour through the heating, it must pass by the required temperature (60° C.), and come down to its initial temperature without coming in contact with air, so as to prevent the action of oxygen taking place during any of the phases of the operation. The extreme temperature which the wine should reach must not be the average of very different temperatures applied to different parts of the wine, but only the average of very close temperatures. If, for instance, we pass wine through a coil submerged in constantly boiling water, coupled with a worm submerged in cold water, although the wine at the exit may be obtained at the same temperature as at the entrance, the heating is defective. In this case, the wine in immediate contact with the metal would be submitted to a high temperature (almost 100° C.), while that in the centre of the tube would only be slightly heated. The average temperature resulting from the mixture of these will, no doubt, be sufficient to insure sterilization, but the wine will have contracted a special cooked taste, because certain parts have been overheated.

* U. Gayon. Etude sur les appareils de pasteurization de vins. Extrait de la *Revue de Viticulture*. Feret et Fils. Bordeaux.

In order not to lose the beneficial action of pasteurization, and avoid contamination of the wine, it should be passed direct into sterilized casks. In most cases, washing the casks with boiling water is sufficient, but the sterilization is more certain, and it is more convenient in practice to steam them.

The wine heated under these conditions has nothing to fear from diseases, and will not acquire as a result modifications of colour or taste. When kept in well-bunged casks, it may be preserved without further alteration of any kind, and has even acquired a special resistance to the germs which might accidentally contaminate it. Heating has made great strides during the last few years, but has still greater progress to make, actually pasteurizers are always to be found in wine merchants' cellars, even of medium importance ; but they are still rare in the vine-grower's cellar. *However, the advantages are so definite, that little by little they force their way into, and will very soon be part of the current material of every cellar.*

FILTERING AND FINING.

To cure diseased wine, or to be more precise, to hinder the development of the disease, we should kill the microbes causing it, or separate them completely from the wine in which they exist. Filtering is a solution of this problem, but is only efficacious if it is perfect, and to be perfect it requires expensive apparatus provided with powerful mechanical appliances.

A large filtering plant was established quite lately at Algiers. The filters employed were of the well-known type Chamberland porcelain candle, the results obtained with this plant were equivalent to those given by heating from the point of view of sterilization, but this is a remedy only practical for cellars in the immediate neighbourhood of such a plant.

Most filters do not insure sterilization. Their effect is excellent in many cases, but quite useless when we have to deal with diseases due to microbes. The disease is almost preferable, when we have not at disposal a good pasteurizer.

The matters used for fining are distinguished according to their mode of action. Finings only acting mechanically (sand, Spanish clay, paper pulp). Finings forming with the acids of the wine, partly soluble salts, chalk, marble, powdered oysters, plaster (all useless), and last the finings coagulated by substances in the wine.

The latter class only are true finings, and should alone be used. They are all bodies known in chemistry as albumenoids, all acting in the same manner, and forming with tannin insoluble flocculent precipitates of a density slightly greater than that of the wine, and which consequently only gradually settle to the bottom dragging down as in a net of infinitely small meshes, all the solid particles, whatever their tenuity may be, which float in the midst of the wine. This makes fining a very special class of filtration.

The different albumenous clarifiers are: several albumens, white of egg, blood, milk, gelatine, isinglass.

These substances are the base of all the products prepared by the trade, and sold more or less modified under various names and aspects. The commercial liquid finings are always solutions of these compounds rendered non-putrescible by the addition of antiseptics, very often sulphurous acid, combined or not, but, unfortunately, sometimes also bodies *interdicted* in the manipulation of wine, and which are found afterwards in the treated wines, such as *boric acid* and *salicylic acid*. The possibility of getting involved very innocently in a police prosecution case should render the proprietor very distrustful of these finings. This is to be regretted, for the preliminary preparation required by the albumenoids used for fining is generally very well done by the trade.

The egg albumenoids are used without any preparation other than separation from the yolk and beating up with water.

Fresh blood, or better, serum, that is to say, the clear amber-coloured liquid which separates after coagulation, is used without any further preparation.

Natural milk is only used for the clarification of vinegar.

Whites of eggs are usually used in the proportion of two per hectolitre (four per hogshead). Blood, or serum, in a quantity of 50 cubic centimetres per hectolitre.

In both cases the method of operating consists in diluting the clarifying matter with a small quantity of water (the five thousandth part of the volume to be treated), pouring the prepared mixture into the wine, and energetically rousing by appropriate means, according to the capacity of the vessel, and allowing the wine to remain undisturbed until the complete subsidence occurs of the precipitate formed. The subsidence takes usually from three to eight days, after which racking separates the wine perfectly bright.

Egg and blood albumen are both sold in commerce in a solid state, but in that form are always expensive, and lose their main advantage, which is the simplicity of their manipulation when liquid.

Gelatine requires a rather longer preparation. It is found in commerce in the shape of transparent sheets, slightly yellow or quite colourless if the gelatine is pure. It swells without dissolving in cold water, but dissolves very readily in warm water. Gelatine is obtained by boiling bones, tendons, cartilage, and other abattoir waste at a temperature over 100° C. under pressure.

Dissolved in water, it has the property of forming a jelly on cooling, if the solution is sufficiently concentrated. We should, therefore, be careful when preparing it as a simple solution in warm water, to dilute it enough to avoid coagulation when cold. In the proportion of 5 per cent. the dissolved gelatine remains liquid at ordinary temperatures. The liquid clarifiers with a gelatine base, sold in commerce, are almost always stronger than 5 per cent., but to keep them liquid they are heated under pressure at a temperature of 128° C. By this treatment the gelatine loses its characteristic property of forming, with tannin, an insoluble compound, and that of solidifying on cooling.

If, perhaps, it is of some utility for the trade to obtain concentrated solutions, it is not necessary for the wine-maker, and the solutions at 5 per cent., which any one can make without the use of special appliances, will render the same services. In cases where the proprietor requires to keep the gelatinous solution prepared in this way he should add to it 1 per cent. of bisulphite of potash to render it unputrescible.

Two hundred cubic centimetres of this solution are sufficient to clarify one hectolitre (22 gallons) of wine, the operation being conducted in exactly the same way as with white of egg or blood.

Fish isinglass obtained by the desiccation of the natatory bladder of certain fish is very recommendable for white wines. Its use seems at first very expensive, as the price of a good quality is 30 francs per kilogramme, but the quantity necessary is so small that the price of the fining for one hectolitre is not, after all, much greater than when using gelatine.

Two grammes of fish isinglass are ample to clarify one hectolitre of white wine. The preparation of this isinglass takes longer than that of gelatine. The sheet of dry isinglass is first split in three thin sections, then placed in a vessel, covered with cold water, and allowed to remain for 10 or 12 hours, during which it swells.

After that the mass is sprayed with boiling water, beating it continually meanwhile. At first it forms a thick paste, becoming almost fluid when the total quantity of water added reaches 50 litres for one kilogramme of isinglass.

The main element for success in this preparation consists in the thorough division of the isinglass. If we possess the means of rasping it, and making a kind of coarse powder, a thick liquid free from lumps is then easily made. If means of rasping it are not at hand, the emulsion may be heated for a few minutes, but it is better in this operation not to let the temperature rise to 100° C.

Two hundred cubic centimetres of this solution of fish isinglass of 2 per cent. strength will be sufficient to fine one hectolitre of wine. The 200 cubic centimetres should be first diluted with half a litre of water, adding it by instalments, the mixture is then further diluted with wine, and introduced into the cask, stirring energetically during the addition, and then left alone during sedimentation.

It goes without saying that the wine-maker may insure the preservation of the prepared solution of fish isinglass, in the same way as in the case of gelatine, by adding 1 per cent. of bisulphite of potash, and may, therefore, in one single operation prepare the fining required for a whole year.

Precautions to be taken to insure the efficacy of fining.— For fining to give good results the treated wines should remain perfectly still during the whole time necessary for the deposition of the fluffy precipitate formed through the action of the tannin in the wine on the albumen or gelatine. It is sometimes said that wines do not *take*, or do not *take the finings* easily, this may be due to different causes.

One of the most frequent in white wines is deficiency of tannin, certain kinds of white wines, especially those obtained from red grapes by the fermentation of the first fraction of drained juice, are very poor in tannin, and consequently cannot produce the coagulation necessary to insure the success of the operation. The remedy consists in the addition of tannin to the wine in a quantity of 25 to 30 grammes per hectolitre.

It is easy to place in evidence a deficiency of tannin by the following simple process.

Portions of the wine to be fined are placed in two glasses; in one in its natural state, in the other with the addition of tannin. After the tannin is dissolved, add to both in equal amount (very small) four or five drops of the fining to be used. If the wine is rich enough in tannin to take the fining, the precipitation will be almost the same or equal in both glasses, while if the wine requires the addition of tannin, the precipitate will be much heavier in the glass to which tannin was added.

We may again place the fining in one hectolitre of wine, and stir in a small quantity of dissolved tannin. If the precipitate does not increase, the wine will not require the addition of tannin.

Another cause of failure in the fining of wines results from the wines being saturated with carbonic acid gas, which, gradually disengaging, forms little bubbles bursting at the surface, carrying during their upward movement small particles of fining, which remain suspended in the wine. This trouble may be avoided by racking in presence of air, when the wines abandon enough carbonic acid gas for that remaining to keep in solution during slight alterations of atmospheric pressure.

Finally, another cause of failure is met with in wines attacked by microbe diseases, if we do not previously paralyze the microbes. While at work the microbes produce movements in the wine, by gaseous disengagement or formation of liquid currents ; these are no doubt slight, but sufficient to prevent the normal action of the fining.

They may be paralyzed by the use of sulphurous acid in a quantity of 10, 12, or 15 grammes per hectolitre. The most convenient way of applying the sulphurous acid is that already described in the vinification of white wines, namely, *sulphuring with the pump*. If the reader refers back he will see that the operation is easy, and does not complicate the operation of fining. (See page 178.)

Let us suppose a cask of wine of 200 hectolitres attacked by *tourne* is required to be fined, and that the quantity of sulphurous acid necessary to paralyze the microbe be 12 centigrammes per litre, or 12 grammes per hectolitre, the mode of operation would be as follows:—Weigh 1,200 grammes of sulphur, burn it, and force the vapours into the cask, as previously explained; this being done, place in a tub the necessary quantity of fining, 40 litres of a solution of gelatine of 5 per cent. strength (*i.e.*, 200 cubic centimetres per hectolitre), dilute with an equal volume of wine, then with the pump used for sulphuring force the mixture into the cask, and continue pumping air into it after the tub is emptied to insure thorough agitation, after that wait till the clarification is complete.

The fining with such a quantity of sulphurous acid presents evidently certain inconveniences, for the colour diminishes and the fined wine acquires a decided taste of sulphurous acid. However, these faults are only transient, the colour comes back after one or two rackings, and the sulphurous acid taste fades away completely, especially if the sulphuring has been done with *pure sulphur*, and *not* with sulphured cloths. For the sulphur compounds formed by the burning of cloth, although in very small quantity, give rise to a very persistent smell in the wine.

Notwithstanding these inconveniences, the fining after previous sulphuring is excellent for all diseased wines, which after such a treatment will be able to keep, and which otherwise would certainly have entailed loss.

Sulphuring, followed by fining, is after all similar in its mode of action and effect to the use of different commercial mixtures, placed for sale under high-sounding names, and at prices still more high-sounding. All those which are lawful are mixtures of sulphurous acid and albumenoids, obscured under trade names; many are excellent, and could be recommended if it were not for their exorbitant price. If the proprietor wishes to use ready-prepared finings, care should always be taken to apply to firms of repute, and insist upon a guarantee as to the composition, if it is desired to avoid the risk of prosecution.

APPENDIX.

Extract from "The Vine in Australia," by Dr. A. C. Kelly. Published in 1841.

Chapter on Fermentation.

"In the warmer parts of Australia the vintage begins sometimes in February, and is generally over in March, a season when the weather is occasionally very hot. It is by no means an uncommon occurrence for the temperature to remain for some days above 90° F. during the day, and never under 80° at night. Must, fermenting under such heat, rises many degrees above the highest temperature of the air—ten degrees probably. The effect of this high temperature is by no means so injurious as might have been anticipated. Much good wine has been made whose temperature during fermentation has risen to 100° F. The temperature of 86° is the limit beyond which a sound healthy fermentation cannot be maintained in beer and other worts, and such was thought to be the case also with grape must; the opinions of modern œnologues, however, have undergone a change on this subject. "An acquaintance with many details with which we are still ignorant is, however, necessary in order to investigate thoroughly the influence of temperature upon a well-tasted wine, which should not spoil with age. The grapes of each country, ripened under different degrees of summer warmth, and very unequally rich in constituents, require different temperatures during fermentation; and different temperatures are required for grapes which are the product of a warmer or colder summer. But we are still ignorant on these points. All we know is, that a high temperature during autumn promotes fermentation, and a low one is detrimental to it; that inequality of temperature during fermentation is extremely injurious, and not infrequently spoils the wine altogether."* Baron Liebig, in writing

* Mulder. Chemistry of wine.

to the late Mr. King on the wines of New South Wales, says:—"As the wine of Irrawang contains an ample quantity of saccharine matter, I deem it expedient that you should allow it to ferment at the highest possible temperature."

The illustrious chemist, however, would surely set some limit to the temperature. One thing is certain, that it is only very strong must which can be allowed to rise so high as it does with us in Australia. The weak must of the North of France and the Rhine, whose specific gravity may be about 106, would pass into vinegar were it exposed to a temperature of 90° and upwards.

In colder countries large vats are employed as best suited to maintain the temperature of the fermenting mass, but they would be objectionable where it is desirable to keep the vats cool. How to keep down the temperature of the fermenting must, is the most difficult problem the Australian wine-grower has to solve. "Experience has taught us that the temperature of fermenting wine cannot be kept down by the use of underground cellars, unless the quantity be insignificant. We prefer a wooden building above ground, with the means of admitting free currents of air on all sides. Any accession of heat which a hot day may occasion is more than compensated for by the cool night air, which has free admission on all sides. A large body of wine will rapidly heat an underground cellar, and it cannot be cooled down again for many days."*

"A free admission of air to the surface of the fermenting liquor has the effect of keeping down the temperature. To this we shall revert shortly. Where it is desirable to exclude the air, as in the fermentation of red wines, some other means are required to prevent the fermenting liquor from rising to an excessive heat, as it must do under a temperature of the air of 90° or upwards. *This may be effected by means of a refrigerating apparatus such as the annexed, which is sufficiently simple to require no particular explanation. It is simply a pipe formed like the worm of a still, through which the cold water from a cistern flows, and is discharged again outside. The entrance and exit parts of the pipe are placed close together, in order to interfere as little as possible with the fixing of a false lid, and also*

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* Rough Notes—Sir W. Macarthur.

to facilitate the strengthening it by a frame. By means of a long flexible tube, to fit on by a coupling screw, the apparatus may be applied to a vat at a distance from the cistern. The supply of water for the cistern must of course be from a well or underground tank, whose temperature is moderate; and care must be taken that it does not lower the temperature too much. This refrigerator has been used with excellent effect in this colony, but was given up from a dread, perhaps a needless one, of the effect of the metal, block tin, upon the wine. The same apparatus is used during warm weather in some breweries in Britain, where great care is employed in conducting the fermentation, and where it is essential to maintain a steady temperature. When the temperature is low the same may be used to keep up sufficient heat in the liquid by passing hot water through it.

"The chief objection that can be brought against this refrigerator is the material of which it is constructed. The powerful action of the tartar upon metals, already alluded to, forbids the employment of any metallic implements which are to come in contact with grape-juice. Silver is the only metal which is not much acted on by tartar; and a copper tube, electro-plated at that part which is immersed in the fermenting must, would, probably, be not too expensive to forbid its use. An iron or copper tube, enamelled, would also be an excellent material for the purpose. Glass might be employed for the construction of refrigerators; it could be protected by a wooden frame, and as it is only the portion immersed which is affected by the tartar, the entrance and exit pipes may be constructed of metal. The only objection to glass is its slow conducting power, but this may be so far obviated by giving it a larger surface.

"It is surprising to find so little attention paid to temperature in the fermentation of wine in these colonies. If the general principles of fermentation are of universal application, we have no reason to treat grape-juice as if it were an exception; and expect that it can be fermented successfully when we disregard the conditions under which alone a healthy fermentation can be conducted. Grape-juice certainly ferments more readily and completely than any other fermentable substance, and has, perhaps, less tendency to go into the acetous state; and wine-makers, trusting too much to its power to resist the deteriorating influences to which it is often exposed, do not consider it necessary to abide by the laws which regulate the fermentation of other substances, but take extreme liberties with the grape must. For example, the temperature of the fermenting must may rise to 100°, and sometimes several degrees above it, and the resulting wine may be sound and good. The conclusion drawn from this is that wine may be fermented at a very high temperature without injury. *Not without injury certainly, as the following experiment shows:*—A quantity of purple grapes was crushed during very hot weather, the temperature of the air being above 90° during the day and never under 80° at night. The must and skins were put into a vat of 250 gallons, and a false lid placed as usual to keep down the mark. There was more than sufficient to fill the vat to the proper height; and the remainder, about 40 gallons, was put into a small vat (a port wine pipe having the head out), a false lid was also fitted into this. The fermentation commenced in each the following day, and in two days the temperature rose considerably during the tumultuous fermentation; but that of the larger vat was, at least, 8° higher than the temperature of the smaller. After this the progress of the attenuation showed a marked difference in the two vats. In the smaller it went on steadily, and in three days after the height of the fermentation it had fully attenuated itself, giving a specific gravity of 100, and was racked off clear and in fine condition; whereas the larger vat attenuated very slowly. On the third day after the violent fermentation its specific gravity was still 102·5; the following day it had come down very little, showing 102, and was full of yeasty matter floating through it. It was racked off into casks, to undergo the secondary fermentation; and, although eventually it attenuated after some time, *it was an inferior wine to that drawn from the smaller vat.*

"It has been often remarked that the first experiments in wine-making are generally the most successful, but it is easy to divine the reason of this. The first quantities made are generally very small, 40 or 50 gallons or less; the temperature of so small a body of fermenting liquor seldom rises high, and the process goes on under much more favorable circumstances in this respect than in the subsequent vintages, when the fermentation is generally conducted in quantities of from one to several hundred gallons, when the increase of temperature is necessarily greater.

"The fermentation of grape-juice is so entirely a natural process, and goes through its course so perfectly, under favorable circumstances, that we are apt to become careless, and say that we are trusting the process to nature when, in fact, we are counteracting her operations, and going in direct opposition to the conditions under which fermentation can proceed with success. There certainly exists in the grape a vital energy, a sort of *vis medicatrix*, which not only resists many evil influences to which it is exposed, but seems also to correct them when they have occurred.

"To none of the conditions necessary to a sound healthy fermentation ought we to pay more attention than temperature; and there is, probably, none which is so much neglected. This arises, doubtless, from the difficulty, and, I may say, the supposed impossibility of counteracting the excessive heat of the climate. The construction of an apparatus for keeping down the temperature, of the nature and form already alluded to, would be neither difficult nor costly, and of its beneficial influence on the fermenting process, and the resulting wine, there can be little doubt, for the great majority of our wines are fermented at too high a temperature. When we find writers such as Liebig and Mulder recommending a high temperature for the fermentation of the wines of warm climates, we solace ourselves with the idea that we are on the safe side in this respect, forgetting that what these writers would consider a high temperature is, probably, 86° F., the highest point assigned to a healthy fermentation; but supposing that they allow a higher limit—say 10° above it, still this is far below what the fermenting vats of these colonies often attain, for in many cases they must rise 10° degrees higher still, to 106°, or 20° above the limit already indicated as that beyond which the fermentation does not go on favorably. This is a temperature surely never contemplated by any of these writers, and which no must ought ever to be allowed to attain.

"The effect of a very tumultuous fermentation in beer, caused by a high temperature, is thus described by Dr. Ure*:—'When the action is too violent, these barmy glutinous matters get comminuted and dispersed through the liquor, and can never afterwards be thoroughly

* *Dictionary of Arts and Manufactures.*

separated. A portion of the same feculent matter becomes, moreover, permanently dissolved during this furious commotion by the alcohol that is generated. Thus, beer loses not merely its agreeable flavour and limpidity, but is apt to spoil from the slightest causes. The slower, more regularly progressive, and less interrupted, therefore, the fermentation is, so much better will the product be.' If such are the results of a too violent fermentation in beer, we cannot doubt that it must also have an injurious effect on wine.

"The grapes of the warm districts of these colonies, which attain a specific gravity of 112, or more, are able to bear, and probably require, a very high temperature to complete their fermentation ; *the exact limit we cannot define, but we may venture to say that 95° is a temperature beyond which it would not be advisable to allow any wine to rise, and probably 90° is the highest it ought ever to attain.*"

THE CONTROL OF THE TEMPERATURE IN WINE FERMENTATION.

By A. P. Hayne,* Director of Viticulture, California.

Bulletin No. 117, University of California, 1897.

The Control of the Temperature.—The fermentation of wine must or the juice of the grape results in the main in the splitting up of the sugar it contains into almost equal parts of alcohol and carbonic acid gas. While there are other products of fermentation, it is not essential for our immediate purpose to dwell on them in this connexion. The transformation of sugar into carbonic acid gas and alcohol is a chemical action caused by minute plants or ferments called yeast. It is well known that *all chemical changes of this sort produce heat;* and thus it will be seen that the temperature of a fermenting mass of a sugar solution (grape juice), while it depends to a certain extent upon the outside temperature, is chiefly dependent upon the *amount of heat generated within the tank itself.* The amount of heat then that is produced in a fermenting tank depends upon, first, the per cent. of sugar in the must and the quantity of must; second, the facilities offered by the tank and air for carrying off the heat generated by fermentation, or conductivity of the tank walls, the amount of surface exposed to the air, the circulation of the must within the tank, &c.; third, the activity of the yeast cells, *i.e.*, the rapidity of fermentation.

Percentage of Sugar.—The amount of sugar in the must varies from year to year in the same place with the same varieties. In hot countries there is, other things being equal, more sugar in the must than in cold countries. Some varieties of grapes give more sugar than others; and as high alcoholic strength is, unfortunately, paid for as such by the merchant, grape growers are apt to select those varieties that produce the most sugar, and hence alcohol in the wine, regardless of true quality. While this may be proper enough in cold climates, it works great injury to the general reputation of the wines of warmer countries, for alcohol is

* *Diplomé de l'Ecole d'Agriculture de Montpellier.*

not the only desideratum in wine. In hot climates there is almost always, with the excess of sugar, a correspondingly smaller amount of acid. It is, however, important to note that very high sugar contents of must and low acid generally go together, and that they are both, as a rule, undesirable.

Excess of Heat.—The amount of heat generated within the fermenting tank is very great, being sufficient, theoretically, to raise above boiling point the whole of a must rich in sugar. Practically, however, the heat is generated gradually ; and much of it is carried off by the gas generated, as well as through the walls of the vat, and from the surface of the fermenting liquid ; otherwise fermentation beyond a certain point would be impossible. This fact has taught wine-makers in warm countries the necessity of a free circulation of air in the fermenting room, unless that air is hotter than the temperature of the fermenting mass. Hence the benefit of the practice of fermenting in small packages with thin walls : first, because of less actual amount or quantity of heat (calories) generated ; and, second, because of the facility with which this heat can be carried off, and thus the equilibrium between the temperature of the fermenting mass and the outside air be maintained. This has led many wine-makers to have their tanks made of small diameter, of great height, and of very thin material of high conductivity, such as thin enamelled iron. While this certainly enables the operator to completely control the temperature, it has proved far too expensive for general use. But, unquestionably, the growing custom of using very large tanks is essentially bad practice.

Activity of the Yeast.—The third factor in the problem is the activity of the yeast-cell. There are many circumstances that modify this activity. First it must be remembered that the yeasts are plants, and that, in a general way, their growth (activity) is modified by the same conditions that affect the higher plants growing in the fields. Extremes either of heat or cold are unfavorable to their maximum development. Thus in cold climates the wine-maker keeps a fire constantly burning in the fermenting-room, while in hot countries all his energies are bent on reducing the temperature to that most favorable for proper fermentation.

It is also noted that the higher plants have different "*optimum*" temperatures ; for there are tropical plants, plants of temperate regions, and plants that grow in the arctic regions. It is the same, within certain limits, with the yeast-plants. This variation is, as yet, but little known, for it is within but a few years that serious attention has been given to this branch of science so magnificently set forth by Pasteur. Suffice it to say that something has been done, and that the beer brewers have put these principles in practice with eminent success. Now the yeast-plant of the brewers splits up sugar into alcohol and carbonic acid gas, just as the wine-yeasts do, and is influenced by exactly the same conditions.

In the case of the seeds of the higher plants of all kinds, activity does not begin until the proper temperature has been reached. Should the temperature in spring rise slowly, the growth of all plant life is correspondingly slow ; but so surely as a sudden great rise in temperature takes place, plant life will be intensified by it until, when excessive temperatures are attained, it is either paralyzed temporarily or the plant may die.

Similarly, if the grapes arrive at the fermenting tank much heated, then we may look for a sudden violent development of yeast-plants or fermentation. This is unfavorable for several reasons : first, because the *heat is generated so rapidly* that a due amount cannot be carried off in time by conduction, and high temperature is reached very quickly, whereby the yeast may be paralyzed or killed. But more than this ; within certain limits each degree of sugar in the must means a corresponding amount of heat generated in the tank. Now, if fermentation starts in at a low temperature, say 56 degrees F., the generation of heat will be slow at first, and the rate of fermentation will be correspondingly slow, and *apparently* less heat will be generated than if started at a higher temperature ; because much is lost by conduction, although the *amount* is actually the same. The starting point was so low that the heat that was not carried off by conduction is not sufficient, when added to the initial temperature, to carry it to the killing point. Let the initial point be 75 degrees F., as is frequently the case, then the extra heat added by the greater rapidity of fermentation will carry the temperature, without doubt, to the death limit. Hence the many efforts made to get the grapes into the tank in a cool state. Wherever this can be done, the fermentation usually goes through well ; but practically this is possible only on a small scale. Hence in a warm climate like that of California the initial temperature of the must is always over 60 degrees F., and in some cases over 76 degrees F. The danger arising from over-heating is, therefore, naturally to be expected. Actually, at all the wineries of this State, over-heating does occur almost continually, and great financial losses result therefrom.

Nourishment.—But aside from the general climatic conditions, all plants are profoundly modified in their growth by the nourishment they receive from the soil in which they grow. Aside from the sugar required to nourish the yeast-plant, one of the most important factors in the problem of its growth is the acid. There are other factors, but these are not essential in this connexion. Now, just as there are plants that will grow in alkali soil, and others that will not, so there are yeast plants that will thrive in a non-acid medium, and others that will not.

Diseases of Wine.—This brings us to the plants that cause the *diseases* of wine; for it should be understood once for all, that a "spoilt" wine is spoiled not spontaneously, but by the growing in it of some minute plant which uses the substances of the wine to nourish itself, and to produce both its natural products, most of which are foreign to normal wine, and unpalatable besides. Thus the bacteria of putrefaction destroy otherwise edible meat and render it unfit for human consumption. In the same manner all diseased or "spoilt" wines have been rendered so by some plant of a lower order than the yeast-plant that gave it its quality.

Importance of Proper Temperature.—Returning to the question of temperature, it has been established beyond the possibility of rational dispute that, in the majority of cases, those temperatures most favorable to the wine-yeast plant are unfavorable for the development and growth of disease-plants or bacteria, and *vice versâ.*

In a general way we may say that the wine-yeast is a plant of the temperate zone, while the disease bacilli are plants of the tropics; the one requiring moderate heat for its normal growth, and the other requiring a much higher temperature in order to grow and act at all. *This explains the practice of keeping wine in cool cellars.* This is a very important point. High temperatures are very *unfavorable* for normal wine-yeast, and very *favorable* to the bacteria which cause wines to spoil. After the limit of temperature favorable to the yeast-plant has been passed, the quality of the wine deteriorates with great rapidity:

not necessarily because the wine-yeast is actually killed, nor that its action has ceased altogether ; but that its activity has been checked, and that the harmful bacteria have begun their work ; producing, not alcohol, carbonic acid gas, glycerine, &c., but their own characteristic products, such as mannite, acetic, lactic, and butyric acids, &c., &c.

Paralysis and Death of Yeast-plants.—The degree of paralysis of the yeast-plant depends upon the temperature and composition of the must. The absolute point of temperature at which paralysis or death will overtake the yeast-plant cannot be fixed absolutely, as it depends upon the variety of ferment or yeast-plant, as well as upon the conditions in which it works best. For normal musts with a normal yeast, the death point is generally from 98 to 100 degrees F. Some varieties of yeast (and these are few) will stand more heat, most of them suffering greatly before this point is reached ; the must also should be of a composition naturally favorable to them. Before this point is reached the bacteria begin to develop, while the wine-yeast stops growth ; and the wine, if not spoiled, is rendered of less value than it would have been had the temperature remained lower.

Effect on Bouquet and Aroma.—It should be noted in this connexion that, with certain reservations, the general rule is that the lower the temperature of fermentation the better the aroma and bouquet of the wine. In other words, the proper regulation of the temperature of the must during the first or tumultuous fermentation means the production of a wine richer in alcohol, of better keeping qualities, and better quality throughout.

Use of Antiseptics and Antiferments.—With this review of the general principles governing fermentation, we come to the practical lessons deducible therefrom. We have had occasion to note the heavy annual loss to wine-makers from "stuck tanks," resulting either in the total destruction of the wine, or the partial loss of its market value. We have also had occasion to listen to the criticisms of the purchasers of Californian wine, both abroad and in this country; and in by far the greater number of cases the fault found was not so much with the quality (for well-made Californian wine compares favorably, grade for grade, with any in the world) but in the *unsoundness*, *i.e.* the tendency to spoil on the hands of the purchaser before reaching the consumer. This has led to the use of antiseptics, "anti-ferments," that is poisons which kill outright or paralyze, not only the wine-yeast but all bacteria that might intervene, and in some cases the consumer as well. The making of wine at high temperatures is simply inviting the use of antiseptics; for, as a matter of fact, *unsound wine can only be marketed by the use of some powerful agent, to keep the bacteria in check.* Few wine-makers realize the great harm done to the reputation of Californian wines by a few unscrupulous or ignorant dealers who systematically buy up unsound wines, "doctor" them, and ship them abroad. The sooner the use of antiseptics of any kind (except pure wine alcohol) is stopped, the better it will be for all concerned in viticulture. It is to be regretted that there is no law enforced that punishes those who use dangerous drugs in wine.

Stuck Tanks.—A "stuck tank" is a very common occurrence at most all wineries in California, as well as in all countries having similar climates. It means that the yeast germs that convert the juice of the grape into wine have suddenly ceased their normal action, and fermentation proper has ceased, while bacterian activity has started up; resulting either in the total or partial loss of the wine. One wine-maker of this State told us that his loss from stuck tanks amounted in a single season to 10,000 dollars; and there are but few who do not suffer to a certain extent from this trouble.

As has been shown, the commonest cause of stuck tanks is too high temperature. The trouble is not by any means confined to California; but is the curse of all wine-making countries in the warmer parts of the world, viz., all Southern Europe, North and South Africa, Australia, &c. The wine-maker of these countries has been found to be less self-complacent than his California brother, and has made serious efforts to control the temperature of fermentation.

Methods of reducing Temperature.—By some wine-makers the amount of sugar was reduced by the *addition of water.* This, in many cases proved of great service, but in others it was not so; for the water also reduces the acid and the body of the wine, and unless there be sufficient acid, normal fermentation does not take place, save under exceptional circumstances. Others tried to reduce the temperature of the wine by the *addition of ice* to the fermenting tank. This had not only the same effect as the addition of water but proved utterly impracticable in the case of red wine and is not economical. Some tried the use of *metal spiral coils* plunged in the fermenting tank through which cold water was passed. This proved successful in the case of wine fermenting without skins or stems (white wine); but was impracticable in all cases where the skins and stems were left in the tank, owing to the impossibility of sufficiently mixing the hot and cold parts of the fermenting mass. Others tried *metal tanks*, but this was found to be too expensive.

Again, some tried pumping the wine from the bottom of the tank over into the top and allowing it to spread out into a spray. This accomplished two results: it *cooled* the wine slightly (but very slightly) and especially did it *revive* the partially paralyzed yeast cells by giving them a fresh supply of free oxygen. The fatal defect of this practice was found to be the too great oxidation and evaporation of the alcohol, which took place at high temperatures, the wine becoming too highly charged with acetic acid (vinegar-sour). Nevertheless, this pumping over of the wine of stuck tanks, or tanks that threaten to stick, is now widely practised all the world over, and in the case of a sudden stopping of fermentation it is necessarily done to supplement the addition of fresh must in active fermentation used to finish the conversion of the sugar into alcohol and carbonic acid gas.

Experiments at the University.—Convinced of the necessity of controlling the temperature of the fermentation of wines in this State (just as the brewers do that of their fermenting wort to a fraction of a degree, always getting a product the value of which is known beforehand), the Viticultural Staff of the College of Agriculture set about to devise some practical method for attaining this end. It was only after having completed the experiments with the apparatus herewith described, that we received detailed data of the European experiments with the refrigeration of wine. We give below a complete description, first, of the French apparatus; second, of the one first devised at the Experiment Station; and, third, of the one modified as found advisable after thorough trial.

Apparatus used in other Countries.—Figure 21 (page 116) represents one of the forms of the apparatus now used throughout Northern Africa and Southern France. As will be seen, it consists essentially of two columns, each made up of nineteen thin, well-tinned, horizontal copper tubes. These tubes are $13\frac{1}{4}$ feet long by $1\frac{1}{2}$ inches in diameter. The total length of the tubes through which the wine passes is thus nearly 500 feet. These tubes are fitted into solid bronze castings, closed by means of a bronze plate over a rubber washer, with thumb-screws. The two columns are connected by a tube (3 fig. 21) running diagonally from the top of one column to the bottom of the other, so that the hot wine entering at the lower end (7 fig. 21) of the first column, and after passing upwards and completing the circuit in this column, passes to the bottom of the second column, from which again it escapes at the top. Above the two columns of tubes is a large metal water-box, having two rows of holes in the bottom corresponding to the two columns, from which cold water is allowed to drip as the warm wine is pumped through the tubes. Under the apparatus is a metal box, which catches the drip of warmed water. Each column of tubes has a stop-cock (13), which allows rapid emptying of the wine when pumping is stopped. The apparatus is, as before said, now actually in use in other countries, and we are indebted to the excellent report of Messrs. Müntz and Rousseaux in *La Revue de Viticulture* for the results of their exhaustive experiments conducted in France during the past season, 1896, as well as during the season of 1895.

The first defects that strike one in this apparatus is the unwieldiness and expense, as well as the large amount of labour required to force a $1\frac{1}{2}$-in. stream of wine through such a length of tubing at a working rate; then the amount of water used in cooling the wine must be very large, unless the temperature of this water be considerably below that of the wine. As in the case of the use of ice, it will do well when all conditions are most favorable.

In a recent article, giving a resumé of the two seasons' experiments, Messrs. Müntz and Rousseaux tell us that to work the apparatus a gang of four men, working in relays, is required to pump 40 hectolitres or 1,060 gallons per hour. With a motor engine double this amount could be pumped through, but the *quantity of water* needed in this case for the proper cooling of the wine is enormous, amounting to from one to one-and-a-half times the amount of wine passed through; or far more cold water than is generally to be had at the average California winery.

The reduction of temperature was in some cases very great, but depended altogether upon the rate of pumping, the amount of water dripping over the tubes, and the initial temperature of this water. There was an average reduction, however, of from 10 to 12 degrees F., but in some cases a maximum of as much as 20 degrees when slow pumping was practised. The cost of cooling the wine was, on an average, one-thirteenth of one cent per gallon.

From the careful tests made by these eminent scientists, the remarkable benefits of cooling the fermenting mass was strikingly shown. In all cases a certain lot of the same must was fermented in the usual way as a check to the experiment, and in every case the cooled wine was sounder and of far better quality. Microscopic examination showed that the uncooled wine was teeming with harmful bacteria, while the amount of unfermented sugar remaining was very considerably more than in the case where the wine had been cooled. The University experiments showed this as strikingly as did those of Müntz and Rousseaux.

We give below a table taken from *La Revue de Viticulture*, in which some of these results are set forth. Unfortunately the recent disastrous fire at the Agricultural Building at the University destroyed all the notes taken at each tank cooled, so that we can but give the general results. These results were, however, *looked over but a few days before the fire*, and, being compared with those made in France by Müntz with his apparatus, were found to be essentially in accord, as appears from the data given below. We give below the exact figures obtained by these observers. This shows the matter to be not of something "*theoretical*" and untried, but something that has been *tried by several, and proved to be a practical success.*

The experiments were made in the Rousillon district of France, near the Eastern Pyrenees, during the season of 1896, with Carignane grapes.

——	Maximum temperature of the must during fermentation.	Alcohol per cent.	Unfermented Sugar.
Cooled Wine ...	96 (F.)	11·00	
,, ,, ...	96·8	11·45	·59
,, ,, ...	99·5	11·50	·65
Uncooled Wine ...	102·2	10·20	2·60
,, ,, ...	104·0	10·10	3·30

It will be recollected that experiments made by Prof. Hilgard at the University, in 1887, gave almost precisely similar results as to alcohol percentage when hot and cool fermentations were compared. (See Report of the College of Agriculture on Methods of Fermentation of 1886–87, p. 28.)

The effects of high temperature on the composition of the wine may be further illustrated by some other analytical results from the French experimenters, Müntz and Rousseaux, who found in 1895 that a wine which had attained a maximum temperature of 98·5 degrees F., during fermentation showed on analysis ·066 per cent. of ammonia, while another wine made from the same lot of grapes, which attained a maximum of 104 degrees, showed ·60 per cent. Similar results were obtained in 1896, when maxima temperatures of 94 degrees and 104 degrees gave ·03 per cent. and ·22 per cent. of ammonia respectively. It is clear, therefore, that serious chemical differences and defects are produced in the wine by high temperature fermentations apart from the swarms of disease bacteria which are always present in such wine. Of the wines made by Müntz and Rousseaux in their 1896 experiments, those that were not cooled threaten to spoil already; while those that were cooled are in perfect condition.

Experiments made by the University at Natoma, Sacramento County, and at Evergreen, Santa Clara County.

Apparatus used.—The results of Müntz and Rousseaux were amply confirmed by the investigations undertaken by the Viticultural Staff during the season of 1896 at the Natoma Vineyard in Sacramento County, and at Mr. Wehner's at Evergreen, near San Jose. The apparatus used by us differed greatly from that used by Müntz and Rousseaux, and the many others abroad who practised refrigeration during fermentation at the same time.

Not being able to avail ourselves of the detail of the numerous experiments undertaken along the same lines abroad during the past few years, we had to construct our apparatus independently upon what we considered the most promising lines; fortunately, as it turned out, committing few mistakes and obtaining results that show our system to be far superior to any thus far proposed for California conditions. However, experience has shown us the desirability of certain changes and modifications as hereinafter shown, especially as mechanical power for pumping and crushing is available at nearly all wineries of this State.

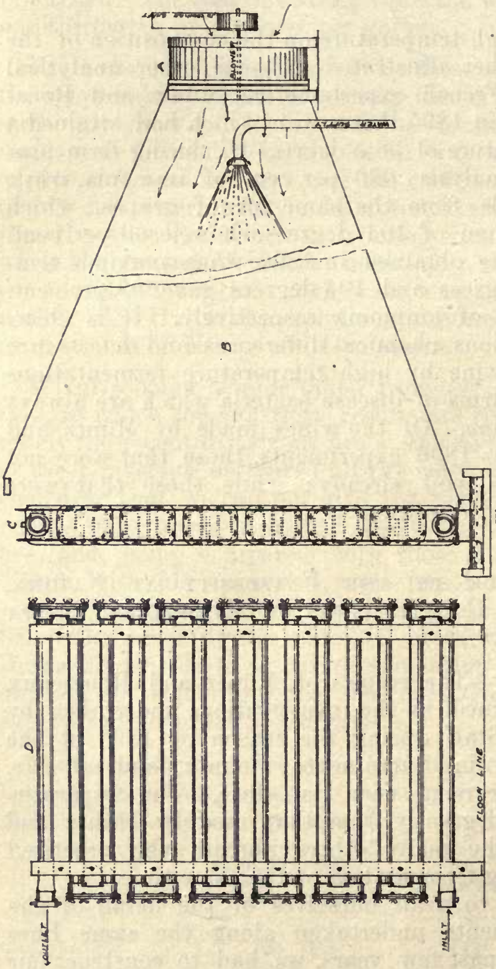


Fig. 2.

The apparatus shown in figure 2 is the one designed and used by us in the experiments. It will be observed that in so far as the pumping of the heated wine through tinned copper tubes goes, the principles are identical with those of the French apparatus. The method of pumping is the same as is in practice at wineries for drawing off the newly fermented wine from the fermenting tank. The wine is drawn off from the bottom of the tank, and strained through a sieve into a tub, from which it is pumped through the apparatus into the top of the tank again. In other respects there are important differences; thus, instead of two columns consisting of 498 lineal feet of tubing, our apparatus consisted of a single column of only 42 feet of tubing. The tinned copper tubing instead of being *perfectly round is very much flattened*, thereby giving greater cooling surface to the same volume of wine, a material improvement on the French system of round tubes. It consists of fourteen pieces 3 feet long and 4 inches broad by 1½ inches deep. These tubes are fitted into bronze castings, which are closed by plates fitting over rubber washers, and fastened by thumb-screws, thus allowing the tubes to be readily cleaned in cases of obstructions that might occur in the pumping through of the muddy, partly-fermented must.

METHODS OF COOLING.

Water-box.—In our first experiments the whole apparatus, that is to say the column of tubes, was fitted into a box, tin-lined and filled with water. A constant supply of fresh water entered the box at the bottom, escaping from the top, while the wine entered the top of the apparatus and escaped at the bottom, in order that the *coldest wine* should come in contact with the *coldest water*, and *vice versâ*. It is well known that this arrangement will give the greatest amount of cooling effect.

It was found that by the use of a very large quantity of water the wine could be sufficiently cooled, but the excessive amount of water thus required caused us to abandon this system. In special cases, where an unlimited water supply is to be had without too great expense, this system should be adopted, for though the cost of water-box and installation will about offset the cost of the blower and canvas sleeve, hereinafter described, it has the advantage of doing away with the necessity of the command of power. In case this system is adopted, it is well to use a greater length of tubing than would be required where the spray and the air current are used. Roughly speaking, the amount of water used in this case should be from 1½ to 2½ times the volume of wine pumped through the apparatus.

Drip, Spray, and Blast.—Instead of depending upon the simple dripping of the water over the tubes to effect the reduction of temperature of the warm wine, a great saving of tubing, as well as labour in pumping, was found to be effected by the use of a fine spray of water carried by a strong blast of air, thus combining the effects of cold water and evaporation. The quick evaporation brought about by the dry air prevailing at our vintage season, when mingled with a fine spray, produces a cooling effect far in excess of what could be obtained from the ordinary water at the wineries alone. This is important, for at many of the wineries the water available is very warm and the difference between the temperature of the water and the wine to be cooled is so slight that it would be impossible to effect a proper amount of cooling, unless enormous volumes of water were used.

The proper proportions between the air blast and the amount of water sprayed is of the utmost importance. It is readily understood that a weak blast with a large amount of coarsely-sprayed water would leave the temperature of the water almost unchanged when it reaches the cooler, and would, therefore, amount to little more than the dripping practised in the French apparatus; while if the blast be in excess and the water deficient, the amount of water carried may not be sufficient to utilize the evaporative power of the blast, nor to thoroughly wet the tubes. Again, to insure the maximum cooling from evaporation, the spray should be so fine that within the short distance from the nozzle to the tubes the air may become fully saturated, and both cooled to the fullest extent. Of course, the heavier the blast the more water spray can be carried and cooled by it. To produce the requisite fineness of spray, an adequate water pressure is necessary.

Another factor of the utmost importance is the dryness, or what is technically called the "relative humidity" of the air used. During the vintage season this is frequently as low as 33 per cent. *outside of the winery*, and the intense evaporating effect producible under such conditions should be utilized by connecting the intake with the outer air. This, of course, can be done either by a canvas tube stretched by hoops, or by a board flume.

When, as may happen near the coast, the moist condition of the air is unfavorable to strong evaporation, the water temperature, on the contrary, is frequently itself so low that an energetic spray without a blast may suffice to do the necessary amount of cooling.

It will be noted, therefore, that the best conditions for cooling will vary, not only in different localities, but on different days, and according to the prevailing wind; so that it is impossible to prescribe the exact strength of blast or quantity of spray that should be used. But a few experiments will determine the best practice in any given locality.

In our experiments the blast of air was generated by means of an 18-in. "double" (8-wing) blower, or "exhaust-fan" reversed. The water escaped from a battery of three Vermorel nozzles placed immediately in front of the blower.

A conical canvas sleeve attached to the outlet of the blower and 5½ feet away to the circumference of the cooler-frame prevents the loss of blast and spray.

The "double" 18-in. blower requires under ordinary circumstances less than one-half horse-power to run it at a rate of 1,000 revolutions per minute, and thus, with a free supply, will pass 3,000 cubic feet per minute through it. The 24-in. "double" blower requires about the same horse-power to run it, but requires only 900 revolutions per minute to send through 5,000 cubic feet in the same time. It should be remembered that the best efficiency of every blower is limited to a definite velocity of revolution. The figures above given refer to the most favorable velocities for the sizes mentioned. The one costs 40 dollars (less discount) while the latter costs 50 dollars. In order that the apparatus may be available at small-scale wineries, where no steam is used, it may be well to state that a small gas engine, run with common "distillate" and giving 2½ horse-power, can be had for 187 dollars (less discount). The cost of running such a motor is 1 cent per horse-power per hour; a trifling expense, especially as the motor, once started, will run itself, so that one man can attend to the pumping of the wine and the running of the engine at the same time. Indeed, with a little fitting, such an engine could be made to do all the pumping in the cellar, and there are no labourers who will do 1 horse-power of work for a cent an hour.

While the French apparatus was movable, ours was of necessity fixed, but with one man at the pump at Mr. Wehner's place it was found that he could pump from the most distant tank at the rate of 1,000 gallons per hour, in some cases as much as 1,400 gallons. At this rate a reduction of temperature of from 10 to 13 degrees was obtained in the wine. The temperature was taken at the point where the wine left the tank and again where it re-entered the tank after having passed through the cooler.

Precautions.—We found that the much-feared *deposit of cream of tartar* on the inside of the tubes was very slight indeed. It would seem that while warm wine on cooling will deposit cream of tartar on the lining of the vessel, wine constantly in motion (as when being pumped) will not deposit much. Even after long use it was found that the thin coating of cream of tartar on the inside of the tubes could be removed by pumping the apparatus full of water and leaving it over night after a few barrels had been pumped through. The apparatus should be flushed out at least once in twenty-four hours, for the deposit of cream of tartar, be it ever so slight, interferes greatly with the conduction of heat, and anything that has this effect must be carefully avoided. Even the surface of the tubes should be polished once a day with ashes or lye, for there forms on the surface after a day's use a "greasy" film, due to the lubricant necessarily used in the blower, which not only interferes with the conduction of heat, but causes the water to run in streaks over the surface instead of spreading over it, much cooling surface being thus lost.

The seeds and skins should be kept out as well as possible from the pump and consequently from the apparatus. By exercising due precaution in this regard, we did not have to clean the apparatus from this cause once during the entire trial.

Control of Temperature.—We found, as did Müntz and Rousseaux, that when the wine passed 100 degrees F. cooling was useless, for the ferments or yeasts were too badly injured to be revived. Thus a tank at Natoma (where the conditions were unfavorable on account of hot weather) was fermented with some Algerian yeast, and was allowed to go as high as 104 degrees F. The tank "stuck" before fermentation was finished, and it could not be revived by cooling.

Müntz and Rousseaux state that if a tank is cooled before the temperature reaches the danger limit there need be no fear that a subsequent rise to this limit will take place. We found at Mr. Wehner's that under the conditions existing, when the temperature in the tank reached 88 degrees F., if we pumped about one-half or two-thirds of the contents of the tank through the cooler, nothing disastrous ever happened, although the fermentation kept right on and the rise in temperature continued, yet it seemed that a sufficient amount of heat (calories) had been removed from the fermenting mass to enable it to complete fermentation without reaching the danger point. This favorable result, however, must largely depend upon special conditions, and should not be relied upon so as to relax vigilance.

Considering the fact that low temperature fermentation gives a wine of a different composition from that fermented at high temperature, and leaving for a moment the killing of the yeast out of the question, it is evident that it would pay to keep the temperature constantly below the danger limit on account of the superior quality of the resulting wine.

It might not pay in ordinary cases to go to this expense for quality alone, yet if extra fine wine is to be made, extra care must be bestowed upon it.

Aeration of the Wine.—It was deemed advisable to aerate the wine whenever it was pumped over. In order to accomplish this, and at the same time to prevent the cooled wine from forming a channel in the cap and passing at once to the bottom and thus leaving the warmer wine at the top, we caused the wine to escape from the end of the hose in a fan-like jet, the direction of which was, from time to time, so changed as to reach all parts of the cap during the cooling. In this way the cap was very greatly cooled, which is important, as it is the hottest part of the fermenting mass in a tank.

In all cases where the cooling took place at or about 88 degrees F., the tank "went dry" perfectly well, and the resulting wine was drier and far clearer than in case of the wine not cooled and aerated. This was especially noticeable in cases where pure cultures of yeast were used, especially some of the foreign varieties.

In some cases we tried the use of an extra empty tank into which the cooled wine from the first tank pumped was put, and the cooled wine from subsequent tanks was pumped into the first tank. At the end of a certain time the wine first cooled was pumped into the last tank. In this way one avoids cooling the same wine or part of it twice, but an extra pumping is thus necessitated. The avoidance of cooling wine that has just been cooled and pumped back to the top of the tank is certainly an important problem, that must be solved by each wine-maker according to circumstances. We would suggest that a storage tank, at a greater elevation than the fermenting tank, be used as a common receptacle for all cooled wine. As soon as a sufficient amount of wine in any given tank has been cooled, it can be returned by gravity, and thus all danger of wasting energy by pumping the same wine twice through the cooler can be avoided. It is true that there will be an extra amount of labour required to force the cooled wine to a greater level than that of the fermenting tank.

Faults of the Apparatus.—It was found that with our first apparatus we had made the mistake of placing the tubes too far apart (2½ inches), losing thereby a very considerable amount of air and spray. This we had to remedy for the time by filling up the space with 2-in. slats; but this, of course, caused a great waste of cooling effect. We, therefore, in our modified apparatus, recommend that the tubes be placed 1 inch apart, which is the practical limit for the successful soldering of the tubes into the castings, more especially when the tubes are of such greater width as we now find desirable. The horizontal position, moreover, will always prove a source of waste, on account of allowing too ready a passage for the current of air and spray. It was also found that for large scale operations the cooling capacity of the apparatus was not adequate.

The New Apparatus.

In the construction of the new apparatus the need of greater capacity was first considered. The lengthening of the tubes, as in the French model, renders it very cumbersome; and it, therefore, seemed preferable to retain the same length of tubes, but to give them an increased cooling surface by enlarging their dimensions to 5½ inches x 1½ inches, and to use two batteries or columns placed one behind the other. This arrangement would serve in any case to utilize better the cooling current, which must always waste through a single system of tubes, however placed. Moreover, the increased cooling surface obtained by widening the tubes does not involve an increase of friction, as would a lengthening of tubes, to attain the same purpose.

Another modification deemed wise is to have the extremities of the tubes closed by a single bronze casting instead of separate castings for each pair of tubes. These castings are fastened by thumb-screws over rubber washers, as in the case of the first machine. The advantages are that it not only requires fewer thumb-screws (and hence allows greater rapidity in cleaning), but also that the solidity of the whole apparatus is greatly enhanced, and the necessity for an extra frame is done away with. We found that with the great number of small castings it was difficult to keep any frame from "giving" a little. (See Fig. 3.)

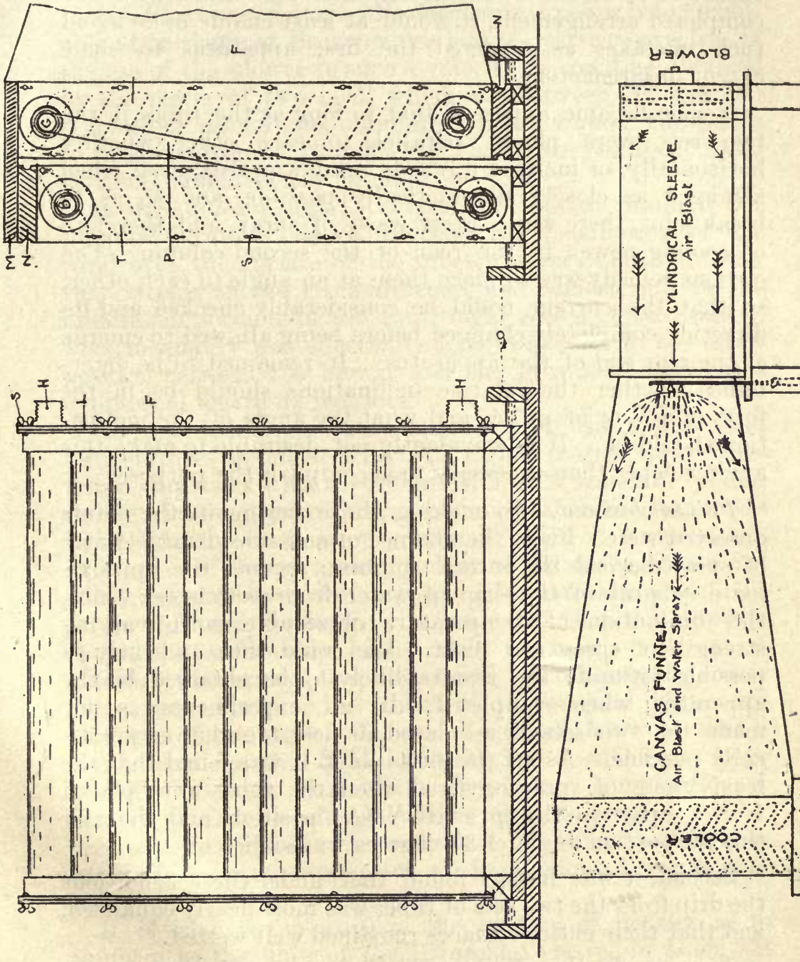


Fig. 3.

Relative Position of the Sets of Tubes.—In order to determine as nearly as possible the various conditions needful to secure the best results, two sets of tubes of twelve each were placed in a convenient frame, and so suspended on chains that both their distance and their relative positions could be readily changed at will. While this would not enable us to determine exactly all the best conditions in the completed arrangement, it would at least enable us to avoid such mistakes as rendered the first apparatus to some extent unsatisfactory.

It soon became apparent that so long as the tubes in the two sets were placed parallel to each other, whether horizontally, or inclined upwards or downwards, even when arranged as closely as practically possible, and so as to break joint, there was a great waste of spray, and therefore of cooling power, in the rear or the second column. The obvious remedy was to place them at an angle to each other, so that the current could be considerably checked and its direction completely changed before being allowed to emerge at the rear end of the apparatus. It remained to be determined whether the relative inclinations should be in the form of a V or of an A, and what the angle of the inclination should be. It was evidently not desirable to make this angle steeper than necessary to accomplish the purpose.

Points observed.—In making the experiments the points observed were : First, the absence of any considerable waste of spray beyond the second column ; second, the approximate equality of the drip of water from both sets ; third, the diminution of temperature obtainable with varying strength of spray and blast. We could thus as nearly as possible estimate the results likely to be obtained by the apparatus when completed. In all experiments so far made the two sets were placed as near together as practically possible. As to the first point it was found that the least waste of spray occurred when the tubes were placed 1 inch apart in the inverted V (A) position, and that for this purpose an angle of 30 degrees was sufficient.

Second, it was further found that under these conditions the drip from the two sets of tubes was most nearly equalized, and that their entire surfaces remained well wetted.

As regards the third point, it was found that in the space between the two sets the temperature was mainly governed by the strength of the blast and the amount and kind of spray used. In this respect our preliminary experiments could give only comparative values, since the saturation of the air at Berkeley at the time was between 75 and 80 per cent., and the air temperature varying but slightly above and below 60 degrees F.

Air Blast and Spray.—No mechanical power being available at the time at Berkeley, we had to restrict ourselves in the use of the blower to such a velocity as could be obtained by the power of two men, which was between 700 and 750 revolutions per minute, obtaining probably about two-thirds to three-quarters of the effect of the blower, or about 2,000 or 2,500 cubic feet per minute.

It was quickly noted that, as transmitted through the pyramidal canvas sleeve directly, the distribution of the wind over the surface of the tubes was very unequal, being very strong at the circumference, and almost null in the middle, on account of the centrifugal action of the blower. This inequality was effectually done away with by the interposition between the blower and the pyramidal sleeve of a cylindrical sleeve $3\frac{1}{2}$ feet long.

As regards the spray, a comparison of the reduction of temperatures obtained with the rather coarse spray heretofore employed, with that obtained from a standard cyclone nozzle yielding very fine spray, showed that the latter was by far the most efficacious, besides which it permits of a shortening of the pyramidal portion of the sleeve, on account of the rapidity with which evaporation can take place. To attain this end, however, it is necessary that the pressure should be sufficiently high; that is, nearly such as is obtained with spray pumps—not less. Manifestly the coarse spray carried with it too much of the original high temperature of the water. It was also found, however, that a single nozzle of this kind does not yield a sufficiently large quantity of water, and that, therefore, a combination or battery of such nozzles should be used, *varying in number according to the water pressure and the strength of blast at command.* In our apparatus we have adopted five as probably sufficient.

It is easy to so arrange the battery of nozzles as to conform to the flare of the pyramidal sleeve, in order *not to waste the spray upon the canvas* on the one hand, nor to leave part of the space unutilized on the other.

Beneath the apparatus should be placed a shallow box to catch the drip, which should be drained off through a pipe or trough. A screen may be placed in the rear of the apparatus to catch the spray that has passed through, and may be of boards, sacks, or any thing that is convenient. If the apparatus be placed facing a door or window, no screen is necessary. The current of air in itself is not objectionable in a hot winery. The drawback to the free circulation of the current of air and spray is that the workmen working immediately in front of it after coming from some hot part of the cellar are in danger of contracting colds, or even pneumonia.

Conclusions.—Accepting, then, the fact that in California the tendency is to ferment at high temperatures, on account of the initial as well as the air temperatures being higher than in cooler countries, such as the Medoc, Burgundy, the Rhine, Champagne, &c., and also the fact that in this State we use exceptionally large fermenting tanks, and that our musts are, as a rule, very high in sugar, and, in many cases, low in acid, the simple question is—Shall we not attempt to overcome these natural defects of our climate, and control fermentation, just as wine-makers of other countries do under similar circumstances, and as the brewers have long done under all circumstances?

Competition is now so keen that if we would succeed we must place on the market a wine that is equal, if not superior to that of other countries. Under favorable conditions we produce a wine that is equal to any in the world, but under unfavorable conditions we make wines that are distinctly inferior.

It is the custom at all the wineries of the State, in case of the tank threatening to "sick," to pump the wine from the bottom over the top, at the same time aerating it by causing it to fall in a spray. Should the cooling apparatus be used in connexion with this procedure, there would be *no extra cost beyond the original expense of the apparatus*, which will last indefinitely with proper care.

An apparatus such as we recommend will cost very little compared with the enormous saving that can be effected in a single unfavorable season. To provide several for use at a large winery should not cost over 1,000 dollars, while for a winery of ordinary size an apparatus capable of reducing the temperature of the wine a minimum of 10 degrees at the rate of 1,000 gallons per hour, would cost far less. Messrs. Müntz and Rousseaux found that the cost of cooling wine in France with their cumbersome apparatus was one-thirteenth of a cent per gallon. This includes four men at 70 cents per day for pumping, and the wear and tear, interest on the original cost of the apparatus, and all possible extra expenses. It would not cost much over one-twelfth of a cent per gallon in this country, even if we had to buy a 200-dollar motor ($2\frac{1}{2}$ h.p.) in addition to the apparatus itself. It need not cost any more than this, for the motor takes care of itself when once started, and any extra horse-power could be used to advantage in pumping wine from one tank to another.

In conclusion, we wish to express the sincere thanks of the University to those who helped us with suggestions, money, and material.

Messrs. Toulouse and Delorieux, of 622 Commercial-street, San Francisco, constructed the apparatus according to our designs, and it is due in no small degree to the extra time and trouble bestowed by them upon its construction and modifications that the experiments proved successful.

Mr. D. M. Doub, of 137 First-street, San Francisco, came forward in the most public-spirited manner, loaning us several of the "blowers" and "exhaust-fans" needed. But for such liberality the experiments could not have been undertaken.

The Pelton Water-wheel Co. also helped us not only with the loan of machinery, but also by making for us on the shortest possible notice such alterations as were suddenly found necessary.

Mr. J. Henshaw Ward provided for our exclusive use at the Natoma Vineyard 150·00 dollars worth of the best wine hose, not otherwise obtainable.

Mr. J. H. Wheeler and Mr. J. Rennie, the lessees of the Natoma Vineyard, allowed us to use part of the vintage and cellar.

To Mr. Wm. Wehner, of Evergreen, we are especially indebted, not only for the use of the cellar, vintage, labourers, &c., but for the hospitality and attention he bestowed upon us. The kindness and assistance we received at his hands was exceptional.

Descriptions of the apparatus used abroad are given alongside of the form we have devised, so that the wine-maker may choose between them.

All that we desire is that some kind of effort shall be made to control temperatures, be it the use of ice, water, air, or anything else; for it is certain that if the temperature is controlled there will be an improvement of from 10 to 100 per cent. in the quality of Californian wine.

The Viticultural Staff of the College of Agriculture will cheerfully confer and advise with any persons interested in this subject, and assistance in the construction or working of coolers of any sort will be given. While we think that our apparatus is better than any of the rest, all that we desire is *that there be some sort of cooling apparatus used*, and if our efforts contribute to the attainment of this end we will be satisfied.

THE METRIC SYSTEM.

Measure.

The Metric System takes for its basis the distance from the Equator to the Pole, dividing this into ten million parts. One such part is a metre. The words denoting multiples of the Metric standards are derived from the Greek, and those denoting divisions, from the Latin, thus :—

10	metres equal	one	decametre.
100	,,	,,	hectometre.
1,000	,,	,,	kilometre.
10,000	,,	,,	myriametre.
$\frac{1}{10}$	of a metre equals	one	decimetre.
$\frac{1}{100}$	,,	,,	centimetre.
$\frac{1}{1000}$	,,	,,	millimetre.

Weight.

The weight of one cubic centimetre of water at 4°C. is the standard, and is called a gramme.

10	grammes equal	one	decagramme.
100	,,	,,	hectogramme.
1,000	,,	,,	kilogramme.
$\frac{1}{10}$	,,	,,	decigramme.
$\frac{1}{100}$	,,	,,	centigramme.
$\frac{1}{1000}$	,,	,,	milligramme.

Fluid Measure.

The volume of a cubic decimetre is the standard, and is called a litre.

100	litres equal	one	hectolitre.
$\frac{1}{10}$	,,	,,	decilitre.
$\frac{1}{100}$	,,	,,	centilitre.
$\frac{1}{1000}$	,,	,,	millilitre.

The hectolitre is the wholesale standard for wine. One hectolitre of water weighs 100 kilos.

THE METRIC AND BRITISH SYSTEMS.

Metric Measures.

One metre	=	39·37079 inches.
One decimetre	=	3·937 ,,
One centimetre	=	0·3937 ,,
One millimetre	=	0·0394 ,,

Millimetres = Inches.			Centimetres = Inches.					
Millimetres.		Inches.	Centimetres.		Inches.	Centimetres.		Inches.
1	=	0·039	1	=	0·394	10	=	3·94
2	=	0·079	2	=	0·787	20	=	7·87
3	=	0·118	3	=	1·181	30	=	11·81
4	=	0·157	4	=	1·575	40	=	15·75
5	=	0·197	5	=	1·969	50	=	19·69
6	=	0·236	6	=	2·362	60	=	23·62
7	=	0·270	7	=	2·756	70	=	27·56
8	=	0·315	8	=	3·150	80	=	31·50
9	=	0·354	9	=	3·543	90	=	35·43

Metres = Feet.

Metres.		ft.	in.	Metres.		ft.	in.	Metres.		ft.		yds.
1	=	3	3⅜	10	=	32	10	100	=	328	=	109
2	=	6	6¾	20	=	65	7	200	=	656	=	219
3	=	9	10	30	=	98	5	300	=	984	=	328
4	=	13	1½	40	=	131	3	400	=	1,312	=	437
5	=	16	5	50	=	164	0	500	=	1,640	=	547
6	=	19	8	60	=	197	0	600	=	1,968	=	656
7	=	22	11½	70	=	230	0	700	=	2,297	=	766
8	=	26	3	80	=	262	0	800	=	2,625	=	875
9	=	29	6½	90	=	295	0	900	=	2,953	=	984

SQUARE METRES = SQUARE FEET = SQUARE YARDS.

Square metres.		Square feet.		Square yards.
·0929	=	1	=	—
1	=	10·76	=	1·196
2	=	21·53	=	2·39
3	=	32·29	=	3·59
4	=	43·06	=	4·78
5	=	53·82	=	5.98
6	=	64·59	=	7·18
7	=	75·35	=	8·37
8	=	86·11	=	9·57
9	=	96·88	=	10·76
9·29	=	100	=	10·76
10	=	107·64	=	11·96
20	=	215·29	=	23·92
50	=	538·21	=	59·80
92·90	=	1,000	=	59·80
100	=	1,076·43	=	119·60
500	=	5,382·15	=	598·02
1,000	=	10,764·30	=	1,196·03

Square feet.		Square yards.		Square metres.
9	=	1	=	·84
10	=	1	=	·929
18	=	2	=	1·67
27	=	3	=	2·51
36	=	4	=	3·34
45	=	5	=	4·18
54	=	6	=	5·02
63	=	7	=	5·85
72	=	8	=	6·69
81	=	9	=	7·52
90	=	10	=	8·36
100	=	10	=	9·29
180	=	20	=	16·72
450	=	50	=	41·80
900	=	100	=	83·61
1,000	=	100	=	92·90
4,500	=	500	=	418·05
9,000	=	1,000	=	836·10

Cubic Metres = Cubic Feet = Cubic Yards.

Cubic metres.		Cubic feet.		Cubic yards.	Cubic metres.		Cubic feet.		Cubic yards.
1	=	35·32	=	1·31	9	=	317·85	=	11·77
2	=	70·63	=	2·62	10	=	353·17	=	13·08
3	=	105·95	=	3·92	15	=	529·75	=	19·62
4	=	141·27	=	5·23	20	=	706·33	=	26·16
5	=	176·58	=	6·54	50	=	1,765·83	=	65·40
6	=	211·90	=	7·85	100	=	3,531·66	=	130·80
7	=	247·22	=	9·16	500	=	17,658·29	=	654·01
8	=	282·53	=	10·46	1,000	=	35,316·58	=	1,308·02

1 cubic metre of water at 4° C. weighs 1,000 kilos.
1 cubic foot = 0·0283 cubic metre.
1 cubic yard = 0·7645 cubic metre.

Comparative Pressure per Square Centimetre and per Square Inch.

Grammes per square centimetre.		Lbs. per square inch.	Kilos. per square centimetre.		Lbs. per square inch.
50	=	0·71	1	=	14·22
100	=	1·42	2	=	28·45
200	=	2·84	3	=	42·67
300	=	4·27	4	=	56·89
400	=	5·69	5	=	71·11
500	=	7·11	6	=	85·34
600	=	8·53	7	=	99·56
700	=	9·96	8	=	113·78
800	=	11·38	9	=	128·01
900	=	12·80	10	=	142·23

Metric Weights.

One decigramme	=	1·543 grain.
One gramme	=	15·4323 grains.
One decagramme	=	0·353 oz. avoirdupois.
One hectogramme	=	3·527 ozs. ,,
One kilogramme	=	2·2046 lbs. ,,

Ounces Avoirdupois to Grammes.

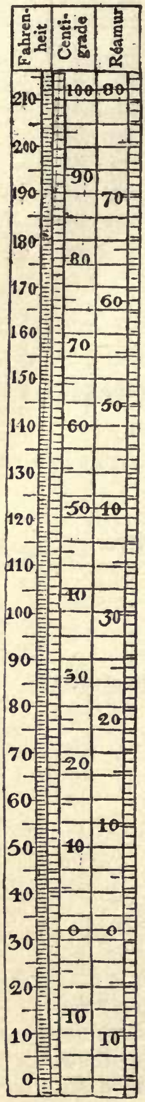
Ozs.		Grms.	Ozs.		Grms.
$\frac{1}{4}$	=	7	8	=	227
$\frac{1}{2}$	=	14	9	=	255
$\frac{3}{4}$	=	$21\frac{1}{4}$	10	=	283
1	=	$28\frac{1}{3}$	11	=	312
2	=	57	12	=	340
3	=	85	13	=	369
4	=	113	14	=	397
5	=	142	15	=	425
6	=	170	16 or 1 lb.	=	454
7	=	198			

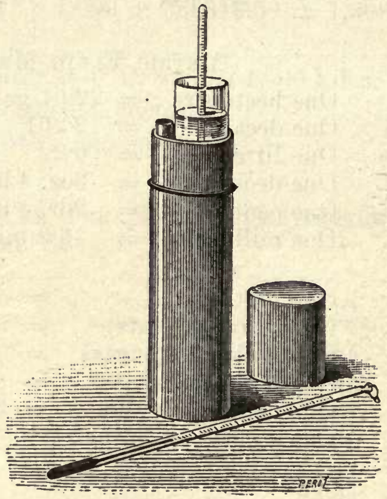
Metric Fluid Measures.

One hectolitre	=	22·01 gallons.
One decalitre	=	2·201 ,,
One litre	=	0·22 ,, or 1·76 pint.
One decilitre	=	3oz. 4dr. 10·4min.
One centilitre	=	2dr. 4·9min.
One millilitre	=	16·9 minims.

One pint	=	0·5679 litre.
One quart (2 pints)	=	1·1359 ,,
One gallon (4 quarts)	=	4·5435 ,,
One peck (2 gallons)	=	9·0869 ,,
One bushel (8 gallons)	=	36·34766 ,,
One quarter (4 bushels)	=	2·9078 hectolitres.

Conversion of Thermometer Scales.





Salleron's Portable Mustimetre.

GENERAL INDEX.

APPENDIX.

ALPHABETICAL INDEX.

D.

E.

F.

U.

V.

W.

Y.

By Authority: Robt. S. Brain, Government Printer, Melbourne.

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