DEPARTMENT OF AGRICULTURE.

VITICULTURAL STATION, RUTHERGLEN, VICTORIA.

STUDIES ON WINE-STERILIZING MACHINES,

BY

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Translated by

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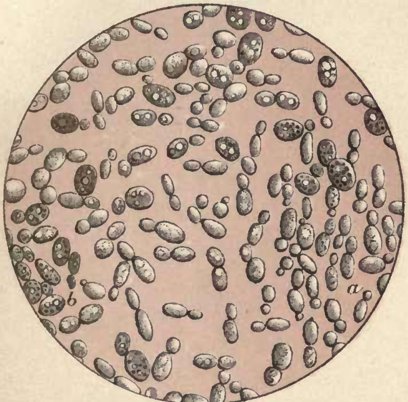
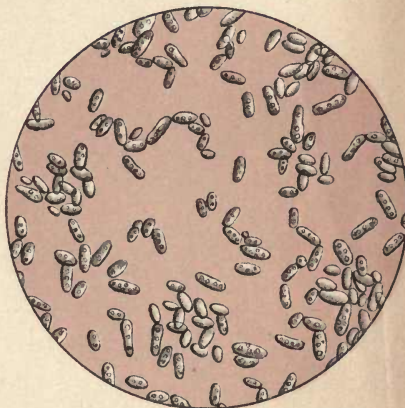
WINE FERMENTS.

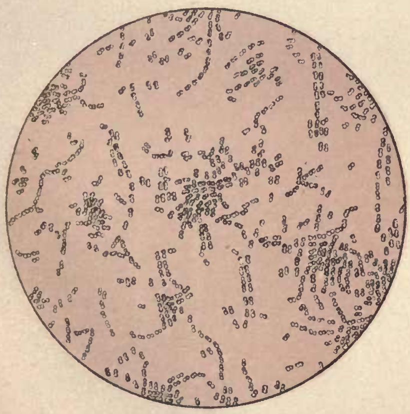


1.—WINE YEAST. $\frac{500}{1}$



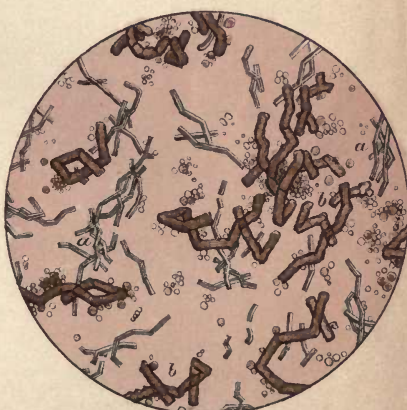
2.—MYCODERMA VINI. $\frac{500}{1}$

(Disease known as Flower.)



3.—MYCODERMA ACETI. $\frac{500}{1}$

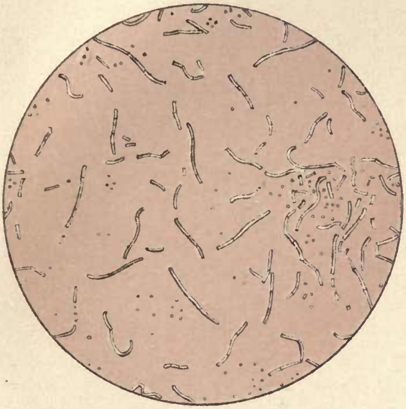
(Vinegar Disease.)



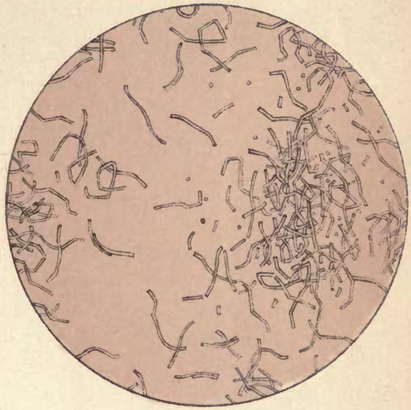
4.—AMERTUME. $\frac{700}{1}$

(Bitter Disease.)

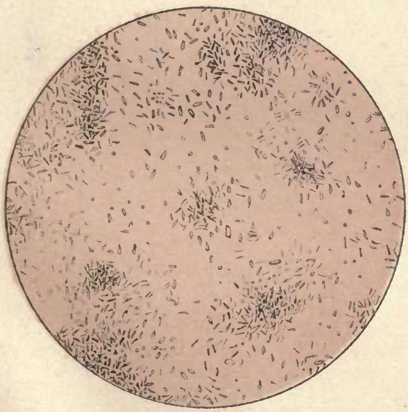
WINE FERMENTS.



5.—TOURNE. $\frac{700}{1}$
(Young.)



6.—TOURNE. $\frac{700}{1}$
(Old.)



7.—MANNITIC FERMENT. $\frac{700}{1}$

8.—GRAISSE. $\frac{500}{1}$
(Disease peculiar to White Wines.)

TRANSLATORS' PREFACE.

The deterioration of wine has always been a source of constant financial loss in all wine-producing countries. During many centuries the causes of deterioration, souring, &c., of wine remained unknown, and the only treatment wine was subjected to in the hope of preventing or ameliorating the evil, consisted in repeated racking, fining, and sulphuring.

It was reserved for Pasteur, in a series of classical researches commencing with the study of putrefactive fermentation* in 1863, to prove in a decisive manner the origin and causes of deterioration in wine and other fermented liquors, which were traced to the action of micro-organisms (disease ferments) of various kinds, and to show that the numerous diseases known in wine were due in each case to a characteristic micro-organism. At the same time, Pasteur developed a rational method of treatment, rendering it possible to keep wine perfectly sound, and to guard against diseases or alterations due to micro-organisms for a practically unlimited period. This method, depending on the application of heat, although previously empirically applied by Spallanzani, Scheele, and Appert,† is now known as *sterilization* or *pasteurization*.

The machines used for the practical application of Pasteur's discovery are generally called *pasteurizers*. They exist in very varied forms, according to requirements, for the sterilization of wine, unfermented wine, beer, milk, &c.

* Compte rendus de l'Académie des Sciences [lvi.], 1863.

† As early as the year 1765 Spallanzani heated extract of meat in closed flasks, and demonstrated that the contents remained unaltered until air was admitted. From this he concluded that the germs which developed in the open flasks had come from the air. Later on, in 1782, C. W. Scheele showed in his work "*Anmärkningar om sättet att conserva ättika*" that vinegar could be prevented from decomposing by the application of heat. In 1810 Appert published his book "*Le livre de tous les ménages, ou l'art de conserver pendant plusieurs années toutes les substances animales ou végétales,*" in which he described a method of preserving various foods and organic liquids by means of heat. In the 4th edition, which appeared in 1831, Appert gave directions for the treatment of wines, the method being essentially the same as that used nowadays under the name of "*Pasteurization.*"

As no comprehensive description of these machines and their efficiency as applied to wine has yet appeared in the English language, we undertook the present translation of Professor Gayon's "*Etude sur les appareils de pasteurization des vins, en bouteilles, et en futs*,"* with the desire of benefiting the Australian wine industry.

The large quantities of off-wine annually distilled throughout Australia would be greatly reduced by the general adoption of pasteurizers as part of the outfit of every fermenting house and wine cellar; much wine at present condemned to the still could be then easily saved through pasteurizing at an early stage, or, in other words, by preventive sterilizing in every case of latent disease,† obviously with considerable practical advantage to wine-makers and merchants.

The application of pasteurization to the young wines destined for our rapidly increasing export trade would insure their withstanding the extreme variations of temperature which occur during the sea voyage and transit across the equator, and consequent arrival in sound condition.

Although the benefit of pasteurization is more or less admitted by many Victorian wine-makers, it is regrettable, when the small initial outlay as compared with the final gain is considered, that they have delayed availing themselves of the decided and obvious benefit which would arise from the use of these appliances, which are recognised as of essential importance in all hot viticultural countries where the difficulties of conducting fermentation under strictly normal conditions present much trouble.

The wine-makers in the hot climates of the South of France, Algeria, Spain, Italy, and California having already proved the immense commercial advantages of pasteurizing wine, we may express the hope that Victorian wine-makers will derive some practical gain from the present translation.

RAYMOND DUBOIS.
W. PERCY WILKINSON.

Viticultural Station,
Rutherglen, March, 1901.

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* *Revue de Viticulture*, Vol. iii. and Vol. iv., 1895.

† See pages 11 and 12 for means of detecting latent disease in wines.

STUDIES ON WINE-STERILIZING MACHINES.*

By U. Gayon, Professor of Physical Sciences in the University of Bordeaux.

I.

GENERALITIES.

The word "pasteurization" has become synonymous with sterilization. It applies to most of the alimentary liquids, but more especially to fermented liquors, such as beer or wine. A liquid may be pasteurized cold by filtration through porous earthenware tubes or plates, such as Chamberland candles, &c., or by heat, by progressive elevation of temperature up to the degree recognised as necessary to kill the germs causing diseases.

We will only study pasteurization by heat, the efficacy of which was established long ago by Pasteur, as a result of his special studies on diseases of wines, their causes, and the means of preventing them.

1. *Effect of Heating.*—Everybody now knows the results of Pasteur's studies. Notwithstanding the greatest care, wines do not always improve with age. On the contrary, they sometimes undergo grave alterations and lose their essential qualities. They are then said to be diseased. Pasteur pointed out that all these diseases (*tourne*, *graisse*, *pousse*, *bitter*, *acetification*), apparently spontaneous, are always correlative to the multiplication of microscopical organisms or microbes ; that these micro-organisms invariably exist in wine, and that they develop and multiply when circumstances are favorable.

All the usual manipulations in vinification have for their object, either the mechanical elimination of those germs or the prevention of their development by constantly modifying the chemical constitution of the liquid, fining, &c. Most of these manipulations would be unnecessary if the liquid were

*Revue de Viticulture. Vol. III. and Vol. IV., 1895.

completely free from living germs—if it were "sterilized." Heat enables one to reach this object without injuring the development of the natural qualities of wines (maturation), as proved by Pasteur.

Pasteur's experiments were made about 30 years ago, with wines in bottles, varying greatly in quality, from the most common kind of wine to the finest Bourgogne (Nuits, Volnay, Chambertin, Romanée, Voujeot). The results were most conclusive, and the Commission appointed to taste and report upon heated wines and non-heated wines, the year the heating was done, and several years after, were unanimous in recognising the "immense results achieved."

More recent experiments made under the direction of Gayon, with Bordeaux wines, have fully confirmed the above results.

There cannot be any doubt now, whatever may be the origin and nature of wines, that properly applied heating preserves them from all diseases; and, further, that this operation does not alter the colour or bouquet, or injure the maturing, neither hastening or retarding it, and that it is practical and cheap.

The advantages resulting from this method of preservation of wines have been quickly appreciated, and a great many heating machines were invented, directly after the publication of Pasteur's discoveries. Since then, a number of vine diseases (phylloxera, mildew, &c.) by their indirect action on the qualities of wines have rendered pasteurization more necessary than ever. New machines have been invented, considerable improvements made, and viticulturists and wine merchants now recognise heating as one of the most important processes in vinification.

2. *Conditions for effective pasteurization.*—Heating can only preserve wines from developing diseases after leaving the vat. It is naturally powerless against alterations taking place during the fermentation of must. This is why it cannot prevent the production of mannite, but can arrest its formation after de-vatting. Before describing the machines most in use, we will indicate the essential conditions for effective pasteurization.

Firstly, the wine must be bright, if not, the matters in suspension might be partly re-dissolved under the action of the heating, and communicate, at least transiently, a special taste to it, altering its *finesse* and natural bouquet. Consequently bottled wine should be heated soon after bottling, and wine in casks should be filtered, if necessary, before entering the pasteurizing machine. If we desire to sterilize old bottled wine it should be previously decanted to separate it from the deposit.

Selection is necessary in the case of a filter, as it is important not to submit recently ærated wine to the action of increased temperature. Filters working out of contact of air, under reduced pressure, should be preferred. If they are not available those allowing the use of carbonic acid or sulphurous acid gas in moderate amount should be selected.

For wine to preserve all its required qualities, and not to age too rapidly, it must be heated and cooled in the same closed recipient, so as not to come in contact with the air, or absorb oxygen at any moment during the operation. Under these conditions, which are, as far as possible, realized by heating in bottles, not only is the destruction of the existing germs complete, but, also, the introduction of outside germs rendered impossible, therefore the preservation of the wine is assured indefinitely. The wine also preserves its limpidity, colour, and bouquet, and acquires with age all the qualities compatible with its constitution, origin, and vintage.

If, on the contrary, during pasteurization the warm wine comes in contact with the air—or if, for instance, it is placed in casks without previous cooling—the colour and taste get modified, and it may acquire, according to the temperature reached, the characteristics of old wine.

It is therefore possible to produce artificial ageing, which may sometimes be useful for blending purposes. This process, however, is only used for very common wines, and, if applied carefully to fine wines, it may enable them to reach in a few years the most favorable point for their consumption.

3. *Degree of Temperature.*—The degree of temperature to be reached varies between 55° and 65° C. (131° to 149° F.), according to the composition of the liquid. For light wines deficient in acids it is advisable to go up to 65° C. (149° F.). For wines of average constitution 60° C. (140° F.) are sufficient, and wines rich in alcohol and acids only require 55° C. (131° F.). If there is no disadvantage in over-reaching the temperature fixed beforehand, there is, however, economy in keeping as close as possible to it.

The above temperatures have been determined by practice, but experiments were necessary to determine more precisely the action of heat on the different ferments of wine. Gayon and Dubourg made researches on the subject, the main results of which were published in 1891 in the *Memoires de la société des sciences physiques et naturelles de Bordeaux*. They studied more specially the *Mycoderma aceti*, *M. vini*, *Alcoholic yeast*, and *Tourne*.

4. *Action of Heat on the Tourne Ferment.*—The *tourne* ferment is certainly the most dreaded of disease-ferments ; for under various shapes it attacks all wines—fine, common, rich or poor in alcohol or colour. Much more frequent than the *bitter* (*amertume*), it is the main cause of alteration of wines (off wines). Its germs, which are generally present in the fermenting vat, when the alcoholic yeast starts to multiply, are not always easy to eliminate by ordinary manipulations ; they often start to multiply again when the wine is bottled, rendering it unfit for consumption.

With the object of ascertaining the effects of temperature on this ferment, wine recently attacked was selected, and a series of small cylindrical glass tubes of 1 mm. in diameter filled with its sediment. Each series was placed in a water bath, the temperature of which was kept constant, during a time varying between a quarter of a minute and two minutes. After rapid cooling the heated ferments were placed on proper cultures, kept during one month, in a stove at 35° C. Microscopical examination and analyses were made to determine the ferments which remained fecund and those which were sterilized by the heat.

Repeated trials with different *tourne* wines proved that the temperature of 60° C. (140° F.) was always sufficient, even when acting only one-quarter minute, to destroy all germs, but when below that temperature the results were a function of the alcoholic strength of the liquid and of the duration of heating.

The following table gives comparative examples :—

Time, in ¼ minutes.	Alcohol, 8%; Acidity, 3·1 grm.						Alcohol, 12%; Acidity, 2·8 grm.					
	55° C.	56°	57°	58°	59°	60°	55°	56°	57°	58°	59°	60°
1	−	−	−	+	−	+	−	−	+	+	+	+
2	−	+	−	−	+	+	−	−	+	+	+	+
3	−	−	+	+	+	+	−	+	+	+	+	+
4	−	−	+	+	+	+	−	+	+	+	+	+
6	−	+	+	+	+	+	+	+	+	+	+	+
8	+	+	+	+	+	+	+	+	+	+	+	+

The sign − indicates non-sterilized ferments.
The sign + indicates those sterilized.

We see that with wine containing 8 per cent. (by volume) of alcohol, the *tourne* ferment was not killed in one-quarter minute at 59° C., neither in one-half minute at 58° C. or 57° C., neither in one minute at 56° C., neither in one minute and a half at 55° C., while with a wine containing 12 per cent. of alcohol three-quarters of a minute was sufficient from 56° C. and one minute and a half at 55° C.

It results from the above that pasteurization may be efficacious below 60° C., but the weaker the wine is in alcohol and acids the longer the heating must be continued. In practice it is simpler to adopt a minimum temperature of 60° C.

5. *Action of Heat on Mycoderma aceti and Mycoderma vini.*—Analogous results have been obtained with *Mycoderma aceti* and *Mycoderma vini*, in so far that duration of heating balances temperature attained. Their germs were killed in one-quarter minute at 60° C. as shown by the following table :—

Time, in ¼ minutes.	Mycoderma aceti.					Mycoderma vini.				
	40°C.	45°	50°	55°	60°	40°	45°	50°	55°	60°
1	−	−	−	−	+	−	−	−	−	+
2	−	−	−	−	+	−	−	−	−	+
3	−	−	−	−	+	−	−	−	+	+
4	−	−	−	+	+	−	−	−	+	+
6	−	−	−	+	+	−	−	−	+	+
8	−	−	−	+	+	−	−	−	+	+

The sign − indicates non-sterilized ferments.
The sign + indicates those sterilized

6. *Action of Heat on Alcoholic Yeast.*—Gayon and Dubourg repeated the same experiments with alcoholic yeasts after failures obtained by wine merchants who had pasteurized sweet wine, or mixtures of musts artificially prevented from fermenting, with old dry wines. These wines, perfectly heated up to 60° and 65° C. in excellent machines and stored in casks sterilized by steam, slowly started to ferment, after weeks or months, without any apparent cause. Microscopical examination showed in all of them young wine-yeasts multiplying, but no ferments of diseases. It was simply an alcoholic fermentation of the sugar remaining or added, but "How could this yeast have been brought there?" There are certainly germs of Saccharomyces floating in the

atmosphere of a cellar, but they could not have fallen into the casks for they were bunged and placed on the side and had not yet been racked. The only explanation was therefore that the heat had left some of the cells of Saccharomyces, which are always found in wine, alive, and that these, distributed throughout the mass, had slowly developed and multiplied. Experiments proved this explanation to be the correct one. The following table is a condensed account of the results obtained, by heating, in small tubes, two liquids of different alcoholic strength, still fermenting and sowing them afterwards with grape must :—

Time, in ¼ minutes	Alcohol 4·[illegible] %; Acidity, 1 7 grm				Alcohol, 9·2 %; Acidity, 2·9 grm.			
	55°C.	60°	65°	70°	55° C.	60°	65°	70°
1	2	8	+	15	1	+	+	+
2	2	2	15	15	13	17	21	+
3	2	14	+	+	4	+	+	+
4	2	+	+	+	6	+	+	+
6	2	+	+	+	15	+	+	+
8	2	+	+	+	+	+	+	+

The figures printed above show that there has been development of the yeast, and also show the number of days which elapsed before the alcoholic fermentation was noticed. The sign + indicates cultures which remained sterilized after one month in the stove.

We see, in this case, that the effect of heat on the yeast depends on the duration of its action, the temperature reached, and the composition of the liquid. In any case the cells of alcoholic ferment resist heat better than the germs of diseases ; this is perhaps due to their relatively large size. When pasteurization is done on a large scale, with large machines, in which the wine travels rapidly and only remains a short time in the calefactor, the temperature of 60° C. to 65° C. which is sufficient to preserve the wine against alteration by diseases, does not necessarily prevent the alcoholic ferment from starting vinous fermentation sooner or later.

To obtain this special result it is necessary to bring the liquid up to 70° C. (158° F.) ; this temperature being a minimum, if it is of average alcoholic strength, or to let it remain at least one minute in the machine at 60° C. We will later on indicate the devices realizing these conditions.

The yeast remaining in heated wines is sometimes only one variety of those which produced the initial fermentation; this is in accordance with the well known facts of the physiology of Saccharomyces, which are often isolated from one another by progressive heating.

It is therefore possible by pasteurization to preserve the vinous yeast alive, while killing the ferments of diseases. This fact is particularly advantageous in wines remaining sweet when racked off the fermenting tank, their fermentation not having been completed, on account of the temperature rising too high and the vinous yeasts remaining in a dormant state, handicapped in their multiplication by numerous foreign microbes. By destroying the latter, the former are left free to resume their natural activity. A healthy secondary vinous fermentation starts in the casks, and proceeds without check.

7. *Characters of Pasteurized Wine.*—When should wine be pasteurized?—It is best not to wait until deterioration can be detected by tasting, for heating is only a preventive and does not restore a diseased wine, it only arrests the progress of the disease. If the taste and bouquet of a wine have already deteriorated, it is rarely that it will improve with time, notwithstanding the effects of slow etherification.

If the wine-maker does not desire to heat all his wines indifferently, and wishes to perform this operation only on doubtful wines or those in which disease is latent, he may easily ascertain at any time, if they are really endangered and to what extent, even if nothing can be detected through tasting.

Microscopical examination gives the surest indications. If, when the wine and lees are carefully examined through a microscope, no filamentary or rod microbes are detected, and if the matters in suspension are only colouring matter, crystals, or alcoholic yeasts, nothing is to be feared.

New wine, it is true, generally contains numerous filaments, which develop in the fermenting vat, and certainly constitute a serious danger for its future. As a rule, if wines are well constituted, and if proper care is taken of them, the germs do not multiply in the casks, and are gradually eliminated with the lees. Microscopical examination after each racking is a means of verifying if this elimination really takes place.

The measurement of total acidity, and especially volatile acids, performed after each racking completes the results given by the microscope, for if a wine remains healthy these matters do not sensibly increase. If, on the contrary, the amount of acidity increases between two rackings, if for instance, the amount of volatile acids reaches 1 per 1,000, it is necessary to pasteurize.

The age of the wine is of no importance, as there is no disadvantage in heating wine during the first months following the vintage, if the alcoholic fermentation has been completed, and if it has acquired its normal characters. It has even a great advantage, as the wine may be left in casks lightly bunged, thus saving future manipulations. The heating of new wines in bottles saves the losses resulting from successive rackings, which during the first three years reaches at least 20 per cent. of the initial volume.

Many wine-makers complain that wines heated in large machines acquire a special taste (*cooked taste*), *this accident, which is extremely rare if the operation is properly conducted*, seems due to momentary overheating, or insufficient cooling, or to the machine not being in good order; however, after a while, this taste disappears and the wine resumes its normal taste and qualities.

This cooked taste is never observed when wine is heated in bottles.

According to Pasteur, heating in bottles realizes the ideal process of sterilizing, for, "after the wine has been heated, it is promptly brought down to the surrounding temperature, and is never in contact with the oxygen of the air either before, during, or after the operation."

II.

HEATING WINE IN BOTTLES.

1. *Preparation of the Bottles.*—The corks of bottles containing wine to be pasteurized, should be securely fastened, if not, the liquid, expanding under the influence of heat, would push them out and come in contact with the air. The excess of liquid will simply exude between the glass and the cork, sterilizing those parts. When the corking has been done with a machine, and the bottles well capsuled, this precaution is often unnecessary.

A cheap and handy method of fastening the corks is shown in Fig. 1. One man may with a little practice prepare 1,000 bottles in a day.

2. *Boldt and Vogel's Cork Clamp.*—Many cork clamps which may be used repeatedly, have been invented. One of the most practical is shown in Fig. 2; it is made entirely of iron, with two vertical claws, one of which A is soldered

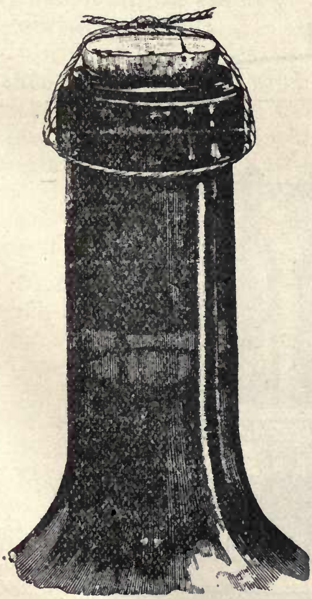

Fig. 1.—Mode of securing Cork with String.

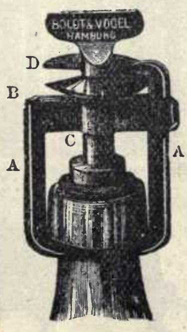

Fig. 2.—Boldt and Vogel's Cork Clamp.

Fig. 3.—Gasquet's Cork Clamp.

to a kind of nut B, the other A′ is articulated on that nut. A bar C passing through the centre of the nut, presses upon the cork and bears an helicoidal plate D at its upper extremity, upon which the hook of claw A rests. This little device is placed as shown in the figure, the helicoidal plate turned from left to right presses the bar C upon the cork, which cannot come out. It is easy to remove this clamp after the sterilizing is finished.

3. *Gasquet's Cork Clamp.*—Gasquet has recently devised a clamp, which is simpler than the above, and which he calls "bride-goulot." It is made of a very soft copper ring A (Fig. 3) to which is fixed a brace of hard metal B. The ring, which is larger than the welt of the neck of the bottle, is passed over it, and fixed by a little wooden wedge, C. This clamp is very strong, and holds the cork firmly in position.

When the sterilization is over, the unfastening is easily performed by drawing out the wooden wedges. This clamp may be used over and over again.

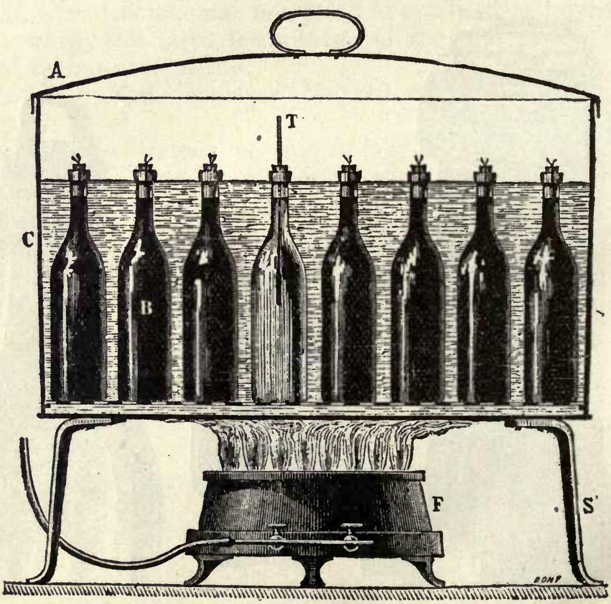

Fig. 4.—Portable Wine Heater.

4. *Portable Heater.*—When a small quantity of wine only is to be pasteurized, any kind of open heating tank may be used, the bottles being placed in it, side by side, as in Fig. 4, and the tank filled with cold water. If the tank is without a false bottom, folded cloths may be placed under the bottles, to prevent the heat from acting too suddenly on the glass and wine. In any case, a few bottles filled with water and provided with a thermometer T passing through the cork, must be placed amongst the wine bottles to indicate the real temperature of the wine, which is always below that of the surrounding water.

Gas as a source of heat is simpler and easier to regulate than wood or charcoal fires, these, however, may be used.

As soon as the required temperature is shown by the thermometers, the fire is put out, the tank emptied, and the bottles taken out and left to cool down. If a greater number of bottles are to be pasteurized, one half only of the water in the tank is removed, but the water contained in the bottles provided with thermometers must be renewed.

It happens sometimes that corks come out partly, notwithstanding the clamps. In this case they are driven down again after cooling.

Corks should never be replaced after the heating has taken place, for the wine would come in contact, not only with air, which would affect its quality detrimentally, but also with new corks, which, not being sterilized, would destroy the effects of pasteurization. It is simply through not observing these self-evident precautions that winemakers have met with failures, and denied the efficacy of pasteurization.

5. *Fixed Heaters working on a large scale.*—Only a few machines have, up to the present, been made to heat bottled wine on a large scale, but those in use for the pasteurization of beer in bottles may be used, with slight modifications.

Such is that represented in Fig. 5. An open rectangular iron tank A which may contain 100 bottles, is heated from a lateral fire-grate, the heat from which distributes over the bottom of the tank; movable frames (Fig. 6) allow a number of bottles to be plunged easily in the water, and taken out as soon as the temperature shown by the thermometer in the water bottle has reached the required degree. An exit tap R′ and an entrance tap R allow the water to be changed rapidly.

In a large installation, it is advisable to heat the water tank from a steam-boiler, and move the bottle-frames with a small horizontal crane.

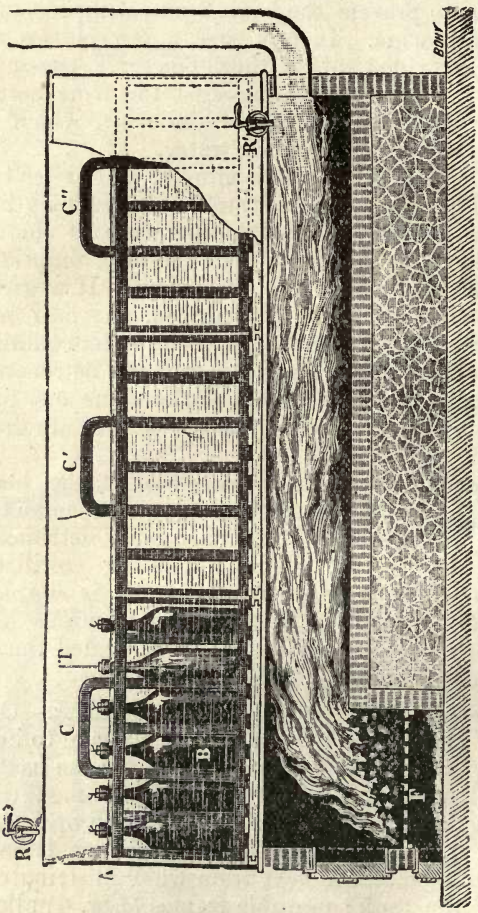

Fig. 5.—Fixed Wine Heater.

6. *Boldt and Vogel's arrangement.*—Some merchants use an arrangement allowing the sterilization of a large number of bottles simultaneously, heated by steam only, as invented by Boldt and Vogel, of Hamburg.

Two vertical sections of the complete machine are shown in Figs. 7 and 8. It consists of a large iron tank, into which an iron truck with two shelves, holding 500 quart bottles, is wheeled upon rails. The entrance is shut by an iron door, provided with thumb screws.

Fig. 6.—Movable Frames.

When the bottles are in position, cold water is filled in up to the level of the opening *b* of the siphon tube *a* and

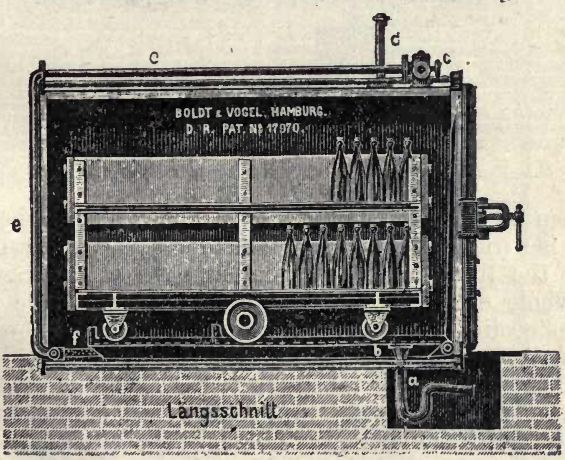

Fig. 7.—Boldt and Vogel's Pasteurizer (longitudinal section).

steam slowly introduced through the tube *e*. The regulating is done by the two taps *c*. The steam travels through the worm *f* bubbles through the water, heating it and the inside of the iron case, gradually.

The thermometers *d* indicate the temperature inside. Too rapid heating should be avoided, as it tends to break the bottles.

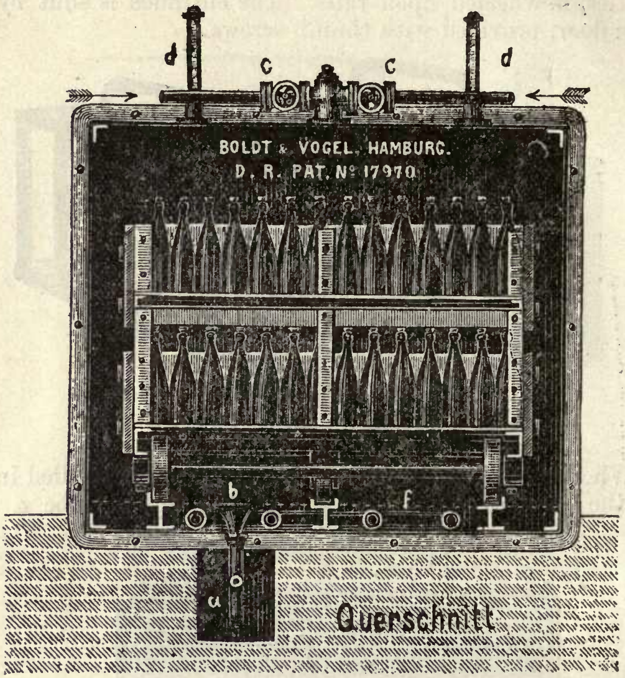

Fig. 8.—Boldt and Vogel's Pasteurizer (transversal section).

When the required temperature has been reached, the steam is turned off and the machine left to cool down, after which the front door is opened and the truck drawn out. The whole operation, including the heating of the bottles and the cooling of the machine, requires about one hour. If a second truck is in use, this time may be used to load or unload that previously taken out of the machine.

The temperature as shown by the thermometer can only be determined by experience, to assure that the temperature inside the machine reaches the required degree for effective pasteurization. The temperature could be better ascertained by means of an electric thermometer, plunged in a bottle filled with water and placed in the tank.

Boldt and Vogel's machine, which we have seen at work, answers perfectly for pasteurization on a large scale. It enables one to heat from 4,000 to 5,000 bottles per day. It costs £70. The installation does not require much room.

Instead of iron machines, large stove-rooms are sometimes built with a double wall, inside which 10,000 bottles can be piled together. They are slowly heated with steam, and then left to cool down.

These large stove-rooms have the defect of not allowing perfect control of the temperature in all parts of the room, and the piling up and removal of the bottles requires a very long time. Cooling takes place very slowly, as the room is well isolated, and the wine remains warm longer than necessary, thus injuring its quality. Such conditions are only good if we require to mature wines quickly; and, in this case, they have the advantage of offering more security from the point of view of disease than the rapid means used in the South, as the wines are perfectly sterilized.

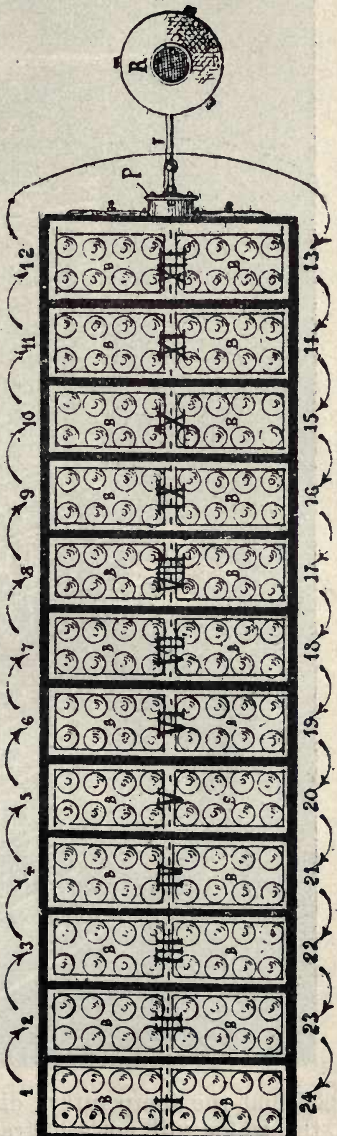

Fig. 9.—Gasquet's Pasteurizer (top view).

When machines heated by steam are used, the bottles may be placed horizontally one above the other, or vertically side by side; but when a water tank is used, we should always place them vertically with the corks out of the water, so that, should it

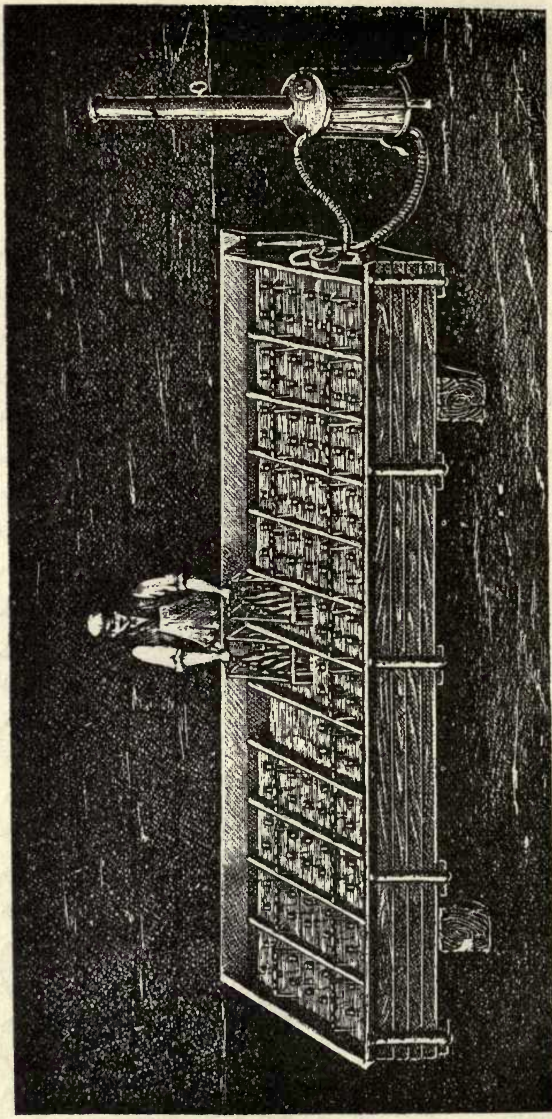

Fig. 10.—Gasquet's Pasteurizer.

happen that the temperature diminishes during the operation, the water will not penetrate through the cork and get mixed with the wine.

7. *Gasquet's arrangement.*—The machines so far described have the disadvantage of being intermittent, and, therefore, of requiring tedious and costly manipulation. Gasquet overcame this with his continuous machine, which is both simple and cheap ; it should render great services to wine-makers and wine merchants. A plan of it is shown in Fig. 9, and the perspective in Fig. 10.

It consists of a large rectangular tank C made of wood lined with zinc, resting on two props S and divided into compartments I., II., III., &c. These compartments communicate by means of openings made through the partitions; a kind of iron frame B filled with bottles, fits into each of them.

A stove R heats the water, and communicates with the tank by two tubes T connected with the pump P. The fuel used is generally coal or charcoal. When the machine works regularly, the temperature gradually rises from the compartment No. I. to compartment No. XII. If the wine is at a temperature of 10° C., and has to be heated up to 60° C., the water in the tank will rise from 15° to 60° C. in the following ratio :—

Compartment.	Temperature of Water.	Compartment.	Temperature of Water.
I.	15° Centigrade	VII.	40°–41° Centigrade
II.	18°–19° 〃	VIII.	45°–46° 〃
III.	22°–23° 〃	IX.	50°–51° 〃
IV.	26°–27° 〃	X.	55°–56° 〃
V.	30°–31° 〃	XI.	60°–61° 〃
VI.	35°–36° 〃	XII.	65° 〃

The thermometer, immersed in a bottle filled with water placed in the last compartment, indicates when the temperature of 60° C. has been reached.

When this temperature is reached, the frame No. 24 is taken out and replaced by the frame No. 23 ; 23 is replaced by the frame 22, and so forth, until the 24 frames are shifted, a new one being placed in compartment No. I. The whole operation is done in less than one minute.

The substitution of frame No. 11 for frame No. 12 slightly lowers the temperature of compartment XII. The pump is then worked to introduce a small quantity of warm water and raise the temperature to 65° C.

This pumping is repeated every five minutes; the cold wine takes one hour to rise gradually to the temperature of 60° C., and another hour to gradually fall down to the initial temperature.

According to size, the machine pasteurizes from 24 to 300 bottles per hour, with a very small expenditure of fuel and labour.

It requires one hour to start the machine. All the frames charged with bottles are placed in the compartments, the tank filled with cold water up to the required height, and the water in the stove rapidly heated. When the latter has reached 65° C., the water of compartment I. is sucked with the pump and pumped in the stove, the rate of flow being regulated in such a way that the temperature of 65° C. in the stove is not lowered by the regular flow of cold water.

The water pumped into the stove displaces an equivalent amount of warm water, which travels towards compartment XII. The overflow of the latter passes into compartment XI., the overflow of XI. goes into X., and so forth, till it reaches compartment I., the level of which is lowered through the suction of the pump.

The ratio between the temperatures in the different compartments is gradually established, and when the water in compartment XII. reaches 65° C. the machine is ready to work continuously. However, the bottles in the frames 14 to 24 which have not been sufficiently heated require to be pasteurized over again. It seems rather useless to cool the bottles very slowly, as is done with other arrangements, and with this machine they are simply taken out of the tank and left in contact with the air.

But Gasquet's arrangement has a double advantage. Firstly, it prevents the sudden cooling which might break the bottles, and secondly, as every compartment receives at the same time a frame cooler, and another one hotter than the water it contains, the mean temperature is not affected. The double movement of the bottles in opposite directions serves, therefore, to maintain a regular heat, and to insure effective working of the machine.

8. *Filling up Pasteurized Bottles.*—Whatever mode of heating be adopted with bottles, a certain quantity of the liquid always leaks out round the cork, and after cooling, a vacuum is always produced under the cork. This vacuum

does not interfere with the preservation and the maturing of the wine, but certain buyers object to it now that they have adopted the habit of filling the bottles completely by means of the needle corking machine. Many devices have been constructed with the object of filling up this vacuum with pasteurized wine. So far the best results seem to have been obtained with a little device due to René Merman, of Bordeaux, which enables bottles to be completely filled without uncorking them and without exposing the wine to contact with air. We regret that the inventor refuses to authorize us to describe it.

III.

HEATING WINE IN BULK.

The machines used for heating wine in bottles are comparatively few and not generally used. This is due no doubt to the fact that bottled wine is generally of superior quality, and that it has acquired during two or three years keeping in casks, a relative resistance to germs of diseases, consequently pasteurization is rarely necessary.

This does not apply to the machines used for heating wine in bulk. They answer a far more general demand, and have been designed under many different forms since Pasteur's studies on the diseases of wines.

1. *Arrangements without Refrigerators.*—We will not describe the pasteurizers constructed for direct, intermittent, or continuous heating, without refrigerators, as in these machines the wine comes out warm and remains so a long time in the casks, oxidizes, and matures too rapidly. They are useful in special cases, but they generally modify the qualities of wine to too great an extent, to allow us to recommend their use in the case of simple sterilization.

2. *Intermittent arrangement with Refrigerators.*—The only machines realizing to the fullest extent the conditions for perfect sterilization of wines in casks are those in which complete cooling takes place before the wine reaches the cask. The majority of them are worked with a continuous current. There is one, however, which has been recently constructed and is intermittent. We will describe it first. It is W. Kuhn's sterilizer.

3. *Kuhn's Sterilizer.*—This machine was first invented for the sterilization of beer, and was slightly modified for the heating of wine. It is composed of a large cylindrical tank closed at both ends, with double walls, and resting on two cast-iron stands. (Fig. 11.) Inside this is a long tube running from one end to the other, bent in the shape of a spiral, with the spires very close together. The two ends of the tube D and P pass through the wall of the cylinder, and are used for the exit of either warm or cold water. A coupling tube P N allows the space comprised between the two walls of the cylinder to be filled with warm or cold water, as the case may be. The wine to be pasteurized is brought into the

central part of the cylinder and warm water injected through the spiral tube, then directly the thermometer plunged into the wine records the required temperature the warm water is replaced by cold water. The pasteurized wine is therefore

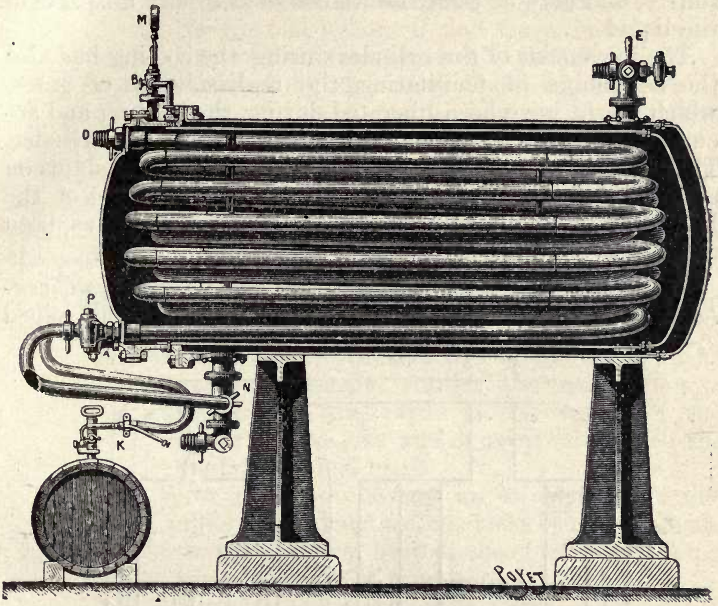

Fig. 11.—Kuhn's Sterilizer (transversal section).

cooled as quickly as it was heated, and during the whole operation is never exposed to contact with air. It is therefore returned to the casks at its initial temperature, as if it had simply been submitted to racking.

Fig. 12 shows the complete installation of the plant.

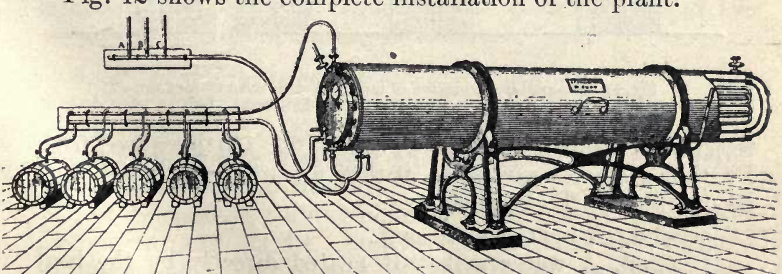

Fig. 12.—Kuhn's Sterilizer.

With Kuhn's sterilizer one may pasteurize at a single operation a great bulk of wine. If the cylinder was left immobile during the whole operation, the wine would lose its homogeneity ; to prevent this the cylinder is mounted on rollers, and may be easily oscillated so as to mix all parts of the liquid.

The movement of the cylinder during the cooling has also the advantage of facilitating the re-dissolution of gases, which might have been liberated during the heating and accumulated in the vacuum left in the top of the cylinder. These disengaged gases, however, are not very abundant, on account of the compression caused by the expansion of the liquid retaining them in solution. This machine has been tried at Bercy and gave satisfactory results.

4. *Arrangement with Refrigerators and Continuous Circulation.*—These machines should be formed of four parts, joined

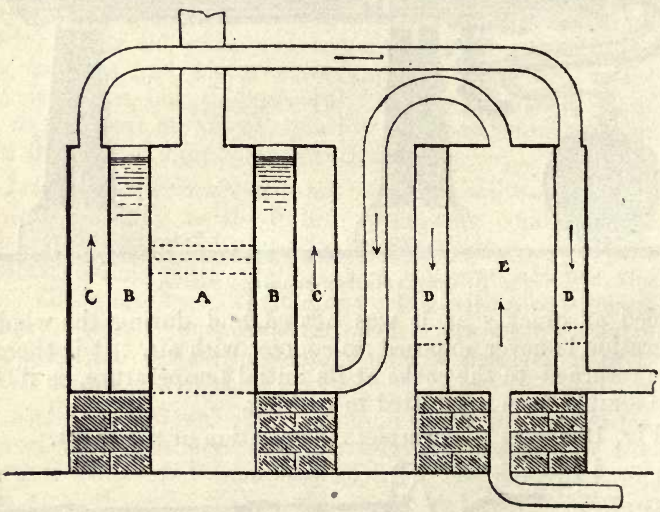

Fig. 13.—Diagrammatic section of machines with refrigerators and continuous circulation (after Pasteur).

together as shown in the diagram (Fig. 13) borrowed from Pasteur's *Etudes sur le vin*, if they are to work cheaply and be complete. These parts are :—

1st. A heat generator A.

2nd. A water jacket B heated directly by the heat generator, transmitting this heat to the vessel containing the wine.

3rd. A vessel C in which the wine reaches the maximum temperature of sterilization, the liquid entering at the bottom and overflowing at the top.

4th. A refrigerator D receiving the hot wine from the top and letting it flow from the bottom at the initial temperature. The cooling is obtained by the wine itself, which, arriving from the cask, enters the recipient E and gradually rises as it becomes warmer.

With this arrangement the movement of the liquid harmonizes with the various densities due to the heating or cooling in different parts, the heated wine always rising and the cool wine always descending.

5. *Economic yield.*—Raulin has studied the working of heat generators and established the following rules :—

1st. With machines constructed on the same model and geometrically similar, the rate of flow in the unit of time varies as the square of the linear dimensions and is proportionate to the quantity of fuel used.

2nd. With machines having an equal volume but differing in structure, the yield is proportionate to the surface heated, the fuel used being equal per unit of time in each case.

3rd. As a practical result it is found necessary to increase as much as possible the surface heated under a given volume, so as to obtain as great a yield as possible with small machines.

The shape of these surfaces and their area has therefore a preponderating influence on the yield. They also have very great importance with regard to the sterilization and the mounting and dismounting of machines.

6. *Principal types of Machines.*—Continuous pasteurizing machines may be, from this point of view, divided into three classes :—1st, those with coiled tubes (worms) ; 2nd, those with tubular bundles ; and 3rd, those with cylindrical or helicoidal compartments.

Let us assume these different parts placed in similar recipients, and let us compare the area of the surfaces through which the exchange of temperature may take place, assuming the recipients to be cylindrical, and measuring, for the sake of argument, 1 foot in diameter by 4 feet in height.

In such a cylinder a worm S made of a tube $\frac{3}{4}$ inch in section and having ten spires of 8 inches in diameter each

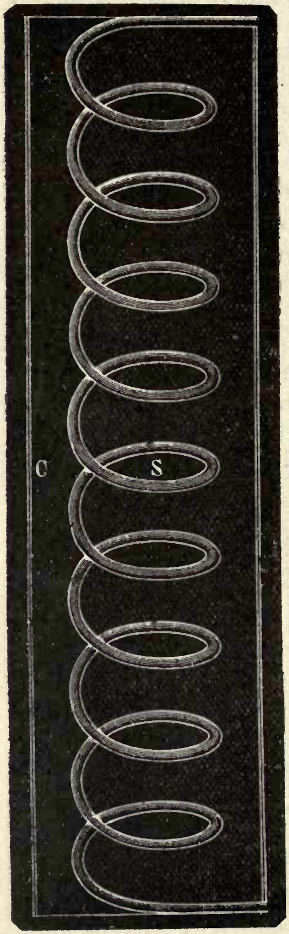

Fig. 14.—Diagram of coiled tube system.

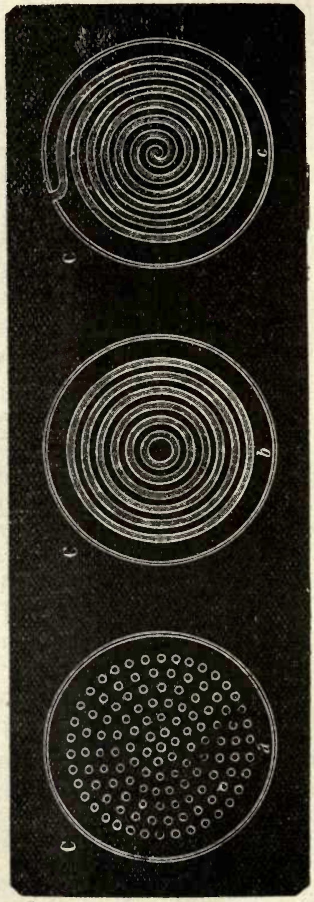

Fig. 15.—*a*, Section of tubular bundle system. *b*, Section of cylindrical compartments system. *c*, Section of helicoidal compartment system.

(Fig. 14) may be easily placed. A simple calculation results in the following figures for each spire :—

Length of tube	25·2 inches
External surface	0·4327 sq. ft.

And for the whole worm—

Total length	21 feet
Total surface opened out ...	4·3057 sq. ft.

The heating or cooling surface is, therefore, in this case, less than 5 square feet.

Let us substitute a tubular bundle formed of vertical tubes 0·4 inch in diameter *a* (Fig. 15) for the worm. They may be placed 0·4 inches apart in concentric circles of $9\frac{1}{2}$, 8, $6\frac{1}{4}$, $4\frac{3}{4}$, $3\frac{1}{8}$, $1\frac{1}{2}$ inches in diameter.

The number of tubes in each row is—

Circle $9\frac{1}{2}$ inches diameter	...	37 tubes
" 8 " " ...	...	31 "
" $6\frac{1}{4}$ " " ...	...	25 "
" $4\frac{3}{4}$ " " ...	...	18 "
" $3\frac{1}{8}$ " " ...	...	12 "
" $1\frac{1}{2}$ " " ...	...	6 "
Total ...	...	129 "

If we add to this a tube in the centre we have a bundle of 130 tubes, with a surface for exchange of temperatures of:—

For each tube ...	0·4058 sq. ft.
For the whole bundle ...	52·7450 "

The tubular bundle has, therefore, a surface of exchange ten times greater than the worm.

If instead of tubular bundles we use concentric compartments placed vertically 0·4 inch in thickness, *b* (Fig. 15) and having diameters corresponding to those of the circles of tubes in the previous arrangement, their total in horizontal projection will be :—

For the compartment	$9\frac{1}{2}$	inches in diameter,	$29\frac{1}{2}$ inches
"	8	"	$24\frac{3}{4}$ "
"	$6\frac{1}{4}$	"	$19\frac{3}{4}$ "
"	$4\frac{3}{4}$	"	15 "
"	$3\frac{1}{8}$	"	10 "
"	$1\frac{1}{2}$	"	5 "
Total	...	...	8ft. 8in.

As each compartment has two surfaces and measures 4 feet in height the total surface of exchange of temperature will be 8ft. 8in. $\times$ 4 $\times$ 2 = 69ft. 4in. It is, therefore, larger than that of the tubular bundles.

The vertical compartment, helicoidal in shape, *c* (Fig. 15), having six spires with diameters corresponding to the six cylindrical compartments, would offer a surface of exchange practically equal to that of the previous arrangement.

These tubes, therefore, show very great differences, but for the comparison to be complete we must take into account the corresponding volumes of liquid and their respective capacities. These volumes are:—

For arrangement with worm, $3\frac{1}{2}$ pints.
For arrangement with tubular bundles, $21\frac{1}{2}$ pints.
For arrangement with cylindrical or helicoidal compartments, 7 gallons.

The ratio of the surfaces of exchange expressed in square feet and the volumes previously expressed in pints are in round numbers:—

For worm	20
„ tubular bundles	40
„ cylindrical or helicoidal compartments	20

These figures are comparable, and it results from them that worms and cylindrical or helicoidal compartments offer relatively greater surfaces for the exchange of temperature than tubular bundles.

The rate of flow for the same difference of level, not taking friction into account, is (all things being equal) a function of the horizontal sections, that is to say, proportionate to the following figures:—

With worm	3
„ tubular bundles	102
„ cylindrical or helicoidal compartments	265

From the above figures it follows that machines with cylindrical or helicoidal compartments offer the greatest advantages (all dimensions being equal). Their yield and surface of exchange (absolute and relative) are greater. But their construction presents special difficulties, and it is only during the last few years that they have been overcome in a practical manner.

The machines with tubular bundles, or worms, are much more generally used because they are easier to construct and easier to manage.

With all types of machines it is important to have them constructed in such a way that all their parts may be easily dismounted and cleaned, so that those in charge may ascertain before every operation if the tinned tubes are in perfect order.

If the whole surface in contact with wine is not tinned the machine should not be used, as the wine would attack the copper and become contaminated. On the other hand, if there is the slightest hole in the tube the machine should not be used, as pasteurization cannot be effected, on account of the heated wine becoming mixed with non-heated wine containing disease germs. Pure tin worms are much more practical, for they are made with stout strong walls without soldering, and are not attacked by wine.

The first condition a pasteurizer should realize is to bring all parts of the wine to the required temperature, and to maintain it at that temperature for a certain time.

It would not be sufficient, for instance, for a mixture of cold and heated wine to accidentally reach that temperature when coming out of the calefactor, for the ferment of the former would not remain long enough at the temperature to be killed, and the mixture would not be asepticised. With machines provided with worms, the complete heating of the liquid is assured by the length of the tube and by its slanting position, which forces all parts, varying in density on account of their different heat, to strike against each other, become mixed, and come several times in contact with the hot walls of the tube. In other machines, in which the axis is generally vertical, the wine rises evenly and vertically, and one might fear that that remaining at an equal distance from the walls did not get sufficiently heated. But as a matter of fact this accident is always avoided, for the liquid travels through a very small column, and the height, together with special arrangements, are always sufficient to force it to become mixed during the course of the operation.

All these machines with continuous circulation and refrigeration operated by means of cold wine, never bring wine back exactly to its initial temperature. For fine wines this difference should be reduced as much as possible, and never be over 4°; if the machine used gives a greater difference, the wine must pass through a water refrigerator before reaching the cask.

We will first describe machines with worms (coiled tubes); second, machines with tubular bundles; third, machines with cylindrical or helicoidal compartments.

A.—MACHINES WITH COILED TUBES (WORMS).

1. *Perrier-Deroy's Sterilizer.*—The first machine of this kind was invented in 1869 by Perrier Bros., of Nimes, and is described in Pasteur's work. It is now constructed by Deroy, of Paris, and presents the following features (Fig. 16):—

The heat generator is composed of:—

1st. A tubular boiler, with a fire grate inside, heating the water jacket.

2nd. A worm tube immersed in the water, passing into the central collecting cylinder, surrounded by warm water.

3rd. A fire grate surmounted by straight tubes communicating with the funnel.

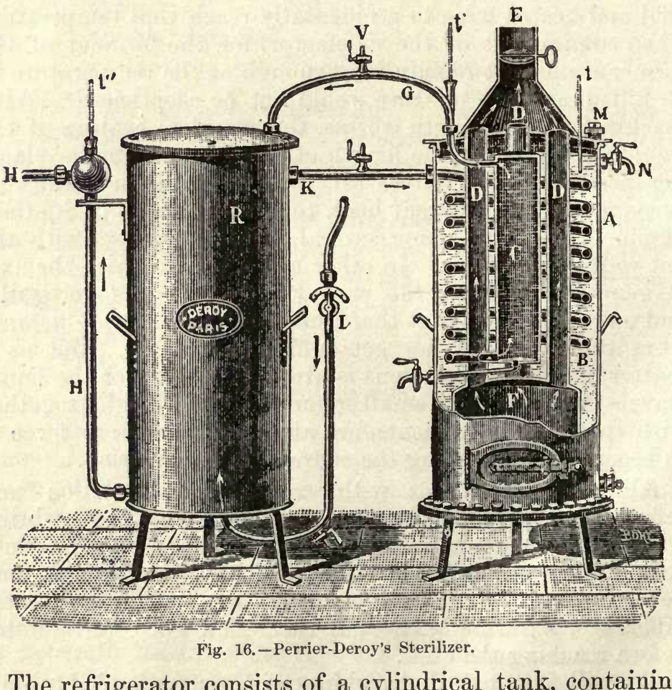

Fig. 16.—Perrier-Deroy's Sterilizer.

The refrigerator consists of a cylindrical tank, containing the worm, one end of which communicates with the heat generator, the other end serving for the exit of wine.

The cold wine enters the machine by the tube L, and passing through a delivery controlling tap, reaches the bottom of the refrigerator, fills the annulary space, forming a kind of worm parallel to the first worm. It then reaches the heat generator (calefactor) through the horizontal tube K, then descends into the worm of the calefactor, rises through the collecting cylinder C, intermixing thoroughly, and from there reaches the worm of the refrigerator through the tube G, where it becomes cooled by contact with the cool wine surrounding the tube.

Thermometers, t, t', t'' record the temperature of the water jacket, and that of the wine coming out of the calefactor, and out of the refrigerator.

Before starting, the steam generator is filled with water, through the plug M. When the level of the water reaches the over-flow tap N, the plug M is closed, and the fire lighted.

Directly the thermometer t records 80° C, the tap is opened to allow air to escape, and the wine is introduced through the delivery controlling tap L. When the wine has filled the worm, collector and steam generator, it reaches the tap, which is closed, and the flow of liquid, as well as the fire, are regulated in such a way that the thermometer t' continuously records the required maximum temperature for pasteurization.

When the operation is finished the fire is put out, and all the parts of the machine are emptied by taps fixed for that purpose.

Perrier-Deroy's machine may be easily dismounted for cleaning, and the re-tinning of the tubes performed without difficulty. It is easy to supervise, and requires very little fuel.

The cost and the yield are as follow :—

—	Wine Treated per hour.	Cost.
No. 1 ...	66 gallons	£32
No. 2 ...	132 ,,	£48
No. 3 ...	220 ,,	£60
No. 4 ...	440 ,,	£88

2. *Bourdil's Sterilizer.*—This sterilizer, patented in 1876 and 1884, is extensively used in the southern regions of France. A plan of it is shown in Fig. 17.

It is composed of a vertical column for heating the wine C, and of one or two other cylindrical columns R and R′ connected by tubes *a* and *a′;* the whole machine resting on a cast-iron bed plate.

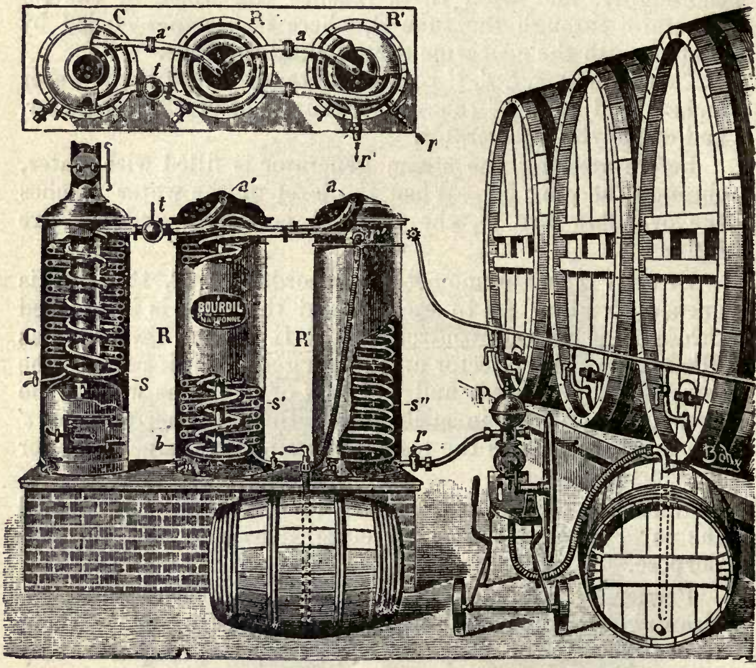

Fig. 17.—Top and side views of Bourdil's Sterilizer.

The wine heater consists of a water jacket, heated by a central fire grate F, inside the cylinder. Between the outside wall and the fire grate, are two worms with concentric spires S, immersed in the water, through which the wine circulates. The thermometer *t* surrounded by a copper tube to prevent it from getting broken, is placed at the exit of the column, and records the maximum temperature reached by the wine.

The construction of this machine may be slightly modified so as to allow the use of coal, gas, or steam, for heating.

Each refrigerator is made of tinned copper, formed by a completely closed column, filled with non-pasteurized wine, in which a double worm S′S″, conveying the heated wine is completely submerged.

The exchange of temperature takes place through the walls of the worm, in such a way that the wine which has not yet been treated enters the calefactor already warm, and the treated wine leaves the machine at its initial temperature.

In each column the wine enters from the bottom, rises, is collected by the tube *a a′* curved vertically, and carried to the following column, or to the worm of the calefactor.

The machine is fed from a tank placed at a certain height above it (tank, vat, cask) or by a pump P, the forcing hose of which is coupled at *r*, at the bottom of the first refrigerator.

Owing to the pressure exerted in this way, the gases in the wine do not become disengaged and the treated wine may go back to the casks even if they are placed above the level of the machine.

The calefactor is filled with water up to the level of the over-flow tap placed at its upper part. All the taps are closed except that of the exit *r′*, which should be left open to allow the air to escape; a rubber hose is coupled to the tap *r′* the other end dipping into the cask which is to be filled. The coupling *r*, is then connected with the pump or the tube coming from the tank and the wine forced into the machine so as to gradually fill all its parts. When it starts flowing through the exit tap the pump is stopped and the fire lighted. A few moments after wine is forced through, at intervals, to measure the temperature of the liquid in the calefactor, and when the required degree has been reached the machine is worked continuously. The inflow of wine and the fire are regulated according to the temperature indications of the thermometers.

The first portions of wine coming out of the machine are not sterilized and should be passed through again.

When the work is finished the fire is drawn and the wine emptied through taps fitted for that purpose, if the machine is not to be worked the following days, it is cleaned with warm water until it runs out of the machine quite clear.

Bourdil's machine is one of the cheapest to work, as shown by the following table, giving the yields and cost for the different models :—

—	Yield per Hour.	Number of Columns.	Cost.	
			Without Additional Refrigerator.	With Additional Refrigerator.
	Gallons.		£	£
No. 1 ...	55	2	11	22
No. 2 ...	120	2	20	40
No. 3 ...	220	3	26	53
No. 4 ...	330	3	34	66
No. 5 ...	440	3	48	88
No. 6 ...	660	3	60	120
No. 7 ...	880	3	80	152

A second refrigerator is necessary in warm climates, especially in summer, to allow the wine to be completely cooled before returning it to the casks. This necessarily increases the cost of the machine.

Owing to the double worms used in this arrangement, the wine remains in contact with the warm water or the cool wine a long time, therefore all its parts get completely intermixed ; much more so than with machines having a single worm. All parts of the liquid reach the temperature of pasteurization, this is a very great advantage, especially for wines which have not finished fermenting and have remained sweet.

In special cases, to increase this mixing of the different parts, Bourdil adds to his sterilizer a collecting cylinder made of tinned copper provided with taps placed on different levels.

The wine coming out of the calefactor is received in the collector, remains in it from one to five minutes (this is regulated by opening one of the taps at a certain level) and passes on the refrigerating columns.

The rate of flow is not altered, but the prolonged action of the heat kills even the most resistant disease germs.

The addition of this special collecting recipient increases the cost of the machine by 10 per cent.

Bourdil's machine has been imitated in a very rough way in other countries.

3. *Velten's Sterilizer.*—Velten, who was the first to use heat for the preservation of beer, invented a machine for heating wine in 1886. Although this machine is not generally used we will describe it, for it is simple, and its disposition allows the wine to remain several minutes at the temperature of sterilization, which renders it very useful for the treatment of sweet wines.

The calefactor is composed of a worm tube B (Fig. 18), made of tinned copper or tin, submerged up to the level of the tap N, in warm water, heated by a fire grate F, or by a steam pipe if steam is used.

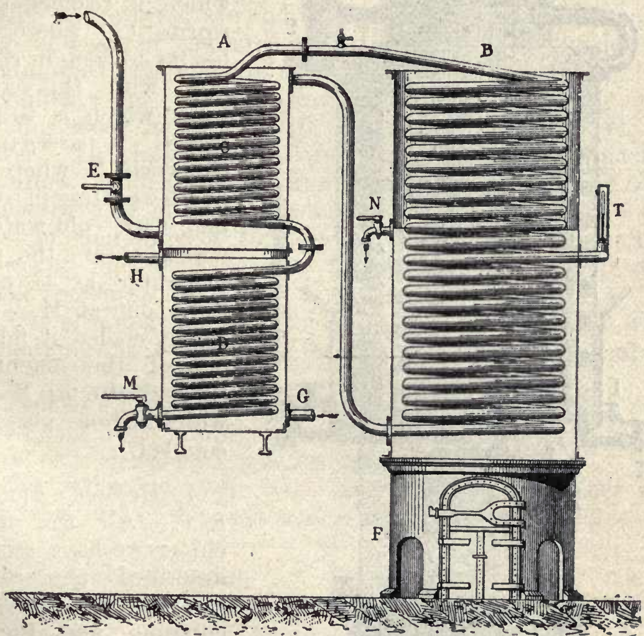

Fig. 18.—Velten's Sterilizer.

The refrigerator A contains two worms C and D, the first one surrounded by cold wine, the second surrounded by cold water.

The wine enters through the tap E, gradually becomes warm by contact with the worm C, in which the warm wine circulates ; from there it passes into the bottom part of the worm B, and gradually gets warmer as it rises up to the level of the thermometer T, which is placed a little below the level of the water in the calefactor.

This thermometer records the maximum temperature the wine reaches, which can be regulated either by the temperature of the water or by the rate of flow.

After the wine has reached the required temperature it continues to rise in the worm B, instead of entering the refrigerator directly, as in other arrangements, and it maintains its heat for a certain time, after which it reaches the worm C, where it begins to cool in contact with the cold wine, which is to be heated. It passes into the worm D, where it finishes cooling in contact with cold water, which enters the refrigerator at G and flows out at H, and finally cooled it flows out of the machine through the tap M, to which a hose may be coupled.

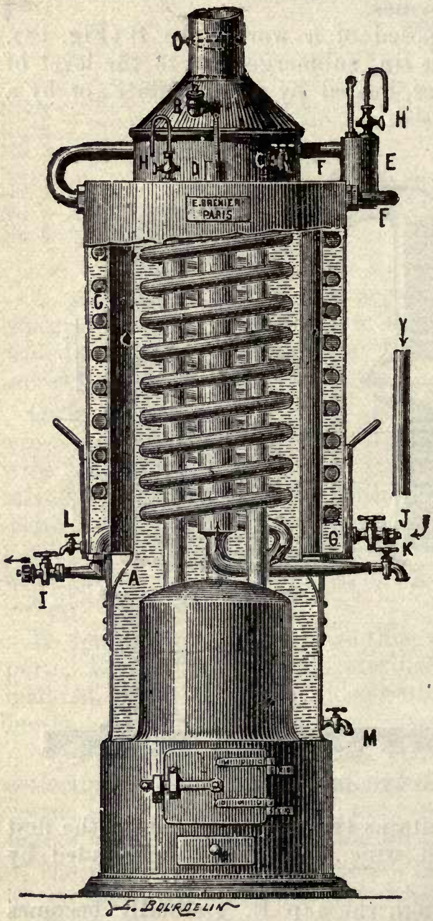

Fig. 19.—Bréhier's Sterilizer.

4. *Bréhier's Sterilizer.*—All the machines we have so far described are composed of several columns, and therefore occupy a considerable space. Bréhier's machine, on the contrary, is formed of a single column, and occupies a very small horizontal space.

The calefactor A and the refrigerator G (Fig. 19), are concentric, and isolated from one another by an air space of a few inches.

The wine enters through the coupling tap J, into the bottom part of the refrigerator, fills the whole space between the spires of the worm, penetrates into the calefactor, where it circulates in a worm, and through a vertical collector—both surrounded by warm water.

The heated wine flows out of the calefactor, passes through the box E, provided with a thermometer, and reaches, through the tube F, the worm of the refrigerator submerged in the cold wine; finally, it flows out of the machine, through the coupling-tap I at its initial temperature.

The water in the calefactor A is heated from the metallic walls of the fire grate and through the vertical tubes carrying the gases of combustion to the chimney. The level is maintained constant by an overflow tap C. If this level diminishes during the operation it is raised again by introducing more water through the plug B screwed on the cover. The taps H and H′ are used when filling the machine to allow the air to escape, and during the operation to allow the escape of gases which might accumulate in the tube system, and prevent the free circulation of wine. This, however, may be avoided by forcing the wine under sufficient pressure.

The cleaning taps K L and M allow the wine and water remaining at the end of each operation to be emptied out.

Bréhier's machine has the advantages of being very compact, and very simply constructed. The heating may be done with either coal, gas, or steam.

The following table gives the dimensions, together with the cost, of the principal models actually constructed :—

Yield per Hour.	Height.	Horizontal Projection.	Cost.
Gallons.	ft. in.		£
88	5 3	27½ in. × 27½ in.	40
110	6 6	31½ in. × 31½ in.	44
132	6 10	35½ in. × 35½ in.	50
176	7 0	37½ in. × 37½ in.	58
220	7 4	39 in. × 39 in.	68
330	8 3	43 in. × 43 in.	96

5. *Grenet aud Baurens' Sterilizer.*—Grenet, ex-demonstrator to Pasteur, with the object of doing away with recipients or compartments made of tinned copper,

constructed, together with Baurens, a *pasteurizer with concentric worms* (Fig. 20) made completely of pure tin—that is to say, unaffected by wine.

This machine, which realizes in a practical way a mode of construction already applied to Gervais' machine in 1827, is composed of two principal parts, viz., a calefactor A and refrigerator B.

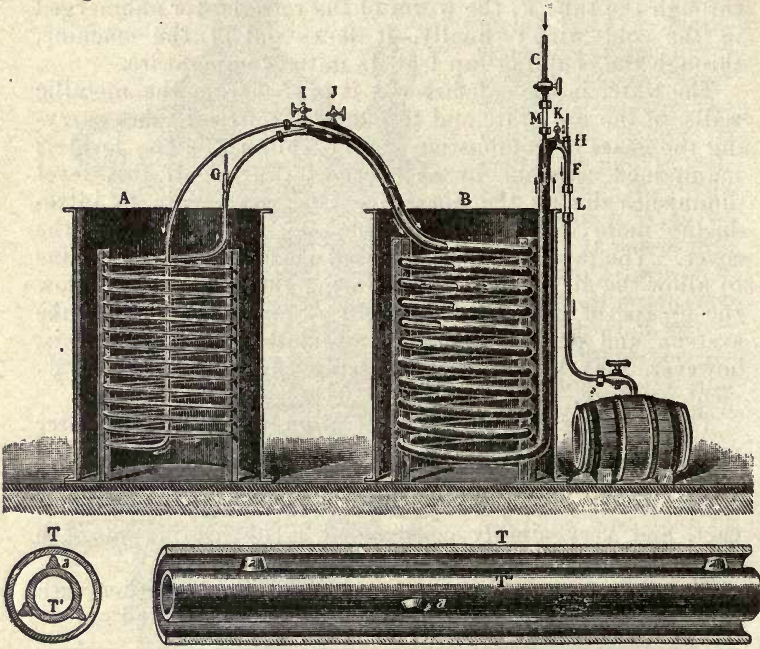

Fig. 20.—Grenet and Baurens' Sterilizer with concentric worms.

The calefactor is formed by a cylindrical tank containing warm water, which may be heated by coke, coal, wood, gas, or any other fuel, or even by steam. An automatic temperature regulator may be added to it. A worm is submerged in this tank, receiving the wine from the refrigerator by a tube T′; the wine reaches the required temperature, and flows out of the worm by the tube T, in which a thermometer G is placed.

The tube T enters into the tube T′ at I, and these two concentric tubes coiling together, form the refrigerator.

The tank B surrounding this worm, may be filled with cold water to increase the cooling power.

The two concentric tubes, the dimensions of which are calculated in accordance with the friction of the liquid, are introduced one into the other before coiling, and the space between them is maintained by small bosses *a* fixed on the outside of the smaller tube, leaving a uniform annular space between the two tubes.

At the exit of the tank B, the two concentric tubes separate. The tube T′ is connected with the tank by means of a small glass tube M and a tap C; the tube T is bent and connected by means of a second small glass tube L with a hose used for filling the casks. The thermometer H shows the temperature of the wine after the cooling operation is finished.

The wine leaving the feeding tank passes through the tap C, penetrates inside the worm T′ of the refrigerator, rises into that worm, reaches the bottom of the calefactor, rises into the worm of the calefactor, and continues its course through the annular space *a*, till it reaches the exit tube F L.

At the beginning of the operation all the tubes are filled with water, leaving the taps I, J, K open, to allow all the air to escape. When the tubes are filled with water, these taps are closed, and the heating begins. When the thermometer G shows the temperature at which the wine is to be sterilized, the wine is forced through the tube C, pushing the water before it. A small glass tube L allows one to ascertain when the heated wine comes out.

When the operation is finished, water is again forced through the tube C, pushing the wine remaining in the machine before it, and the fire is put out.

If the pasteurizer is not to be used again, it should be filled with a solution of borate of soda. This cheap antiseptic has the double advantage of preventing any alteration in the water and of keeping the inside of the tubes perfectly sterilized, therefore dispensing with frequent cleaning.

The yield of the pasteurizer with concentric worms is in direct relation to the height of the feeding tank. It may therefore be modified at will.

As the wine travels under pressure, the gases and aromas, which would have a tendency to become disengaged under the influence of heat, are held in solution, or, at any rate, are dissolved gradually and completely during the course followed by the wine in the refrigerator.

On account of the large size of the worms, the surfaces of exchange of temperatures are considerable. Grenet and Baurens' machine has also the advantage of the worms being entirely made of pure tin tubing, without any soldering. The wine, therefore, is never in contact with any other metal, as is the case with other machines made of tin and copper soldered with compounds containing lead.

Other constructors have also applied the principle of concentric tubes to calefactors or refrigerators. We have two examples of this in the pasteurizers of Gasquet, of Castres, and Perillot, of Bordeaux.

6. *Gasquet's Sterilizer.*—This machine is made of two very distinct parts—first, a pile of tubes, serving the purposes of a heater or refrigerator; second, a water jacket, provided with a thermo-syphon.

The pile of tubes is in the shape of a quadrangular worm, formed with tubes equal in length, assembled together by right-angled couplings.

The word "worm," which does not seem to apply to an assemblage with right angles, indicates, however, very well in this case the winding round of the tubes, which have a uniform slope of $\frac{1}{3}$ inch per foot.

It is formed of two concentric tubes, made of tinned copper. One of them A, is 1 inch in diameter; the other B, 2 inches (Figs. 21 and 22).

The bottom spire of the worm is provided with a third outside tube C C′ C″ C‴ of 4 inches in diameter. The union of these three tubes form the calefactor, while the rest of the worm forms the refrigerator.

The mode of assembling the tubes is such that, by using bent couplings of a special make, the mounting and dismounting are easy, and, notwithstanding the wider part formed by the couplings, the liquid current, which is to flow through the tube B, and inside the tube A, is not compressed at the points of junction of the straight tubes of the worm.

The tube A remains perfectly concentric to tube B. No accumulation of air or vapour is possible during the filling or during the working of the machine, and no liquid can remain in the tubes after the machine has been emptied.

In the same way the large tubes C of the lower spire are coupled, so as to remain perfectly concentric to the two smaller tubes.

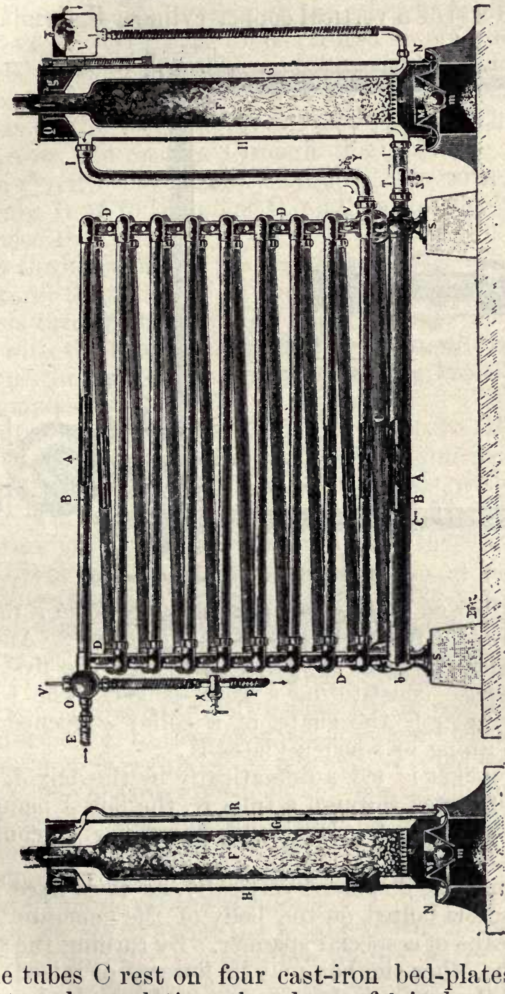

Fig. 22.

Gasquet's Sterilizer.

Fig. 21.—Vertical Section. Fig. 22.—Vertical Projection.

Fig. 21.

The tubes C rest on four cast-iron bed-plates, varying in height, and regulating the slope of $\frac{1}{3}$ inch per foot. The rows of tubes B are started at regular distances by cast-iron straps D, joining them together and keeping them at the required distance apart.

This whole frame of tubes connects on one side by the tube E with the feeding tank, and on the other by the tube P with the casks to be filled with sterilized wine. The heat generator is composed, as shown in the longitudinal section (Figs. 21 and 22) of a vertical copper cylinder F, forming the

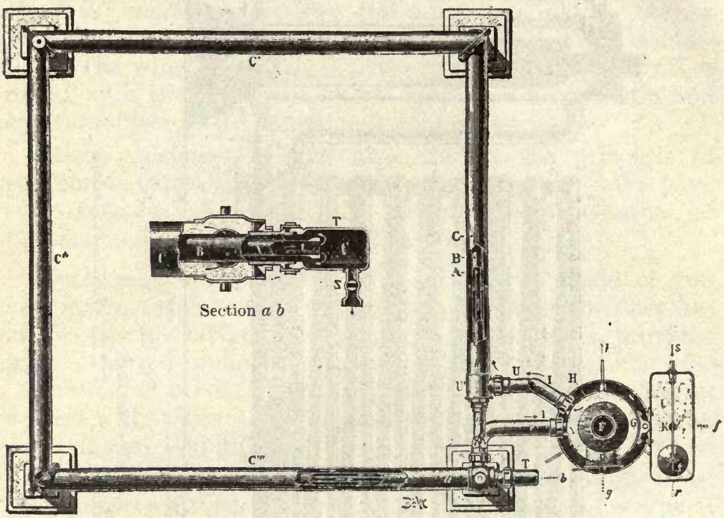

Fig. 23.—Gasquet's Sterilizer (horizontal projection).

fire grate, narrowed at the top part so as to form a funnel. A door p allows the fuel to be placed on the grate e. Another cylinder G, also made of copper, forms, with the first one, an annular space constituting a water-jacket. The top of the latter cylinder is the shape of a collar g opened, and isolated by a lining of wooden plates H.

The water jacket is fed automatically by the box J, with which it is connected through a tube K, the box J being fed through a flowing tap f, maintaining the water at constant level.

This box may be displaced vertically, as it is fixed by a nut upon a screw bolted on the body of the generator, and worked by means of a special spanner. By turning the screw one way or the other the box may be lowered or raised.

The top of the water jacket is connected by tube I, with a tube U (Fig. 23) at the highest point of the tube C, and the bottom is connected by the tube I′ with the tube T at the lowest point of the tube C‴. The whole of these tubes form a true thermo-syphon. The water jacket is mounted on a cast-iron frame forming a double basin, one of which is perforated and constitutes an ash tray M. The cast-iron ball *m* works as a valve, preventing the air passing through it. The draft passes through the other basin N.

Working.—The wine to be treated enters the worm at O, travels through the tube A, filling it and pushing the air before it. It reaches the point T at the bottom of the pipe, arrives at the box t' (Fig. 23, section *ab*) in the direction of the arrow, and returns through the tube B in the annulary space t'' left between the two tubes. The wine rises through the tube B up to the point O, and reaches the cask through the hose P.

On the other hand, the water arrives at a constant temperature through the branch I and the thermo-syphon, travels through the tubes C, C′, C″, C‴, becomes cool in contact with the tube B containing the wine, which it heats, and returns through the water jacket by the branch I′ to regain its temperature.

The wine travelling through the tube B reaches the maximum temperature at the precise moment when it leaves the point *n*, that is to say, at the point where the flow of water is at its maximum temperature. The maximum temperature of the wine is recorded by the thermometer V, fixed in a brass cage to protect it.

The warm wine surrounding the tube A, which contains cooler wine travelling in an opposite direction towards the source of heat, exchanges its temperature with it during the whole course it follows from the bottom to the top of the worm, and gradually gets cooler till it comes out at a temperature equal to that at which it entered the machine.

The flow is regulated at the exit by a delivery controlling tap X, the opening of which depends on the pressure of the wine in the tube and the temperature at which it is to be heated. The temperature in the water jacket is maintained constant by a special device from which the heat generator takes its name *thermo-regulator*.

Let us assume that the height at which the box J must be fixed for the temperature of the water not to exceed 64° C. (a temperature sufficient with this machine to pasteurize a wine at 60° C.) has been ascertained.

The water bath, the tubes I, I′, and the space between the tube C and the tube B, are completely filled with water before lighting the fire. The level of the water is evidently the same in the water bath as in the box J, as those two vessels communicate by the tube L.

The fire is lighted, the water expands in volume, and its circulation in the thermo-syphon begins. But as the heat gradually gets higher the volume of the water increases and its level rises in the water jacket, remaining fixed in the box J, which is prevented by a special device from receiving the warm water.

When the temperature reaches 64° C. the level of the water in the water jacket is precisely that of the top of the collar *g*. The slightest elevation of temperature will cause the water to overflow in the space Q (Fig. 21) and reach, through the tube R, the basin N, where it closes the draft from the fire grate.

The basin is provided with a very small hole, which allows the water to slowly run out in order to establish, after a few minutes, the normal draft of the fire grate.

Immediately after the overflow of water from the water jacket an inflow of cold water takes place from the box J, and compensates the excessive heat due to the activity of the fire.

For these reasons the water in the water jacket can never exceed the maximum temperature fixed beforehand. This is one of the main advantages of Gasquet's pasteurizer—it avoids any excess of temperature in the calefactor, and therefore any "*cooked*" taste in the wine.

The machine is not provided with taps for the escapement of air or gases, as they are not needed here—first, because the wine is heated at the lowest part under its maximum pressure due to the height of the worms and the height of the feeding tank above the machine; second, because the vapours, ethers, or gases are (notwithstanding the pressure, they might have disengaged under the influence of heat) immediately carried away by the slope of the liquid flow towards cooler parts, where they are redissolved.

The great length of the tubes in the calefactor and in the refrigerator, and the small thickness of the walls of the central tubes, assure the complete heating and cooling of the wine.

The temperature of the treated wine might be still lower if the few top rows of tubes were surrounded with hessian cloth kept wet. The evaporation produced would cause the wine to flow out of the machine cooler than it entered it, and this could be done by using a very small volume of water. One might in this way dispense with the use of auxiliary refrigerators, the use of which is often necessary in warm climates, and usually greatly increases the cost of some machines.

In the illustration the water bath and the worm tubes are shown on the same level. It is better in practice to raise the worm on four cast-iron columns, so as to bring the bottom of the calefactor level with the tube I of the water bath. The space between the four columns may be used for the filter or the casks to be filled with the treated wine.

At the end of the operation the fire is removed, and the worm tubes completely emptied by means of the tap Z, fixed at their lowest point.

All the wine in the tubes A and B comes out at this tap, and can be collected cool after cold water is substituted for warm water in the tube C, which might easily be done by connecting it with the tank supplying the cold water. The tubes are then washed with warm water, and the tap Z left open to allow them to drain.

If after the machine has been in use for a long time the tubes become covered with tartar, and if the tartar cannot be dissolved easily, one may pull the machine to pieces and scratch-brush the inside and the outside of the tube without difficulty. It is easy with Gasquet's machine to ascertain if there is any leakage by plugging the extremities of the tubes and filling them with water. The complete machine, with water bath and 358 feet of tubing, sterilizing from 220 to 264 gallons per hour, is sold for £80.

7. *Perillot's Sterilizer.*—The refrigerator of this machine is also composed of concentric straight tubes 6ft. 6in. in length, piled parallel to one another, and numbering 25. They are fixed slantingly, so as to allow the cold wine to rise while the treated wine descends in the opposite direction.

The calefactor is submerged in a water jacket placed on one side, heated with coal, gas, or steam, but to allow the wine to remain longer at the temperature of pasteurization it circulates through a long tube surrounded with warm water flowing from the water jacket in a thermo-syphon arrangement. Thermometers fixed at different points show the temperature reached by the wine.

We regret being unable to give an illustration of this machine.

B.—MACHINES WITH TUBULAR BUNDLES.

1. *Terrel des Chêne's and Victor Febvre's Sterilizer.*—This machine, described by Pasteur in 1868, was probably the first constructed with tubular bundles.

Victor Febvre has constructed it since 1875 in a slightly modified form. It is composed of:—

1st. A water jacket B (Fig. 24) made of galvanized iron, a fire-box of copper, with a funnel provided with a damper, running through the centre of the water jacket.

2nd. A calefactor C, made of multiple worms submerged in the water.

3rd. A refrigerator R, in the shape of a horizontal ring fixed to the water bath, to which it is concentric, and containing a bundle of fine tubes, through which the warm wine and the cold wine exchange their temperature.

The cold wine enters the ring through the coupling E, circulates round the small tubes, and after travelling right round flows out through the tubes *s* and enters the calefactor at *e*. After reaching the maximum temperature it flows out of the calefactor at *s'*, records its temperature at a thermometer *th*, and enters the refrigerator through the tube *e'*, again travels right round, but inside the small tubes, and finally flows out through the coupling S at a temperature equal to that at which it entered the machine.

The mounting, working, and supervision of this machine are easy and simple.

The feeding is effected by means of a pump, or by a tank placed at a certain height above the machine. In the first case the regulating is effected by pumping at a suitable speed. In the second case it is done by means of a tap placed on the feeding pipe, in this case the regulating is much more effective. The man attending the machine generally opens the tap more or less, according to the indications of the thermometer, but it would be easy to adapt an automatic regulator, checking the flow of wine into the calefactor.

The heating may be done with coal, gas, or steam, except in the case of the large machines treating 1,000 to 2,000 gallons per hour, which are all heated by steam generated by a boiler.

When the operation is finished the fire is removed, and the warm water pumped out and sent through the tube in a direction opposite to that which it normally follows, that is to say, forced through S and flowing out at E. The deposit always left after the machine has been used a certain time may be easily removed in this way.

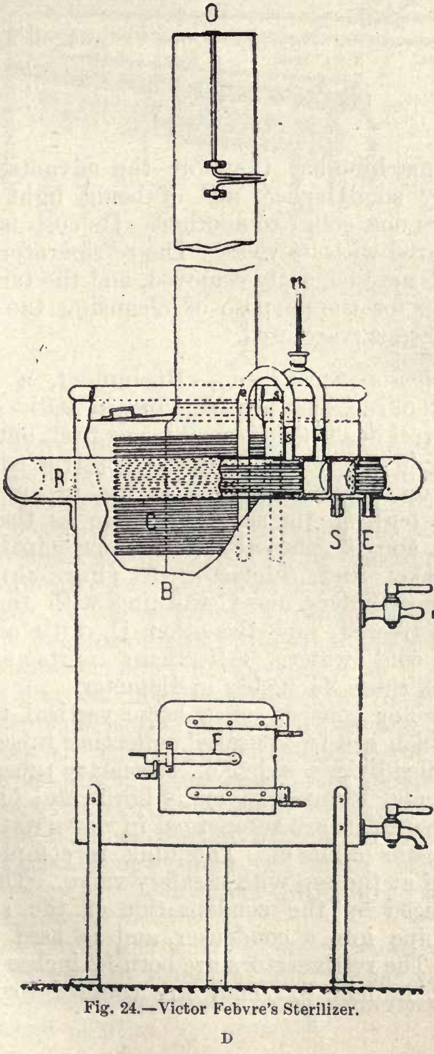

Fig. 24.—Victor Febvre's Sterilizer.

Taps provided for the purpose allow the calefactor and water bath to be completely emptied. The following table gives the dimensions, rate of flow, and cost of the principal models :—

Nos.	Weight of the Machine.	Horizontal Surface.	Height Total.	Yield per Hour.	Cost.
0	...	...	...	3½ gallons	£4 8s.
1	110 lbs.	5 sq. feet	6 feet	110 ,,	£15
2	154 ,,	7 ,,	7 ,,	220 ,,	£23
3	308 ,,	15 ,,	7ft. 9in.	440 ,,	£37

Febvre's machine has therefore the advantage of occupying a very small space, and of being light and easily portable from one cellar to another. Its cost is very small when compared with its yield. The refrigerator R and the calefactor C may be easily removed, and the tank used for heating water for the purpose of cleansing the casks. In this case the taps *r* are used.

2. *Ricaümont's Sterilizer.*—Ricaumont, a wine merchant at Libourne, has heated wine in bulk since 1875. He used Terrel des Chêne's machine at first, but that being too small for his purpose, he himself constructed, in 1884, a large sterilizer, which has been in use in his cellar ever since. It is built on the same principle as that of Terrel des Chêne's, and is composed of three principal parts, viz., a water jacket and calefactor A (Fig. 25), and two refrigerating cylinders, one C working with the cold wine before it is treated, and the other D, with a continuous current of cold water. All these parts are coupled together with tubes 2⅓ inches in diameter.

The calefactor consists of a large vertical tank, in the centre of which are two parallel collecting tubes B and B′, communicating by a number of secondary tubes G, ¼ inch in diameter, and forming so many horizontal circles. The whole of these tubes are submerged in warm water, which is heated by means of steam. The tank is completely closed and provided at the top with a safety valve. The excess of water produced by the condensation of the steam flows through a pipe into a condenser, and is used for feeding the boiler. The refrigerators are both 12 inches in diameter and 16 feet in length. They are coupled together, both sloping in opposite directions, so as to facilitate the flow of liquid. They are fixed to the wall of the cellar by braces T, near the calefactor, and, notwithstanding their great

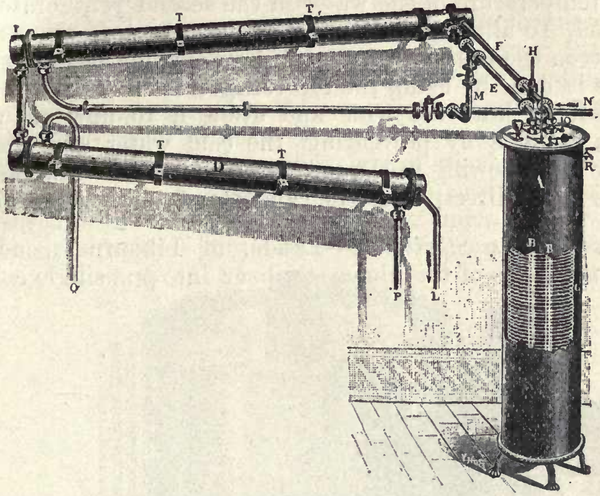

Fig. 25.—Ricaumont's Sterilizer.

length, are not cumbersome. They contain 200 secondary tubes of a diameter equal to those of the calefactor, joined in bundles, and in communication at both extremities with transversal boxes or collectors, dividing the wine regularly through the small tubes, mixing all its parts together and insuring regularity of flow. The wine, forced by a pump into the tube N, flows into the top refrigerator C; surrounding the bundles of small tubes it reaches the exit tube E, through which it flows into the calefactor. After flowing through the division tubes G it leaves the calefactor, records its temperature at a thermometer H and enters, through the tube F on the left, the top collector of the refrigerator C. It travels through the bundles of small tubes, gets cooler, reaches the collector I, and from there passes in the bundle of small tubes of the bottom refrigerator D. It finally flows out through the tube L into the casks. The water for cooling purposes enters through the tube P and is discharged through the tube O.

Ricaumont's machine cannot, on account of its large dimensions, be used by wine-makers for one year's vintage only, but it is found very useful by wine merchants to heat large quantities of wine.

Taps placed at M allow three distinct operations to be performed, the wine following the same course the whole time.

1st. To completely cool the wine and bring it down to the temperature of the water in the second refrigerator.

2nd. To allow the wine to flow out at a mean temperature between the initial degree and the degree of pasteurization. This is done by using the top refrigerator alone.

3rd. To heat the wine and allow it to flow out warm. This is done by preventing the cold water and the cold wine from flowing in the refrigerators, and in this case the wine flows directly into the calefactor from the tube M.

3. *Landé's Sterilizer.*—Landé, of Libourne, condensed all the parts of the above sterilizer into one single column.

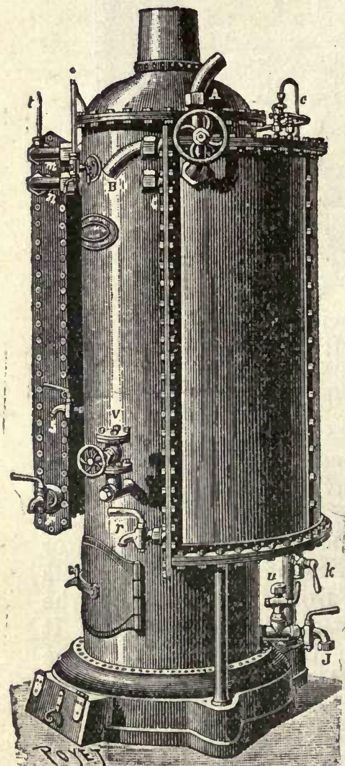

Fig. 26.—Landé's Pasteurizer.

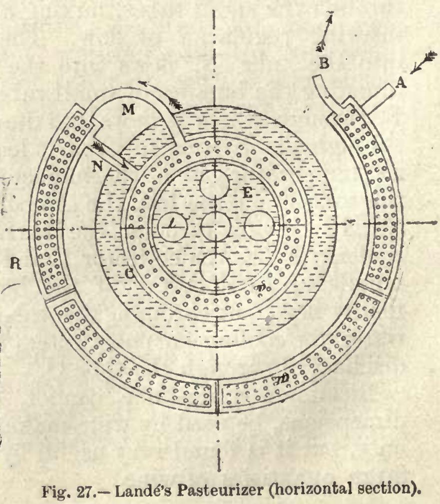

Fig. 27.—Landé's Pasteurizer (horizontal section).

His machine is portable, not cumbersome, and one of the most practical. Fig. 26 shows the whole machine, and Figs. 27 and 29 give horizontal and vertical sections of it.

It is composed of three concentric parts—a water bath E, a calefactor C, and a refrigerator R (Fig. 27), forming one column resting on a single bed-plate. The water bath is tubular, and may be heated with coal; the tubes *t*, dividing the mass of the water, considerably increase the heating surface, and allow the better utilization of the heat of the fire. On top is a kind of conical plug, the weight of which is calculated to allow the water to overflow if the temperature rises too high through the inexperience of the workmen. This water drops on the fire and puts it out, preventing any accident.

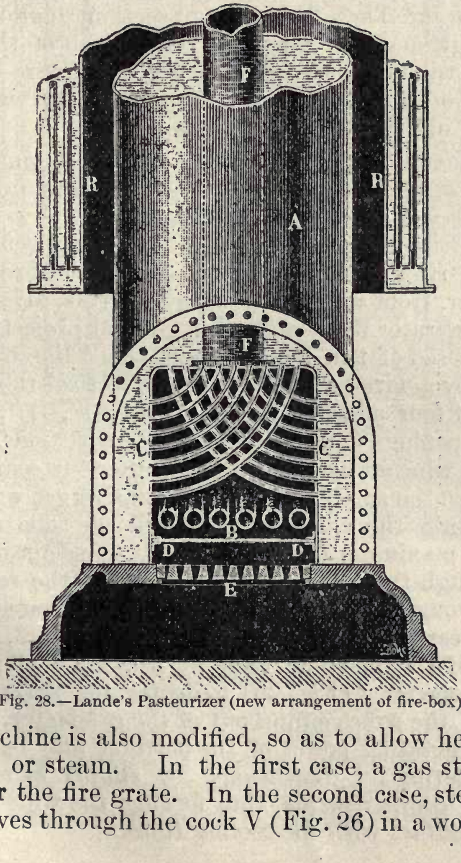

Fig. 28.—Lande's Pasteurizer (new arrangement of fire-box).

This machine is also modified, so as to allow heating with either gas or steam. In the first case, a gas stove is substituted for the fire grate. In the second case, steam from a boiler arrives through the cock V (Fig. 26) in a worm, ending with a special device to prevent the noise resulting from the condensation of steam. The overflow of this condensation is removed by a lateral tube maintaining the level in the boiler constant. The newest machines, heated with gas or coal, have a fire-box of special construction, allowing rapid and regular heating. The fire-box (Fig. 28) is composed of a rectangular case C, surrounded by water, on the top of which a funnel is fixed. A series of tubes, $\frac{1}{2}$ inch in diameter, are fixed between the top and lateral walls of the fire-box, as shown in the figure. These small thermo-syphons offer a surface of heating of 21 to 43 square feet, according to the size of the machine. For heating with gas, a plate D is inserted, closing the bottom of the fire-box, and gas-burners B, placed on it. These have a large section, to allow the free access of air and the complete combustion of the gas. A small mica window placed on the side of the fire-box allows supervision of the burners. The water in the water jacket reaches 65° or 70° C. in 15 minutes.

The calefactor C is formed of a bundle of small vertical tubes *v*, allowing the two collectors to communicate. The whole device is submerged in the warm water. The wine from the refrigerator flows into the bottom collector through the tube N, rises into the bundle of small tubes, reaching the top collector, from which it flows by the tube M.

The refrigerator R, opened out in vertical projection in Fig. 29, is composed of two hollow rings, joined like those of the calefactor by a large number of small vertical tubes *v′*. It is formed of four adjacent boxes—D, D′, D″, D‴, communicating by openings O made through the partitions.

The cold wine arrives at A, flows in the four compartments surrounding the small tubes, and begins to get warmer. It then flows into the calefactor through the tube *n*, where it reaches its maximum temperature. It flows out of the calefactor through the tube *m*, and returns to the refrigerator, passing through the small tubes, where it becomes cold. It passes successively through the collectors 5, 4, 3, 2, 1, and flows out of the machine at B, at the initial temperature. The thermometer *t* (Fig. 26) indicates the maximum temperature of the wine coming out of the calefactor.

The refrigerating power of the machine may be increased, without altering its dimensions, by simply increasing the number of compartments, thus forcing the wine to remain longer in contact with the cooling tubes.

The gases and volatile matters disengaged by the heat are collected in the top of the machine by small tubes n, n' (Fig. 29), connected with two independent horizontal tubes p and p' carrying them into the cold wine, where they are again dissolved.

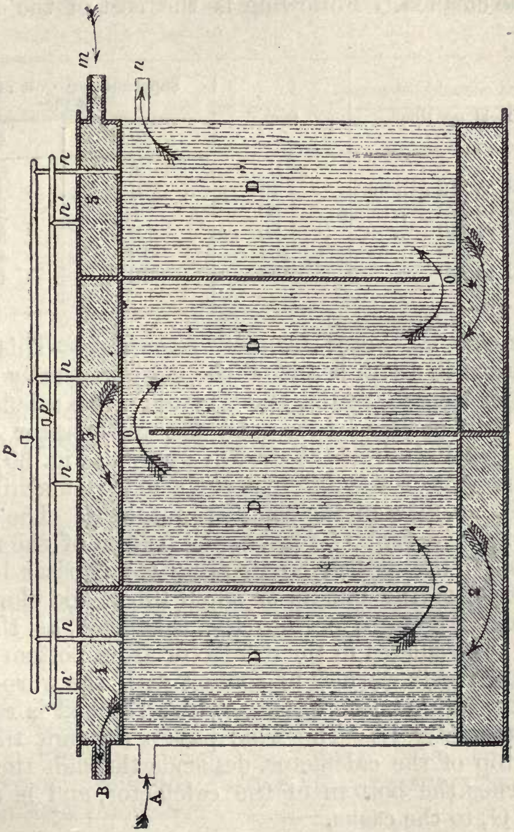

Fig. 29.—Lande's Pasteurizer (refrigerator opened out).

Taps placed at the lowest part of the machine allow it to be quickly emptied and cleaned.

Landé's machine has all the advantages of machines with vertical tubular bundles, great division of the wine, and, therefore, large surface of heating and cooling, all parts of the wine reaching the required temperature of pasteurization; minimum internal friction of the liquid, as well as upon the walls of the recipient; rapid circulation, and large yield. It occupies a very small space, is easily pulled to pieces, examined and cleaned, and may be worked with large or small differences of level.

With the new improved machines the outer walls may be removed, exposing the whole bundle of tubes, and allowing them to be cleaned. Following is the cost of the different models:—

Nos.	Yield per Hour.	Cost.	Supplementary Cost of Heating with—	
			Gas.	Steam.
		£	£	£ s.
1	99 to 110 gallons	49	6	2 0
2	198 to 220 ,,	62	8	3 0
3	330 to 440 ,,	80	9	3 8
4	500 to 572 ,,	104	10	4 0
5	660 to 770 ,,	152	12	4 8

4. *Pommier de Saint-Joannis' Sterilizer.*—This sterilizer, invented in 1872, is one of the most generally used in the South of France, Spain, and Algeria. The calefactor is provided with a worm tube, and the refrigerator with a bundle of small straight tubes. The section (Fig. 30) shows the arrangement of the different parts of the machine, and Fig. 31 gives a view of the complete machine. The wine is pumped into the tank C, reaches the bottom of the refrigerator through the delivery controlling tap E, rises between the interstices of the bundle of small tubes, and flows into the second refrigerator or into the calefactor, as the case may be. It circulates in the calefactor from bottom to top, and gradually gets warmer in contact with the warm water as it rises. The maximum temperature reached is recorded by a thermometer H. The wine passes through the tube D, in the top of the calefactor, descends through the small tubes, reaches the bottom of the calefactor, and is carried by a tube G, to the casks.

The gases, ethers, or vapours disengaged during the operation collect in B, and are condensed in a tube traversing the wine-feeding tank, reaching the exit tube at G.

When the operation is finished, the wine contained in the machine is emptied through small taps placed towards the bottom; the water in the water jacket is left in the machine as well as the fire, while cold water is forced through the machine until it comes out quite clear. It is only after this cleaning is finished that the water jacket is emptied and the fire removed.

If the flow of liquid diminishes through deposition of tartar, cleaning is effected in the ordinary way, simply adding 1 per cent. of hydrochloric acid to the water. The following table shows the capacity of the different models, together with their cost :—

Nos.	Number of Refrigerators.	Yield per Hour.	Cost of Machines heated with—		
			Coal.	Gas.	Steam.
		Gallons.	£	£	£
1	1	33	18	...	...
2	1	66	32	...	...
3	1	132	52	56	48
4	2	286	68	84	92
5	2	440	92	112	124
6	2	660	128	152	...
7	2 or 3	990	182	208	...
8	2 or 3	1,320	240	260	...

5. *Houdart's Sterilizer.*—This sterilizer is *one of the best on the market.* It is composed of three parts.

1st. A calefactor C (Fig. 32), in which the wine is heated in contact with water through a bundle of parallel tubes of very small diameter, tinned inside and outside, or, better, made of pure tin.

2nd. A thermo-syphon water jacket D, where the water is heated. This may be done either by gas or steam.

In the first case (Fig. 32) the gas passes through an automatic regulator, and is carried to burners, the flame of which is directed towards the interior by expanded copper tubes, which reach the funnel after passing two or three times through the water.

In the second case (Fig. 33) steam from a boiler passes through an automatic regulator, and is carried into the tubes of the water bath.

The warm water flowing out of the calefactor rises through the large tube M (Fig. 32), reaches the wine heater, and, after becoming cold in contact with the wine, returns to the calefactor through the tube N, which completes the thermo-syphon.

The thermo-syphon is fed from the water contained in the recipient E.

3rd. A refrigerator B, in which the wine flowing out of the calefactor is cooled by contact with cold wine, through bundles of tubes similar to those of the wine heater.

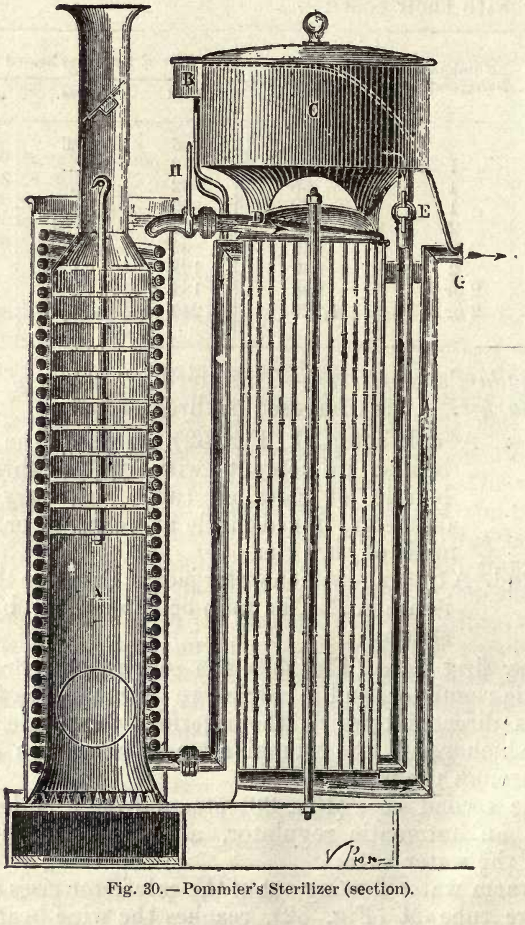

Fig. 30.—Pommier's Sterilizer (section).

The wine flows into the tank A, its level being kept constant by a tap connected with a floater. It travels through the vertical tube H, which is provided with a delivery controlling tap I, reaches the bottom of the wine refrigerator, rises outside the bundle of small tubes, and flows through the tube J, which carries it to the bottom of the wine heater. It rises through the bundle of tin tubes.

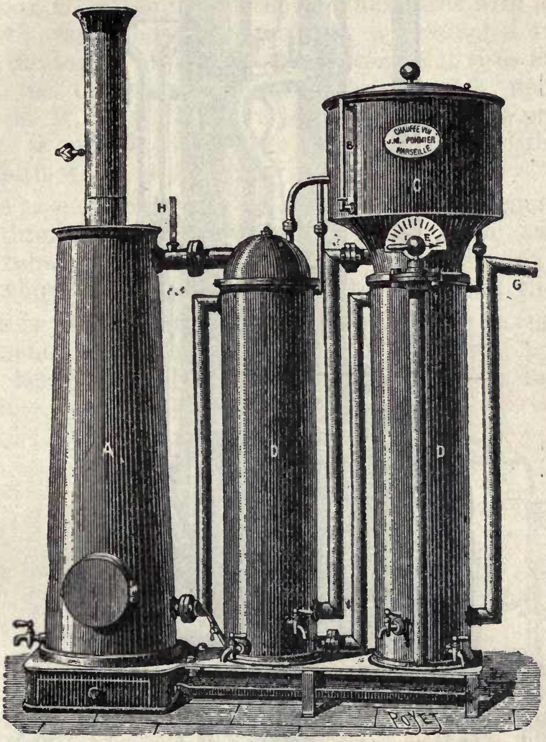

Fig. 31.—Pommier's Sterilizer with two refrigerators.

After completely absorbing the heat of the water it flows through the lateral tube K, reaches the tubular bundle of the refrigerator, becomes cold as it descends, and finally leaves the machine through the tube L at the initial temperature.

Two thermometers indicate, one the maximum temperature of the heated wine, the other that of the water in the water jacket. A self-registering thermometer is often added. This allows one to follow the course of the operation in all its details, and to check exactly how it was conducted.

The gases and aromatic products disengaged from the wine under the action of heat collect in the top of the

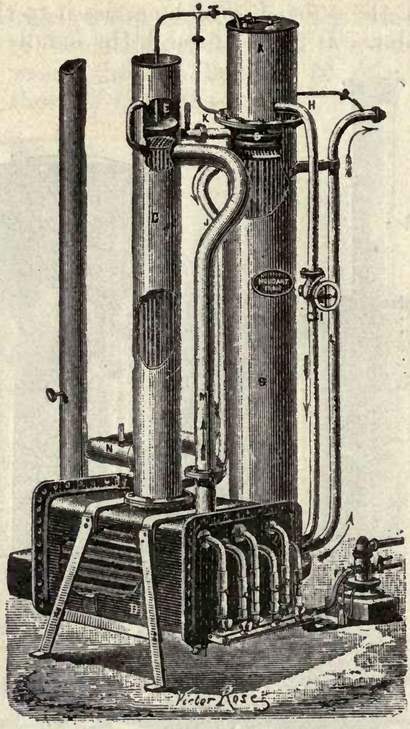

Fig. 32.—Houdart's Sterilizer, heated by gas.

calefactor and of the refrigerating column, and pass through small tubes O immersed in the tank A containing the wine. They are condensed there and carried into the tube L, where they are re-dissolved in the cold wine.

The combustion of the gas is regulated so as to insure a constant and uniform temperature, and prevent any sudden elevation of temperature. This is done by means of the combination of a spirit worm (Fig. 34) and regulator (Fig. 35) connected by a small tube.

The worm G is immersed in the upper part of the refrigerator in the hot wine coming out of the calefactor through the tube K. The spirit expands under the influence of heat, and exerts a certain pressure on the membrane M of the regulator, which is placed at a short distance from the opening of the tube N, through which the gas arrives. This gas, coming out of the tube P, feeds, therefore, more or less, the burners of the thermo-syphon.

The box O of the membrane communicates with a bottle filled with water and surmounted by a graduated tube D, open at the top. When the spirit expands it rises more or less in the tube, and indicates the pressure upon the membrane M. It is therefore easy to regulate the pressure. The tube is only fixed after the hot wine has filled the tank of the spirit worm G for twenty minutes at least.

In the case of the orifice of the tube N being completely closed through the membrane being too much raised, a second tube of small diameter feeds a small gas burner (pilot) which keeps the burner in the calefactor alight.

Spirit is poured into the tube A where the worm starts till itreaches the bottom of the tube D. The tube A is then closed, being careful not to introduce any air into the machine.

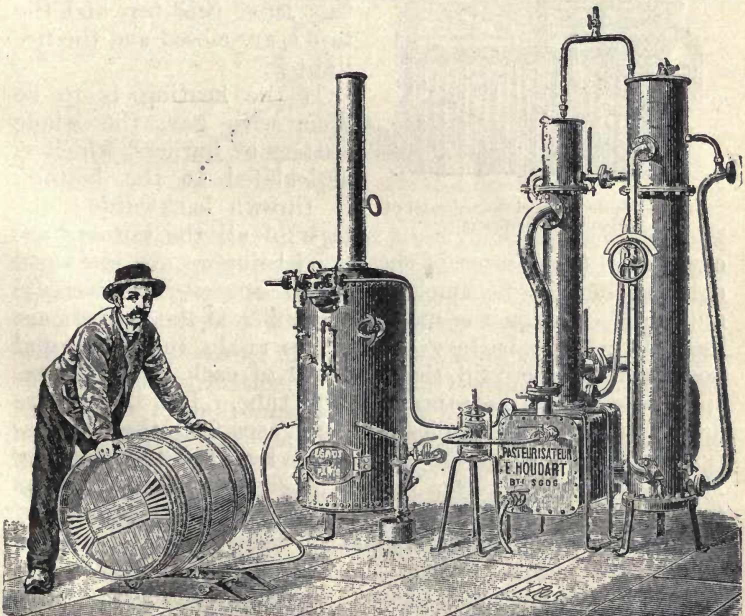

Fig. 33.—Houdart's Sterilizer, heated by steam.

The tank E is filled with water (Fig. 32) so as to completely fill the water jacket D, and the column of the calefactor C to a level of $\frac{1}{2}$ inch to 1 inch from the bottom plate E. It is necessary to leave that space to allow for the expansion under the influence of heat. During this operation the tap O must remain open, to allow the air to escape, and it is closed half-an-hour only after the work is started.

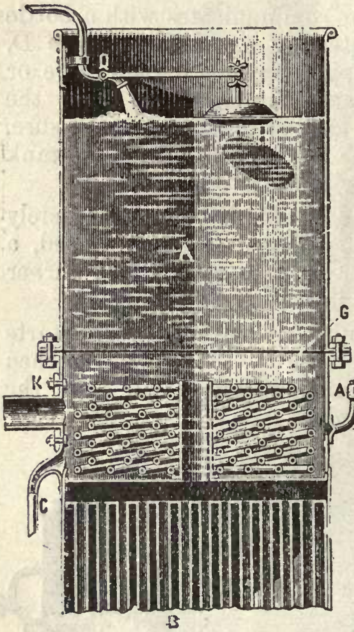

Fig. 34.—Spirit worm of the regulator of Houdart's Sterilizer.

The wine in the tank A is introduced through the delivery controlling tap I, and passes round the tubes of the refrigerator B. It fills the tubes of the calefactor and arrives in the tube C; when it flows through the small tap fixed on the top of this tube, this tap and the tap I are closed and the fire lighted.

If the heating is to be done with gas, the whole battery of burners, which is articulated at the bottom, is thrown backwards; the taps of all the burners are closed, and the damper of the funnel being open, a few wood chips are burnt in the smoke box on the opposite side to create a draught. When the draught is sufficient the burners are lighted and the battery thrown up again in its normal position, being careful that the end of each burner corresponds with the entrance of each tube. The flames are drawn through these tubes and the gases from the combustion escape through the funnel. When the thermometer N indicates 60° C. the tap I is slightly opened, so as to allow the wine to flow out at K at the required temperature of pasteurization. Soon after the wine which has been heated flows out of the tube L, thoroughly cooled, and passing through a hose, enters the cask.

The rate of flow is regulated with a thermometer K, and a delivery-controlling tap I. The heat is regulated automatically with the spirit regulator already described.

Houdart's machine does not require any special supervision after the start. If the heating is done by steam, that steam, coming out of the regulator, arrives in the worm of the calefactor (Fig. 33), where it condenses, and the

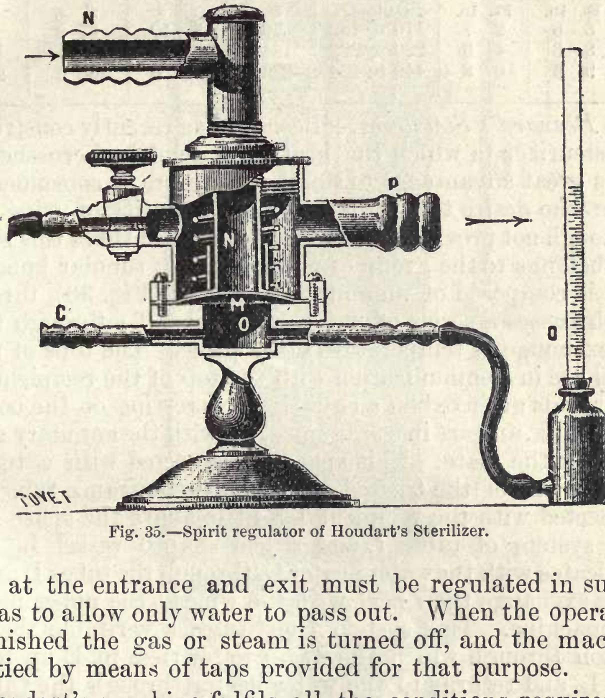

Fig. 35.—Spirit regulator of Houdart's Sterilizer.

taps at the entrance and exit must be regulated in such a way as to allow only water to pass out. When the operation is finished the gas or steam is turned off, and the machine emptied by means of taps provided for that purpose.

Houdart's machine fulfils all the conditions required for effective pasteurization. The wine is heated and brought back to its initial temperature out of contact with air, the heating is regular and automatic, the temperature of the water is only slightly above that to which the wine requires to be heated, and the wine retains all its gases and aroma. The thermometers are easy to examine, the delivery controlling tap is at a convenient height for the workmen to use it when necessary, it requires a very small space horizontally, and owing to its large area for heating and cooling, the wine comes out of the machine at a temperature only slightly above that at which it entered it.

The dimensions and costs of the different models put on the market are as follow :—

Nos.	Total Height.	Horizontal Projection.	Yield per Hour.	Heating with Gas.		Heating with Steam.	
				Without Regulator.	With Regulator.	Without Regulator.	With Regulator
	Ft. In.	Ft. In.	Gallons.	£	£ s.	£ s.	£
1	8 6	2 7	110 to 132	79	87 10	67 8	72
2	8 6	4 0	220 to 222	134	144 0	119 0	124
3	9 9	6 8	440 to 484	220	236 0	202 0	208

6. *Besnard's Sterilizer.*—Besnard has recently constructed a pasteurizer in which the heating is done by kerosene. It offers great advantages to small proprietors or consumers, or those who desire to sterilize a small quantity of wine only. Although not provided with a bundle of small tubes this sterilizer belongs to the group of machines with tubular bundles.

It is composed of an annulary tank R (Fig. 36), through which passes a series of flat vertical tubes T; through these the exchange of temperature takes place. The tops of these tubes are in communication with the top of the recipient, the lower ends are fixed on a circular plate resting on the bottom of the tank, and are in communication with the annulary space K under the plate. This space is connected with a tube A for the exit of the treated wine, and the entrance tube O is connected with the recipient T a little above the space K.

A system of tubes *t*, and a lens-shaped vessel L, communicates with the water heater C, through the tubes D and E, these exchange their heat with the wine at the upper part of the machine. This system constitutes a veritable thermo-syphon through which the warm water rises in E up to the lens L, and returns to the water heater through the tube D after being cooled in contact with the wine.

The non-treated wine arrives in a tank provided with a tap and a floater M, and reaches the pasteurizer through the tube Q, which is connected with a delivery controlling tap S; it rises in the recipient R surrounding the tubes T, absorbing the heat of the treated wine which descends through these tubes; it continues heating in contact with the tube *t* and the lens L, descends through the flat tube where it gradually gets colder, and flows out of K at a temperature only slightly above the initial temperature.

The gases, ethers, and other volatile products of wine which become disengaged under the action of heat, are

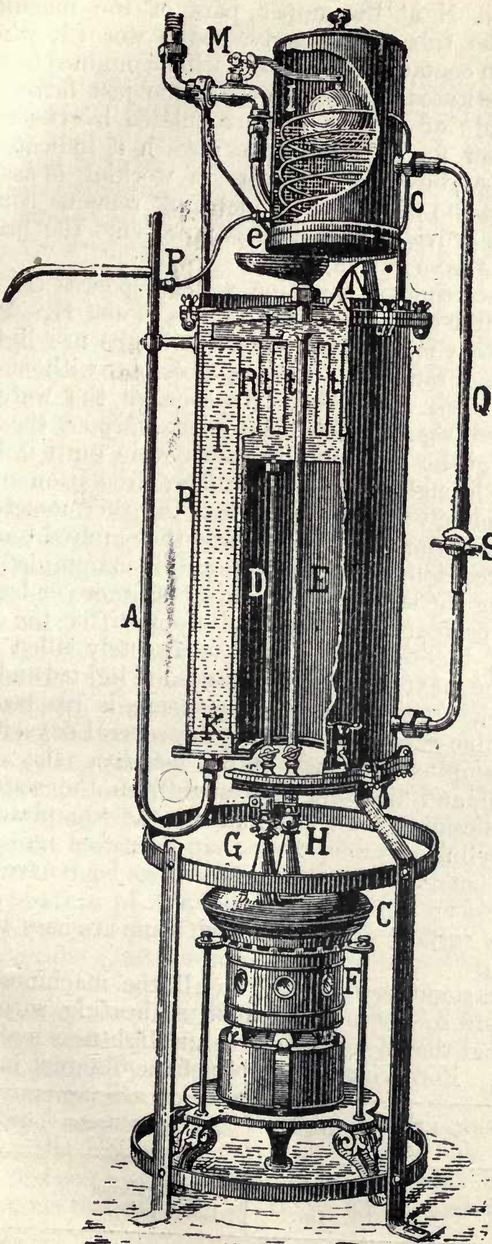

Fig. 36.—Besnard's Sterilizer, heated with kerosene.

gathered in N at the upper part of the machine, pass through the tube O and arrive in the worm I, where they condense in contact with the cold wine contained in the tank, and are restituted in P to the cold wine just before its exit. The aperture of the tube S is regulated by observing the thermometer for a few minutes; when it indicates a constant temperature the regularity of working is assured, for the level of the wine in the upper tank remains constant as the tap M, provided with a floater, prevents the pressure in the tube Q from varying.

Before starting the machine, water is poured through the funnel *e* after having opened the taps G and H. When the whole system is full, the kerosene lamps are lighted, the wicks being raised as high as possible, without however allowing them to smoke. As soon as the water in the lens-shaped vessel L begins to get warmer, the tap S is opened, and the tank R filled with wine until it begins to overflow through the tube A. The circulation of wine is only completely established when the thermometer placed on the top of the machine indicates the required temperature of pasteurization. This temperature is maintained constant by opening the delivery controlling tap more or less.

If the pasteurization is to be stopped (for the night for instance), the machine is left completely filled with the liquids, and, next morning, the lamps are lighted and the tap S opened when the required temperature is reached. When the machine is to stop working for several days it is completely emptied through taps, *ad hoc*, the couplings unscrewed, and the tank separated from the water jacket. All the thumb-screws are undone, the top plate and the outside cylinder removed so that the tubes remain visible from the outside; those tubes can also be removed as they simply rest on the bottom of the tank.

All the surfaces in contact with wine are easy to examine and clean.

This pasteurizer differs from all the machines we have studied—in so far that the mode of heating with kerosene is new, and that its compactness and lightness make it easily portable. Following is the cost of the different models:—

Nos.	Total Height.	Yield per 10 Hours.	Cost with Wheels.
1	6ft. 6in.	550 gallons	£22
2	7ft. 4in.	1,320 gallons	£40

The expense of kerosene is a little over $1\frac{1}{8}$d. per 100 gallons of wine treated.

C.—MACHINES WITH CYLINDRICAL OR HELICOIDAL COMPARTMENTS.

Giret and Vinas' machine (1866) was the first in which cylindrical compartments were used for cooling the wine, but the number of these compartments was too small, the surfaces for exchange of temperature were therefore too much reduced.

1. *Raulin's Sterilizer.*—Raulin adopted later on a more rational disposition of the compartments, and utilized annulary boxes made of a series of concentric cylinders for the hot-air box, water-heater, calefactor, and refrigerator. His machine, which was described in the second edition of *Pasteur's Etudes sur le vin* for the first time, is shown Fig. 37. It consists of ·four similar groupments of cylindrical boxes made of copper *v e*. Each of these is made of an annulary recipient *e*, open at the top, closed at the bottom. and containing a smaller recipient *v*, similar in shape, and closed at both extremities. The open recipients are in communication. They are full of water, and serve as a water jacket; the closed recipients are independent of one another, and constitute the wine heater or calefactor. All the parts in contact with wine are tinned. The fire grate is shown in F. Heated air circulates through the space *f* between the different groupments of boxes, and reaches the funnel. The cold wine enters the three boxes at the same time by tubes *a*, reaches the bottom and passes out through the tubes *b*, reaching the bottom of the central box *v t*. It rises through that central collector, all its parts intermixing as they rise to the temperature of 60°C. It is then received in a horizontal collector, from which it flows towards the casks through a tube *s*, after recording its temperature at a thermometer *t*.

The level of the water in the water jacket is kept constant by pouring water through the glass funnel *i*, connected with the water jacket by a closed tube.

This machine has no refrigerator, but if .one were needed it would be easy to add to the machine an annulary box closed at the top by a movable circular box, containing another one completely closed. The cold wine would enter the machine through one of these boxes, and the treated wine would go out through the other. In this arrangement the shape of the boxes, and their large volume, prevent any obstruction and any irregularity in heating.

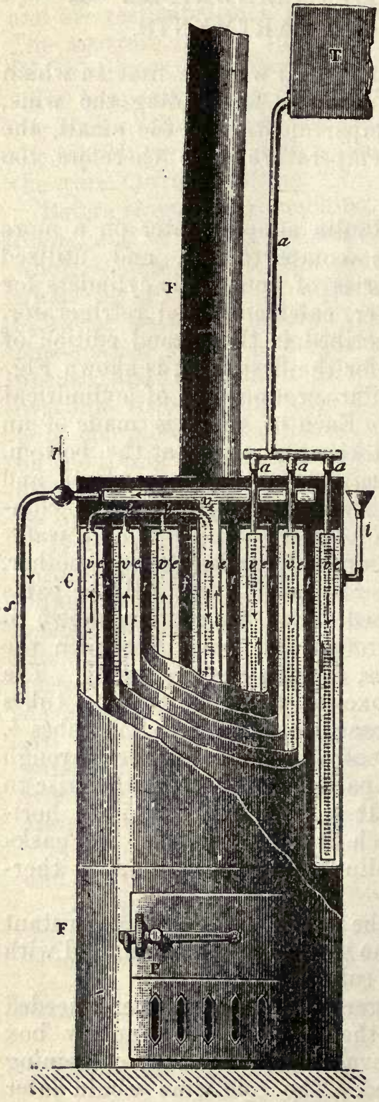

Fig. 37.—Raulin's Sterilizer.

The feeding tubes and exit tubes for the wine are connected to the boxes by a rubber hose. It is therefore easy to pull the machine to pieces quickly, and to clean it easily. The whole machine may be easily inspected, tinned again, or leakage stopped, as when the different parts have been pulled to pieces they are simply so many independent boxes.

Raulin's machine does not seem to have been generally adopted.

2. *Nabouleix's Sterilizer.*—In January 1892, Nabouleix patented a pasteurizer in which the surfaces for exchange of temperature were made of helicoidal boxes.

This machine is composed of three distinct parts—

1st. A boiler D (Fig. 38), in which the water is heated. The warm water comes out of the calefactor through the tube F of the thermo-syphon, and returns to it when cold through the tube G. The heating is done with gas or coal, but gas is preferable, because it is easier to regulate.

2nd. A refrigerator B, made of plates rolled round parallel to each other, and forming two vertical, helicoidal boxes, independent of one another, fixed in such a way that the cold wine circulates in one of them, while the hot wine circulates in the other.

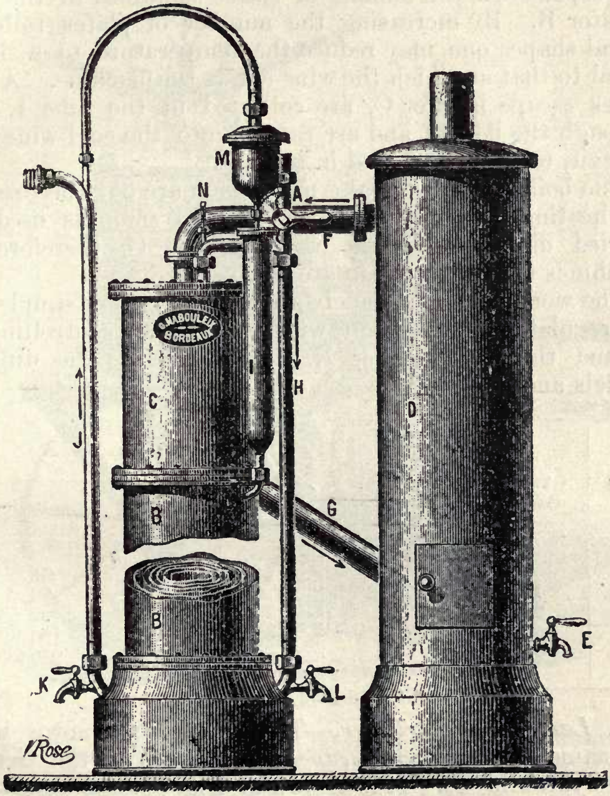

Fig. 38.—Nabouleix's Sterilizer.

The box containing the cold wine is provided with a tube H, and the box containing the warm wine is in communication with the calefactor C, an opening being made through the partition separating B and C.

3rd. A calefactor C, containing a helicoidal compartment into which the wine flows, is heated at the expense of the water of the thermo-syphon. The wine flows out from the centre, records its temperature at a thermometer N, and then reaches the refrigerator B through the vertical tube I, which has a large diameter so as to keep the wine a longer time at the temperature of pasteurization. After the wine has been brought down to the initial temperature it travels through the tube J towards the casks. The degree of cooling depends on the number of spires contained in the refrigerator B. By increasing the number of plates rolled in spiral shape, one may reduce the temperature to a degree equal to that at which the wine enters the machine. All the gases escape in B or C, are collected in the tube I, pass through the box M, and are carried into the cold wine near its exit, to be re-dissolved in it.

The boiler D and the thermo-syphon are only necessary if the heating is done with gas or coal. If steam is used it is carried directly into the water jacket C, therefore the machines used with steam are cheaper.

The working of Nabouleix's sterilizer is very simple, and the regulating is easily done with the delivery controlling tap A, and the thermometer N. Following are the different models and cost :—

Nos.	Yield at 60°C. per Hour.	Cost.	
		Steam Heating.	Gas Heating.
		£	£
0	132 to 154 gallons.	60	72
1	264 to 352 ,,	80	102
2	550 to 616 ,,	140	156
3	990 to 1,100 ,,	232	250

3. *Laurent's Sterilizer.*—This machine, known under the name of *Sterilizer-Recuperator* is built by the General Aerohydraulic Co. It is shown in Fig. 39, and consists of two principal parts, A and B, connected by two tubes, U and V, and both bolted on a truck C D.

The column B is the calefactor and water jacket. It contains a worm surrounded by warm water, through which the non-treated wine travels from bottom to top. The heating is done with gas or coal, in the latter case the draught is regulated by the damper X.

The cylinder A has a refrigerator or recuperator. It contains two vertical helicoidal compartments side by side, independent in all their parts. They are formed of two metallic sheets kept a few tenths of an inch apart by narrow braces. They are rolled in spiral shapes round a central tube, the end of each sheet being soldered in such a way as to obtain a system of two winding channels parallel and adjacent.

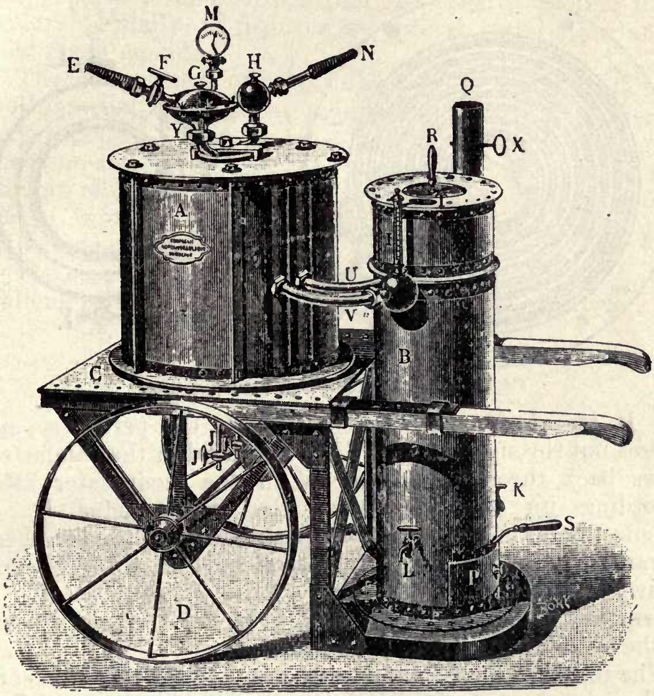

Fig. 39.—Laurent's Sterilizer-Recuperator.

The space between the plates and their stanchness are secured by rubber bands, and by the pressure of the two plates closing the cylinder at top and bottom.

In the horizontal section (Fig. 40), one of the compartments is shown in black, and it is in this that the warm wine coming out of the calefactor travels. The cold wine travels in the other compartment (shown in white) before returning to the calefactor. The two liquids, warm and cold, travel in opposite directions through a very long circuit in which the exchange of temperatures takes place regularly and gradually, and is as complete as possible.

The recuperation of the heat is an important advantage from an economical point of view, as the fuel consumption is diminished. According to the constructors, $3\frac{1}{3}$ lbs. of coal are sufficient to treat 220 gallons per hour under a pressure of 6ft. 10in. The wine enters the machine through the coupling E, passes through the filter G, and descends in

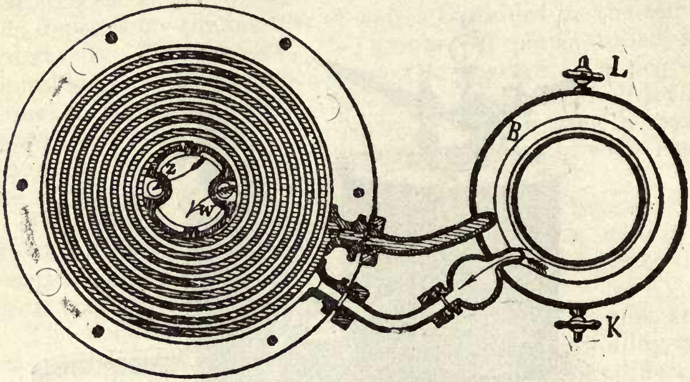

Fig. 40.—Laurent's Sterilizer (horizontal section).

Z. It travels from the centre towards the periphery, and passes out through the tube U, is sterilized in the calefactor, flows back through the tube V in the recuperator after recording its temperature at the thermometer I. It circulates now in the second compartment from the periphery towards the centre, where it is collected in tube W, and delivered in the cask through a hose coupled at N. A thermometer may be placed in H to record the temperature of the wine coming out of the machine.

The machine works under pressure, and for this reason as well as on account of the long course the wine has to follow during its cooling, the gases contained in the wine only disengage in very small quantities, and are totally restituted before the exit. A pressure gauge M, records the pressure at which the machine is working.

Before starting, the water bath is filled with water, and the wine introduced into the recuperator till it overflows in N. The fire is then lighted, and when the thermometer indicates the required temperature the feed tap is slowly opened to avoid a fall in the temperature, and the rate of flow as well as the draught in the fire grate are regulated. The first 10 gallons passing through the machine must be treated again.

At the end of the operation the sterilizer is completely emptied by opening the three tubes J J′ and K. The whole machine is cleaned with a strong current of water, and after being cleaned is kept full of water.

Laurent's machine has the advantage of occupying a very small space (3ft. 5in. × 5ft. 7in. × 3ft. 7in.), and of being easily portable and shifted from one cask to another in the cellar. Finally, it requires no special installation and is sold ready mounted.

The arrangement of bolts allow both compartments to be pulled apart as often as required to ascertain if there is any leakage. This is done by completely emptying the machine and unscrewing the coupling V; when this is done the tap of one of the compartments being left open, water is forced into the other. If there is any leakage the water will come out of the open tap.

The cost of the complete machine, which treats about 220 gallons per hour under a pressure of 6ft. 10in., is £80.

IV.

STERILIZATION OF CASKS.

It is of the utmost importance to receive the treated wine in *sterilized casks* if we desire not to lose the benefit of pasteurization. This precaution is above all necessary if the casks previously contained diseased wines, for in this case the disease germs would start multiplying in the sterilized wine and alter it again.

Casks may be sterilized by washing them with boiling water, but it is safer and handier to steam them. Any boiler can be used for this purpose, for instance we may use the boiler of the pasteurizer. This is shown in Fig. 33, page 61. The steam arrives under pressure in a vertical pipe, above which the cellarman places the bung-hole of the cask. It spreads inside all over the cask, and the condensed water falls through the bung-hole, the cask being at the same time cleaned and sterilized.

Different types of boilers have also been constructed for this purpose. One of the best is that of Bourdil, which, under a small volume, can be used as water heater or steam generator. It is composed of three superposed recipients, A, B, C (Fig. 41), through which a vertical funnel passes, for the escape of the gases of combustion. The top recipient A is used as feeder, and receives the cold water, which comes down through a perforated tube E to the bottom of the calefactor B. The warm water flows into the top part of the tube E′, which carries it to the bottom of the boiler C. The calefactor B is in communication with the outside by tube B′. A glass tube H serves to ascertain the level of the water in the boiler.

A safety valve K is fixed on top of the boiler, and a whistle M can be connected at L if the boiling water is not used, or a rubber hose may replace the whistle if boiling water is required.

In the first case the whistle indicates when the water is boiling. This boiling water is taken out through the tap R and poured directly into the cask to be sterilized. In the second case the safety valve limits the pressure in the boiler, and the hose N is used to inject the steam into the cask.

The fire and feeding tap should be regulated in such a way as to keep the level of the water in the boiler constant. After the casks have cooled and drained they are sulphured

Bourdil's boiler is portable, and is made in two sizes, they cost respectively £14 8s. and £16.

When the machine is stationary the top tank is provided with a tap connected by a rod to a floater reaching the boiler. When the level of the water diminishes in the boiler the floater is lowered and the feeding tap opened. The level of the water rises in the boiler and closes the feeding tap.

In large cellars, working constantly with a great number of pipes or hoses, it is desirable to completely sterilize casks and pipes by injecting steam through them to clean them as well as to kill all germs of diseases.

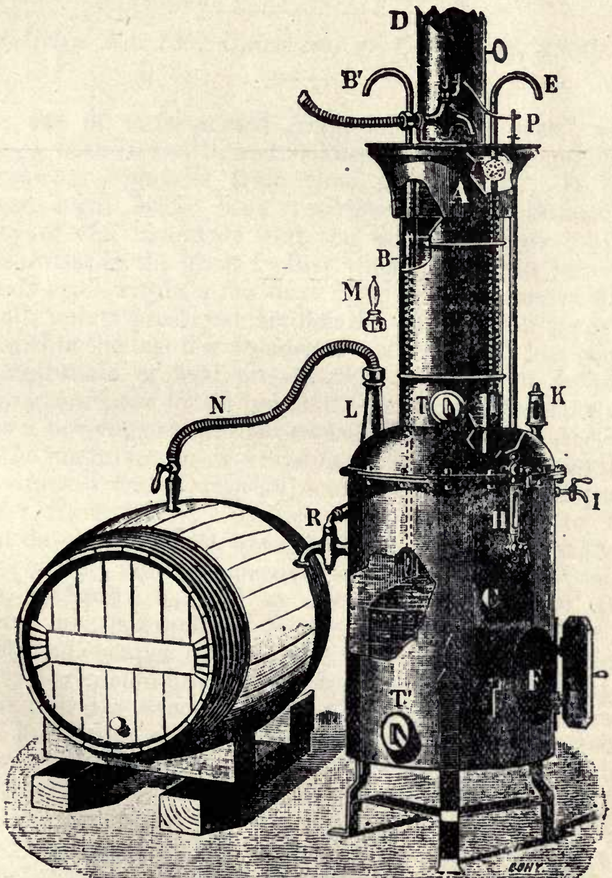

Fig. 41.—Bourdil's Boiler for Sterilizing Casks.

When once a wine has been carefully sterilized it is not subject to diseases. It can immediately be put into casks, kept bung sideways, racked or fined, and later on bottled, as if it had not been sterilized at all. Experience has proved that the few germs which might fall into the wine during these manipulations can never develop. This naturally would not apply to blends of sterilized wine and diseased wine in which the microscope has shown the presence of disease ferments. This is self evident, and we are astonished to see in a great number of cellars blends made of treated and non-treated wines, destroying the effect of sterilization.

APPENDIX.

PRESERVATION OF UNFERMENTED GRAPE-MUST.

By Frederic T. Bioletti and A. M. dal Piaz.

Bulletin No. 130, University of California, 1900.

The use of unfermented grape-juice or "must" as a beverage, both in health and sickness, has been common in vine-growing countries from time immemorial. It has, however, until lately been restricted to the immediate vicinity of the vineyards and the season of ripe grapes. This is owing to the great facility with which fruit juices of all kinds spoil within a few days after being expressed from the fruit, unless preserved artificially. The great progress made within the last few decades in methods, both legitimate and illegitimate, of food preservation, has made it possible to keep grape-juice for an indefinite period, and to make use of it as a beverage at all seasons and in all places. Accordingly the manufacture of grape-must has attained notable proportions in some European countries, and in most parts of the United States. Its use, however, has up to the present day been almost exclusively medicinal, although it is one of the most wholesome and agreeable beverages known, in health as well as disease. The cause of this restricted use is twofold. In the first place, in order to simplify and cheapen the processes of manufacture, injurious preservative agents have been made use of by the unscrupulous, and in the second place, the lack of the necessary special knowledge and technical skill has resulted in many failures of attempts to preserve the must in a legitimate manner, so that the price has been necessarily too high for the regular consumer.

It is to remedy this lack of knowledge on the part of the manufacturer, to warn the consumer against the injurious effects of antiseptics, and to call attention to the merits of this delicious beverage, that this Bulletin is written. More stress is laid on general principles than on actual methods, as the methods will vary considerably according to the scale on which the manufacture is conducted and according to the facilities and appliances at the disposal of the individual manufacturer. The business can be conducted profitably with either small or large quantities, but must necessarily be commenced on a modest scale by the inexperienced. The directions given here should enable almost any grape-grower to commence operations, and gradually, as he acquires confidence and skill, to engage more largely in what should be an important industry in California.

Composition of Grape-must.—A consideration of the following table, showing the constituents of the normal juice of ripe grapes, will make clear its value as a nourishing beverage in health, and also, its therapeutic efficacy in certain cases of disease:—

	Parts in 1,000.
Grape sugar (dextrose and levulose)	180 to 280
Free organic acids (tartaric, malic, tannic) ...	1 to 10
Salts of organic acids (cream of tartar, potassium malate, calcium tartrate, calcium malate) ...	4 to 8
Ash (containing potassium, sodium, calcium, magnesium, ferric oxide, phosphoric and sulphuric acids)	3 to 5
Nitrogenous matter (proteids, amido-compounds) ..	3 to 10

This table shows that some of the principal constituents of wine, such as alcohol, glycerine, &c., are totally lacking in pure grape-juice; and it is to be noted that it contains no unwholesome substance of whatever kind.

Grape-juice should and can be delivered to the consumer so as to contain no other substances than those shown above. If chemical analysis shows any other ingredients, a fraud has been practised, and as all the additions usually made are in the nature of antiseptics or preservatives, they are all more or less injurious. All the antiseptics used are easily detected by more or less simple chemical tests, and if an effective pure-food law were in operation it would be easy for the consumer and the honest producer to protect themselves by occasional chemical analysis of the various brands of grape-must on the market. In the larger European countries, where such laws do exist, the use of injurious adulterants is rendered dangerous, if not impossible.

An analysis of a pure grape-must made by a Government chemist in Austria, and one of must put up by Swett and Son, at Martinez, made by Mr. G. E. Colby at this station, gave the following results:—

ANALYSIS OF GRAPE-MUST.

	Austria. Per cent.	California. Per cent.
Solid contents, by spindle (Balling)	21·62	20·60
Alcohol	none	none
Total acid (as tartaric)	·78	·53
Volatile acid	·01	·03
Grape sugar	19·62	19·15
Cream of tartar	·61	·59
Free tartaric acid	·03	·07
Ash	·37	·19
Phosphoric acid	·02	·04

No cane sugar, starch sugar, or antiseptics were found in the California or the Austrian musts. Artificial (aniline) colouring matter, salicylic, benzoic and boric acids, formalin and fluorides were tested for in the California must but none were present.

This is approximately what should be shown by any pure grape-juice. It is instructive to compare this with some partial analyses made at this station of some of the beverages offered to the consumer in California under such titles as "Unfermented Wine" and "Pure Grape-juice," recommended for invalids and for communion purposes.

SAMPLE 1.

	Per cent.
Solid contents, by spindle	22·00
Total acids (as tartaric)	·59
Sulphurous acid (antiseptic)	·06

SAMPLE 2.

	Per cent.
Solid contents, by spindle	28·80
Alcohol, by volume	2·00
Salicylic acid (antiseptic)	3·90

The first sample was sold as a "curative for throat and lung troubles." The amount of sulphurous acid it contained was sufficient to *cause* throat and lung as well as digestive troubles in a healthy person. The second sample was sold as "pure unfermented grape-juice," but besides containing a large amount of the injurious antiseptic, salicylic acid (more than twenty times as much as was necessary to preserve it), it contained 2 per cent. of alcohol. *Even healthy persons, much more invalids, would contract severe indigestion from the use of such a product, which is a fraud upon the public.*

Causes of spoiling.—In order to make clear the nature of the problem which must be solved in order to preserve grape-juice indefinitely, a short account of the causes of spoiling will be useful. When grapes, or any fruits, are gathered, the surfaces in contact with the air have the spores of various fungi, yeasts, and bacteria adhering to them. All these spores are microscopic, but an idea of their appearance, when sufficiently enlarged by the microscope to become visible, may be obtained by reference to Fig. 42, which shows various forms of these organisms developed on the skin of a muscat grape.

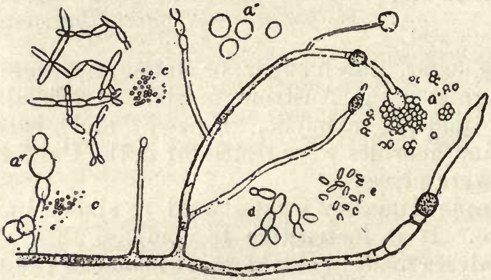

Fig. 42.—Micro-organisms on Grapes—
a, *a′*, *a″* Various forms of Mold (*mucor*).
c, *d*, *e*—Various forms of yeasts, molds, and bacteria.

When the grapes are crushed and the juice expressed, the latter may be contaminated by these spores washed off the skin. In the air they are dry, and therefore inert; but very soon after they are surrounded by the must, which is a very favorable medium for their growth, they assume an active form and commence to multiply. If the must is warm, this change to an active state occurs very soon and the consequent increase in numbers is proportionately rapid. If, on the contrary, the grapes and therefore the must be cool, the increase is much slower; but eventually, if left alone, the organisms increase until the must ferments. This fermentation consists principally in the changing of the grape-sugar into alcohol and carbonic acid, and is the essential part of the process which changes grape-juice into wine.

The main object, then, of the producer who wishes to place "pure unfermented grape-juice" upon the market, is to permanently prevent this fermentation. Besides this, the grape-juice must be quite clear, in order to present an attractive appearance to the consumer.

To attain the first object there are two general groups of methods, which may be called respectively *chemical* and *physical*. All the chemical methods consist in the addition of germ poisons or antiseptics, which either kill the microscopic organisms of fermentation or permanently prevent their growth and increase. Of these substances the principal used are, besides salicylic and sulphurous acid already mentioned, boric acid, saccharin, and of late, formalin. Many patent preservatives are found on the market, but they nearly all contain one or more of these substances as their active principle. They are all injurious to digestion and in other ways; and it may be said in general that any substance which prevents fermentation will also interfere with digestion, and is therefore to be avoided.

The *physical* methods work in one of two ways: they remove the germs by some mechanical means, such as a filter, or a centrifugal apparatus; or they destroy them by heat, cold, electricity, &c. The methods which depend upon the removal of the germs are inapplicable, as this cannot be done thoroughly except with very small quantities of liquid, and the minute organisms with which we have to deal will soon increase sufficiently to spoil the liquid, if a single one escapes the filter. One yeast-cell, for instance, at ordinary temperatures will increase to ten millions in three or four days; and if the temperature is warm the increase will be still more rapid. We are then reduced to those physical methods which destroy the germs; and of these the only one which has been found useful in this connexion is the use of high temperatures. This method depends on the fact that when a liquid is heated to a sufficiently high temperature all organisms present are killed. This temperature is called the "death point" and differs for each particular variety of organisms. The death point will also differ according to the composition of the liquid in which the organism is immersed. Yeast, for instance, is killed at a lower temperature in must than in water, on account of the acidity of the former. Time also, is a factor in determining the death point. An organism may not be killed if heated to a certain degree quickly, and as quickly cooled; while if it is kept at that same degree for some time it will be killed. Some tests made at this station with a pure* yeast isolated from California wine illustrate these facts. The

* Pure in this case means a yeast consisting of only one variety of micro-organism.

yeast was placed in must which had previously been completely freed from all germs, and was heated to various temperatures for various length of time, with results as follows :—The initial temperature of the must was 20° C. (68° F.), and the yeast was killed by heating it gradually up to 60° C. (140° F.) in fifteen minutes ; that is to say, the time taken to bring the temperature from 20° C. (68° F.) to 60° C. (140° F.) was fifteen minutes, and at the end of this time the must containing the yeast was allowed to cool in a room at 20° C. (68° F.). This same yeast was not killed when heated in twenty-five minutes from 20° C. (68° F.) to 50° C. (122° F.), nor even when kept at the latter temperature for five minutes longer. But when kept at this temperature for ten minutes longer, all the yeast cells were killed. Another test with the same yeast showed that if heated from 20° C. (68° F.) to 45° C. (113° F.) in twenty minutes, and then kept at the latter temperature for twenty minutes, few or none of the yeast cells were killed, though in thirty minutes most of them were rendered incapable of growth. However, even in the last case some were left alive, and ultimately spoiled the must. We learn from these tests that heating to 45° C. (113° F.), even for a somewhat prolonged time, cannot be depended on to sterilize grape-must, and that even 50° C. (122° F.) requires too much time to be practical. A heating to 60° C. (140° F.), however, would probably be quite safe, provided that only this particular variety of yeast were present in the must. In practice, however, we have an unknown number of kinds of micro-organisms present, and some of these may be able to withstand a somewhat higher temperature than this.

It must be kept in mind also that fungi, including yeasts, exist in two states, the vegetative or growing state, and the spore or resting state. The latter is more resistant than the former ; and it has been found that yeast spores, for instance, to be killed must be heated about 5° C. (9° F.) higher than the same yeast in the growing state. The above tests were made with yeasts containing no spores ; but, as in practice spores may be and undoubtedly are present, a temperature 5° C. (9° F.) higher than indicated would be necessary. Practical experiments made at this station indicate that must can be safely sterilized at a temperature of 75° C. (167° F.) or 80° C. (176° F.) if all the precautions indicated below are observed. At this temperature the flavour of the grape-juice is hardly changed, though at between 90° C. (194° F.) and 100° C. (212° F.) it is slightly affected.

Another property of fungi and their spores, which is of importance in this connexion, is their great resistance to heat when dry. Yeast can be heated in a dry state to a temperature above that of boiling water without being killed; the spores of some fungi (*e.g.*, common mold) are even more resistant. The bearing of this upon the preservation of must is that during the final sterilization, which takes place in glass bottles or similar vessels, portions of the inner surface of the cork and of the bottle above the liquid are comparatively dry; and if any spores should be adhering to these parts there is danger that they will not be killed, and that afterwards when they come in contact with the must, they will grow and cause fermentation or mold. For this reason both the bottles and the cork must be thoroughly sterilized *before* being used. This can be accomplished for the bottles by boiling them for at least half-an-hour after thorough washing, and then allowing them to drain in a place where they are exposed to no draughts or dust. This boiling should be done as short a time as possible before filling the bottles, and they should be handled carefully, taking care not to touch their mouths, for with the greatest care the hands cannot be kept free from mold spores. To sterilize the corks this method is not always sufficient, as spores that may be in cracks are liable to escape. For sterilizing the corks, some closed receptacle should be used which will safely withstand considerable pressure. The corks when placed in this receptacle can best be sterilized by steam under pressure, which is allowed to flow in until the pressure, as shown by a gauge, is at least 10 lbs. This pressure indicates a temperature of about 115° C. (239° F.), and should continue for at least twenty minutes.

Apparatus required.—The apparatus necessary for preserving grape-must on any but the very smallest scale consists of: 1, a continuous pasteurizer; 2, a pressure filter; 3, a pressure sterilizer for corks (this may be dispensed with); 4, a bottle pasteurizer; 5, a boiler for pressure steam. Certain other utensils are, of course, necessary, but they are such as are found in every wine cellar.

The manner of operating.—The method of proceeding is as follows :—Sound, clean grapes, preferably those having high natural acidity, are picked carefully, while cool, into clean boxes. They should not be too ripe or the must will be too sweet and difficult to clear. They should be crushed as soon as possible after picking, and the juice run into perfectly clean puncheons or other receptacles which have been previously steamed. If the must is cold—15° C. (59° F.) or under—it may be safely left to settle for 24 hours or more. This settling is an advantage as it rids the juice of most of the floating solid matter, and facilitates the subsequent filtering. During the settling the must should be closely watched, in order to anticipate even a commencement of fermentation. After this settling, when the must has become almost clear, it is run through a continuous pasteurizer, of one form of which Fig. 43 gives an idea.

It is heated in this to 80° C. (175° F.) and should come out cool, not warmer than 25° C. (77° F.) and should pass into fresh settling receptacles. For this purpose puncheons or other casks may be used, if they have been thoroughly sterilized by steam, though the best receptacles would doubtless be casks or vats of metal lined with enamel, such as are now made. The greatest care must be taken to avoid

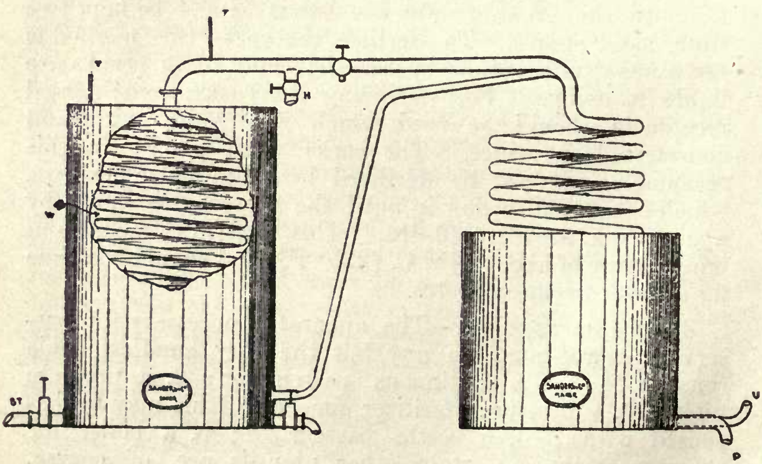

Fig. 43.—Continuous Pasteurizer.

ST. Steam pipe. *H*. Outlet for hot pasteurized must. *U*. Inlet for unpasteurized must.
W. Water bath. *P*. Outlet for cooled pasteurized must. *T*, *T'*. Thermometers.

contamination of the must as it flows from the pasteurizer. It should pass directly, by means of a block-tin pipe, from the pasteurizer into the receiving casks. The end of this pipe should be thoroughly sterilized by plunging into boiling water, and should never be allowed to touch the hands or any exposed surface. When a receiving cask is full it should be closed immediately with a wooden bung, sterilized preferably in the way already described for corks. If all these operations have been conducted with the requisite care, and the casks kept in a cool cellar, the must must remain without fermenting for many days or even weeks. During this time it deposits more or less sediment which has been formed in heating. It is then ready for filtering.

Filtration.—This filtration is best accomplished by means of a filter so constructed that the must passes upward through the filtering medium, under pressure. Such a filter, made by the International Filter Co., of Chicago, is shown in Fig. 44.

This filter consists essentially of two shallow bowls clamped together mouth to mouth with the filtering medium between them. The unfiltered must enters the lower bowl through the pipe on the right of the figure, passes through the filtering medium into the upper bowl and makes its exit, when clear, through a faucet a little to the left of the middle of the figure. The small faucet at the bottom of the lower bowl is for the purpose of cleaning the filter. Occasionally, when filtration becomes slow, this faucet is opened for a few moments. This allows the sediment accumulated at the bottom to escape and at the same time the entering must takes a rotary course in the lower bowl, thus cleaning off the surface of the filtering medium; so that when the cleaning faucet is closed filtration proceeds as before. On a large scale, a filter press, such as is used in large wineries and in beet-sugar factories, might conveniently be used.

It is impossible to prevent a certain amount of contamination by fungous spores during filtration; but it should be minimized as much as possible by the greatest cleanliness, and attention to sterilizing everything with which the must comes in contact. In this regard it should be kept constantly in mind that in the ordinary room or cellar, where there is little dust, there is comparatively little danger of contamination from the air, the main danger being from the solid surfaces with which the must comes in contact. The must may be bottled directly as it flows from the filter, or it may pass into a sterilized temporary receptacle from which it is bottled. It should, however, be placed in its final receptacle (bottles, &c.) the same day on which it is filtered, corked immediately, and sterilized as soon as possible, preferably within 24 hours.

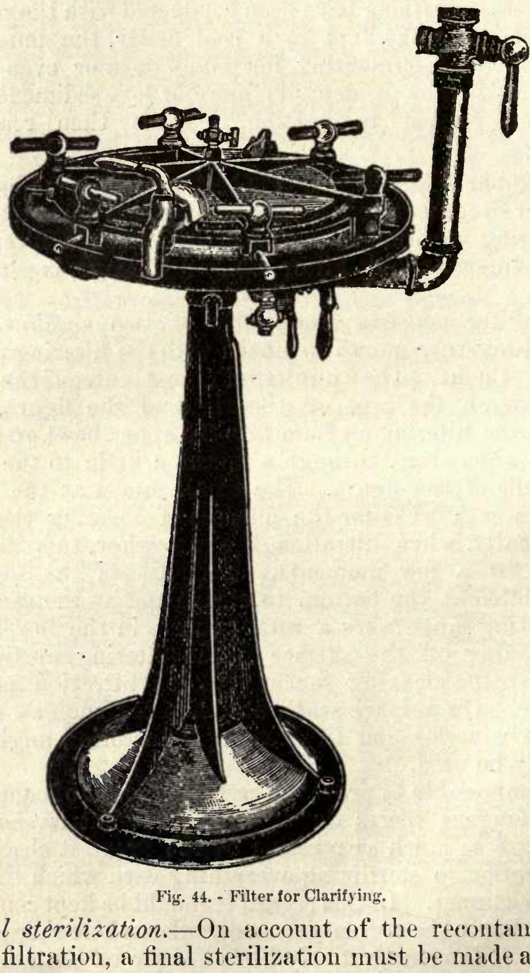

Fig. 44. - Filter for Clarifying.

Final sterilization.—On account of the recontamination during filtration, a final sterilization must be made after the bottles are corked. This is accomplished by means of a bottle sterilizer which the producer can construct himself. A simple and efficient form is shown in Fig. 45.

It consists of a wooden box or trough provided with a wooden grating placed about 2 inches from the bottom. The bottles, after being filled with the filtered must and corked, are placed in perforated or wire baskets which rest upon the grating. The trough should contain enough water to completely submerge the bottles. The water should be kept at a constant temperature of about 85° C. (185° F.) by means of a steam coil placed beneath the grating. The bottles should be left in this pasteurizer for exactly fifteen minutes if they are one-quart champagne-bottles. For other sizes it is necessary to make a test with a bottle of must in which a thermometer has been placed in order to determine how long it takes for the entire contents of the bottle to reach the required temperature. It has been found at this station, that although the must in the upper part of a quart champagne-bottle reaches 75° C. (167° F.) in eight minutes, when surrounded by water at 85° C. (185° F.) it requires fifteen minutes before the must at the bottom of the bottle acquires that temperature. The sterilization in bottle should be conducted at a temperature at least 5° C. (9° F.) lower than that reached in the continuous pasteurizer. Thus, if the water in the first case was kept at 90° C. (194° F.) or 95° C. (203° F.) and the must attained a temperature of 80° C., the water in the bottle pasteurizer should be kept constantly at 85° C., and the time of pasteurizing so chosen that the must in the bottles will attain a maximum temperature of 75° C. (167° F.). *If the final heating is higher than the first, it may cause a precipitation of solid matters which will make the must cloudy in the bottles.*

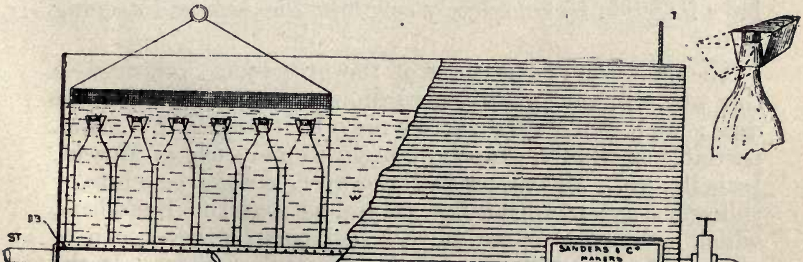

Fig. 45.—Cork Clamp and Pasteurizer for must in bottle.
DB. Double bottom. *ST.* Steam pipe *W.* Water bath. *T.* Thermometer.
(Bottle shows method of adjusting a cork holder of sheet metal.)

During this sterilization in bottle the corks are liable to be expelled by the pressure developed. To prevent this they may be tied down with strong twine ; but it is a great saving of time and labour to use some such contrivance as that illustrated in Fig. 45.

By this operation the must is thoroughly sterilized and will then keep unchanged for years, or until the bottles are opened. If, however, the bottles are to be capsuled, or kept in a very damp place, there is one other cause of spoiling that must be guarded against. However carefully all the various operations are conducted there are sure to be mold spores on the upper surface of the cork. If this surface remains dry these spores will not grow, and are harmless. But when the cork is covered with a capsule the space between the capsule and the surface of the cork finally becomes moist, and any spores there will develop. Some molds have great penetrating power, and may force their way either through the cork or between the cork and the neck of the bottle (especially if the very best quality of corks has not been used) and finally reach the must. The molds which enter in this way do not, as a rule, grow into the liquid, on account of the small amount of air present; but they make a moldy layer on top, which lessens the selling value of the must, if it does not actually spoil it. This danger can be avoided by dipping the top of the neck of the bottle into a 2 per cent. solution of bluestone and water, in such a way as to wet the upper surface of the cork, before putting on the capsule. The same object may be attained by dipping the neck, in the same way, into very hot, melted paraffine. The bluestone acts by killing any spores that may be on the cork, or which may find their way there later. The heated paraffine kills the spores present, and prevents later infection by completely covering the cork and keeping it dry.

The quality and character of the grape-juice prepared in this way will vary greatly according to the variety of grape used; and a pleasing variety may be obtained by using, partially or wholly, grapes of high aroma, such as Muscat, Isabella, &c. The colour will, however, always be white or yellowish, except with a few grapes, such as the Bouschets, which have pink or red juice. Red must, however, can be obtained by a modification of the process described. If the must, after it passes through the continuous pasteurizer, is allowed to come out hot and flow into a vat containing the skins of red grapes, almost any desired depth of colour may be obtained, depending on the variety of grape used and the time during which the hot must is left in contact with the skins. Must prepared in this way, however, differs in other respects than in colour from the white must. Besides colouring matter various substances are extracted from the skins, the principal being tannin. This makes the composition of the red must more like that of red wine, though, of course, it still contains no alcohol. A grape-juice of this character might appropriately be called "Unfermented Wine," and would, doubtless, be useful in medicine, as it would possess certain tonic properties not found in the white must. The regular consumer, however, would in all probability generally prefer the white must.

Grape-must, containing as it does generally from 20 to 24 per cent. of sugar, is too sweet for many palates and constitutions, but it may be diluted with water by the consumer to any desired extent; and a mixture of equal parts of grape-must and carbonated or mineral water makes a beverage much appreciated by many people. In Europe a certain amount of sparkling grape-juice is put up, *i.e.*, grape-juice which has been carbonated, or charged with carbonic acid gas. This, though an addition to the natural juice of the grape, cannot be looked upon in any sense as a fraud or adulteration, and makes the beverage more palatable to many; besides, if properly done, it has no injurious effects on the health of the consumer.

In conclusion the following brief summary of the main precautions to be observed in the manufacture of unfermented grape-must may be useful:—

1. Only clean and perfectly sound grapes should be used.
2. The grapes should be picked and handled when cool.
3. The greatest cleanliness is necessary in every stage of the process.
4. All utensils and apparatus used should be cleaned and sterilized immediately before using, and as short a time as possible after using.
5. The last sterilization should be at a temperature at least 5°C. (9°F.) lower than the temperature used in the first sterilization.
6. Reliable thermometers should be used, and the temperature watched very carefully.

CONVERSION OF THERMOMETER SCALES.

CENTIGRADE = FAHRENHEIT.

Centigrade	Fahrenheit.	Centigrade	Fahrenheit.	Centigrade	Fahrenheit.
100	**212**	**65**	**149**	**30**	**86**
99	210·2	64	147·2	29	84·2
98	208·4	63	145·4	28	82·4
97	206·6	62	143·6	27	80·6
96	204·8	61	141·8	26	78·8
95	**203**	**60**	**140**	**25**	**77**
94	201·2	59	138·2	24	75·2
93	199·4	58	136·4	23	73·4
92	197·6	57	134·6	22	71·6
91	195·8	56	132·8	21	69·8
90	**194**	**55**	**131**	**20**	**68**
89	192·2	54	129·2	19	66·2
88	190·4	53	127·4	18	64·4
87	188·6	52	125·6	17	62·6
86	186·8	51	123·8	16	60·8
85	**185**	**50**	**122**	**15**	**59**
84	183·2	49	120·2	14	57·2
83	181·4	48	118·4	13	55·4
82	179·6	47	116·6	12	53·6
81	177·8	46	114·8	11	51·8
80	**176**	**45**	**113**	**10**	**50**
79	174·2	44	111·2	9	48·2
78	172·4	43	109·4	8	46·4
77	170·6	42	107·6	7	44·6
76	168·8	41	105·8	6	42·8
75	**167**	**40**	**104**	**5**	**41**
74	165·2	39	102·2	4	39·2
73	163·4	38	100·4	3	37·4
72	161·6	37	98·6	2	35·6
71	159·8	36	96·8	1	33·8
70	**158**	**35**	**95**	**0**	**32**
69	156·2	34	93·2		
68	154·4	33	91·4		
67	152·6	32	89·6		
66	150·8	31	87·8		

CONVERSION OF THERMOMETER SCALES—*continued*.

FAHRENHEIT = CENTIGRADE.

Fahrenheit	Centigrade.	Fahrenheit	Centigrade.	Fahrenheit	Centigrade.
212	**100**	**167**	**75**	**122**	**50**
211	99·4	166	74·4	121	49·4
210	98·9	165	73·9	120	48·9
209	98·3	164	73·3	119	48·3
208	97·8	163	72·8	118	47·8
207	97·2	162	72·2	117	47·2
206	96·7	161	71·7	116	46·7
205	96·1	160	71·1	115	46·1
204	95·6	159	70·6	114	45·6
203	**95**	**158**	**70**	**113**	**45**
202	94·4	157	69·4	112	44·4
201	93·9	156	68·9	111	43·9
200	93·3	155	68·3	110	43·3
199	92·8	154	67·8	109	42·8
198	92·2	153	67·2	108	42·2
197	91·7	152	66·7	107	41·7
196	91·1	151	66·1	106	41·1
195	90·6	150	65·6	105	40·6
194	**90**	**149**	**65**	**104**	**40**
193	89·4	148	64·4	103	39·4
192	88·9	147	63·9	102	38·9
191	88·3	146	63·3	101	38·3
190	87·8	145	62·8	100	37·8
189	87·2	144	62·2	99	37·2
188	86·7	143	61·7	98	36·7
187	86·1	142	61·1	97	36·1
186	85·6	141	60·6	96	35·6
185	**85**	**140**	**60**	**95**	**35**
184	84·4	139	59·4	94	34·4
183	83·9	138	58·9	93	33·9
182	83·3	137	58·3	92	33·3
181	82·8	136	57·8	91	32·8
180	82·2	135	57·2	90	32·2
179	81·7	134	56·7	89	31·7
178	81·1	133	56·1	88	31·1
177	80·6	132	55·6	87	30·6
176	**80**	**131**	**55**	**86**	**30**
175	79·4	130	54·4	85	29·4
174	78·9	129	53·9	84	28·9
173	78·3	128	53·3	83	28·3
172	77·8	127	52·8	82	27·8
171	77·2	126	52·2	81	27·2
170	76·7	125	51·7	80	26·7
169	76·1	124	51·1	79	26·1
168	75·6	123	50·6	78	25·6

CONVERSION OF THERMOMETER SCALES—*continued.*

FAHRENHEIT = CENTIGRADE.

Fahrenheit	Centigrade.	Fahrenheit	Centigrade.	Fahrenheit	Centigrade.
77	**25**	**59**	**15**	**41**	**5**
76	24·4	58	14·4	40	4·4
75	23·9	57	13·9	39	3·9
74	23·3	56	13·3	38	3·3
73	22·8	55	12·8	37	2·8
72	22·2	54	12·2	36	2·2
71	21·7	53	11·7	35	1·7
70	21·1	52	11·1	34	1·1
69	20·6	51	10·6	33	0·6
68	**20**	**50**	**10**	**32**	**0**
67	19·4	49	9·4		
66	18·9	48	8·9		
65	18·3	47	8·3		
64	17·8	46	7·8		
63	17·2	45	7·2		
62	16·7	44	6·7		
61	16·1	43	6·1		
60	15·6	42	5·6		

ALCOHOL TABLES.

By Otto Hehner, F.C.S.*

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
1·0000	0·00	0·00	0·00
·9999	0·05	0·07	0·12
8	0·11	0·13	0·23
7	0·16	0·20	0·35
6	0·21	0·26	0·46
5	0·26	0·33	0·58
4	0·32	0·40	0·70
3	0·37	0·46	0·81
2	0·42	0·53	0·93
1	0·47	0·60	1·04
0	0·53	0·66	1·16
·9989	0·58	0·73	1·28
8	0·63	0·79	1·39
7	0·68	0·86	1·51
6	0·74	0·93	1·62
5	0·79	0·99	1·74
4	0·84	1·06	1·86
3	0·89	1·13	1·97
2	0·95	1·19	2·09
1	1·00	1·26	2·20
0	1·06	1·34	2·34
·9979	1·12	1·42	2·48
8	1·19	1·49	2·61
7	1·25	1·57	2·75
6	1·31	1·65	2·89
5	1·37	1·73	3·03
4	1·44	1·81	3·16
3	1·50	1·88	3·30
2	1·56	1·96	3·44
1	1·62	2·04	3·58
0	1·69	2·12	3·71
·9969	1·75	2·20	3·85
8	1·81	2·27	3·99
7	1·87	2·35	4·12
6	1·94	2·43	4·26
5	2·00	2·51	4·40
4	2·06	2·58	4·52
3	2·11	2·62	4·64
2	2·17	2·72	4·76
1	2·22	2·79	4·89
0	2·28	2·86	5·01

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9959	2·33	2·93	5·13
8	2·39	3·00	5·25
7	2·44	3·07	5·37
6	2·50	3·14	5·49
5	2·56	3·21	5·61
4	2·61	3·28	5·74
3	2·67	3·35	5·86
2	2·72	3·42	5·98
1	2·78	3·49	6·10
0	2·83	3·55	6·22
·9949	2·89	3·62	6·34
8	2·94	3·69	6·47
7	3·00	3·76	6·58
6	3·06	3·83	6·72
5	3·12	3·90	6·84
4	3·18	3·98	6·97
3	3·24	4·05	7·10
2	3·29	4·12	7·23
1	3·35	4·20	7·36
0	3·41	4·27	7·49
·9939	3·47	4·34	7·61
8	3·53	4·42	7·74
7	3·59	4·49	7·87
6	3·65	4·56	8·00
5	3·71	4·63	8·13
4	3·76	4·71	8·26
3	3·82	4·78	8·38
2	3·88	4·85	8·51
1	3·94	4·93	8·64
0	4·00	5·00	8·77
·9929	4·06	5·08	8·90
8	4·12	5·16	9·04
7	4·19	5·24	9·18
6	4·25	5·32	9·31
5	4·31	5·39	9·45
4	4·37	5·47	9·58
3	4·44	5·55	9·72
2	4·50	5·63	9·86
1	4·56	5·71	9·99
0	4·62	5·78	10·13

* Analyst, 1880.

Alcohol Tables—*continued.*

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.	Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9919	4·69	5·86	10·26	·9869	8·00	9·95	17·43
8	4·75	5·94	10·40	8	8·07	10·03	17·58
7	4·81	6·02	10·54	7	8·14	10·12	17·74
6	4·87	6·10	10·67	6	8·21	10·21	17·89
5	4·94	6·17	10·81	5	8·29	10·30	18·04
4	5·00	6·24	10·94	4	8·36	10·38	18·20
3	5·06	6·32	11·08	3	8·43	10·47	18·35
2	5·12	6·40	11·21	2	8·50	10·56	18·50
1	5·19	6·48	11·35	1	8·57	10·65	18·65
0	5·25	6·55	11·49	0	8·64	10·73	18·81
·9909	5·31	6·63	11·62	·9859	8·71	10·82	18·96
8	5·37	6·71	11·76	8	8·79	10·91	19·11
7	5·44	6·78	11·89	7	8·86	11·00	19·27
6	5·50	6·86	12·03	6	8·93	11·08	19·42
5	5·56	6·94	12·16	5	9·00	11·17	19·58
4	5·62	7·01	12·30	4	9·07	11·26	19·73
3	5·69	7·09	12·43	3	9·14	11·35	19·89
2	5·75	7·17	12·57	2	9·21	11·44	20·04
1	5·81	7·25	12·70	1	9·29	11·52	20·19
0	5·87	7·32	12·84	0	9·36	11·61	20·35
·9899	5·94	7·40	12·97	·9849	9·43	11·70	20·50
8	6·00	7·48	13·11	8	9·50	11·79	20·65
7	6·07	7·57	13·27	7	9·57	11·87	20·81
6	6·14	7·66	13·42	6	9·64	11·96	20·96
5	6·21	7·74	13·57	5	9·71	12·05	21·11
4	6·28	7·83	13·73	4	9·79	12·14	21·27
3	6·36	7·92	13·88	3	9·86	12·22	21·42
2	6·43	8·01	14·04	2	9·93	12·31	21·57
1	6·50	8·10	14·19	1	10·00	12·40	21·73
0	6·57	8·18	14·35	0	10·08	12·49	21·89
·9889	6·64	8·27	14·50	·9839	10·15	12·58	22·06
8	6·71	8·36	14·66	8	10·23	12·68	22·22
7	6·78	8·45	14·81	7	10·31	12·77	22·38
6	6·86	8·54	14·96	6	10·38	12·87	22·55
5	6·93	8·63	15·12	5	10·46	12·96	22·71
4	7·00	8·72	15·27	4	10·54	13·05	22·88
3	7·07	8·80	15·42	3	10·62	13·15	23·04
2	7·13	8·88	15·56	2	10·69	13·24	23·21
1	7·20	8·96	15·70	1	10·77	13·34	23·37
0	7·27	9·04	15·85	0	10·85	13·43	23·54
·9879	7·33	9·13	15·99	·9829	10·92	13·52	23·70
8	7·40	9·21	16·14	8	11·00	13·62	23·86
7	7·47	9·29	16·28	7	11·08	13·71	24·03
6	7·53	9·37	16·42	6	11·15	13·81	24·19
5	7·60	9·45	16·57	5	11·23	13·90	24·36
4	7·67	9·54	16·71	4	11·31	13·99	24·52
3	7·73	9·62	16·86	3	11·38	14·09	24·69
2	7·80	9·70	17·00	2	11·46	14·18	24·85
1	7·87	9·78	17·14	1	11·54	14·27	25·01
0	7·93	9·86	17·29	0	11·62	14·37	25·18

Alcohol Tables—*continued.*

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9819	11·69	14·46	25·34
8	11·77	14·56	25·51
7	11·85	14·65	25·67
6	11·92	14·74	25·83
5	12·00	14·84	26·00
4	12·08	14·93	26·17
3	12·15	15 02	26·33
2	12·23	15·12	26·49
1	12·31	15·21	26 66
0	12·38	15·30	26·82
9809	12·46	15·40	26 99
8	12·54	15·49	27·15
7	12·62	15·58	27·31
6	12·69	15·68	27·48
5	12·77	15·77	27·64
4	12·85	15·86	27·81
3	12·92	15·96	27·97
2	13·00	16·05	28·13
1	13·08	16·15	28·29
0	13·15	16 24	28 46
·9799	13·23	16·33	28·62
8	13·31	16·43	28·78
7	13·38	16·52	28·95
6	13·46	16·61	29·11
5	13·54	16·70	29·27
4	13·62	16·80	29·43
3	13·69	16·89	29·60
2	13·77	16·98	29·76
1	13·85	17·08	29·92
0	13·92	17·17	30·09
·9789	14·00	17·26	30·26
8	14·09	17·37	30·45
7	14·18	17·48	30·64
6	14·27	17·59	30·83
5	14·36	17·70	31·03
4	14·45	17·81	31·22
3	14·55	17·92	31·41
2	14·64	18·03	31·61
1	14·73	18·14	31·80
0	14·82	18·25	31·99
·9779	14·91	18·36	32·19
8	15·00	18·48	32·38
7	15·08	18·58	32·56
6	15·17	18·68	32·73
5	15·25	18·78	32·91
4	15·33	18·88	33·08
3	15·42	18·98	33·26
2	15·50	19·08	33·44
1	15·58	19·18	33·61
0	15·67	19·28	33·79

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9769	15·75	19·39	33·96
8	15·83	19·49	34·14
7	15·92	19·59	34·32
6	16·00	19·68	34·50
5	16·08	19·78	34·66
4	16·15	19·87	34·82
3	16·23	19·96	34·98
2	16·31	20·06	35·14
1	16·38	20·15	35·31
0	16·46	20·24	35·47
·9759	16·54	20·33	35·63
8	16·62	20·43	35·79
7	16·69	20·52	35·95
6	16·77	20·61	36·12
5	16·85	20·71	36·28
4	16·92	20·80	36·44
3	17·00	20·89	36·60
2	17·08	20·99	36·78
1	17·17	21·09	36·95
0	17·25	21·19	37·13
·9749	17·33	21·29	37·30
8	17·42	21·39	37·48
7	17·50	21·49	37·65
6	17·58	21·59	37·83
5	17·67	21·69	38·00
4	17·75	21·79	38·18
3	17·83	21·89	38·35
2	17·92	21·99	38·53
1	18·00	22·09	38·71
0	18·08	22·18	38·87
·9739	18·15	22·27	39·03
8	18·23	22·36	39·13
7	18·31	22·46	39·35
6	18·38	22·55	39·51
5	18·46	22·64	39·68
4	18·54	22·73	39·84
3	18·62	22·82	40·00
2	18·69	22·92	40·16
1	18·77	23·01	40·32
0	18·85	23·10	40·48
·9729	18·92	23·19	40·64
8	19·00	23·28	40·80
7	19·08	23·38	40 98
6	19·17	23·48	41·15
5	19·25	23·58	41·33
4	19·33	23·68	41·50
3	19·42	23·78	41·68
2	19·50	23·88	41·85
1	19·58	23·98	42·03
0	19·67	24·08	42·20

ALCOHOL TABLES—*continued.*

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.	Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9719	19·75	24·18	42·38	**·9669**	23·69	28·86	50·57
8	19·83	24·28	42·55	**8**	23·77	28·95	50·73
7	19·92	24·38	42·73	**7**	23·85	29·04	50·89
6	20·00	24·48	42·90	**6**	23·92	29·13	51·05
5	20·08	24·58	43·07	**5**	24·00	29·22	51·21
4	20·17	24·68	43·25	**4**	24·08	29·31	51·37
3	20 25	24·78	43·42	**3**	24·15	29·40	51·53
2	20·33	24 88	43·60	**2**	24·23	29·49	51·69
1	20·42	24·98	43·77	**1**	24·31	29·58	51·84
0	20·50	25·07	43·94	**0**	24·38	29·67	52·00
·9709	20·58	25·17	44·12	**·9659**	24·46	29·76	52·16
8	20·67	25·27	44·29	**8**	24·54	29·86	52·32
7	20·75	25·37	44·47	**7**	24·62	29·95	52·48
6	20·83	25·47	44·64	**6**	24·69	30·04	52·64
5	20·92	25·57	44·81	**5**	24·77	30·13	52·80
4	21·00	25·67	44·99	**4**	24·85	30·22	52·95
3	21·08	25·76	45·15	**3**	24·92	30·31	53·11
2	21·15	25·86	45·31	**2**	25·00	30·40	53·27
1	21·23	25·95	45·47	**1**	25·07	30·48	53·42
0	21·31	26·04	45·63	**0**	25·14	30·57	53·56
·9699	21·38	26·13	45·79	**·9649**	25·21	30·65	53·71
8	21·46	26·22	45·95	**8**	25·29	30·73	53·86
7	21·54	26·31	46·11	**7**	25·36	30·82	54·00
6	21·62	26·40	46·27	**6**	25·43	30·90	54·15
5	21·69	26·49	46 43	**5**	23·50	30·98	54·30
4	21·77	26·58	46·59	**4**	25 57	31·07	54·44
3	21·85	26·67	46·75	**3**	25·64	31·15	54 59
2	21·92	26·77	46·91	**2**	25·71	31·23	54·74
1	22·00	26·86	47·07	**1**	25·79	31·32	54·88
0	22·08	26 95	47·23	**0**	25·86	31·40	55·03
·9689	22·15	27·04	47·39	**·9639**	25·93	31·48	55·18
8	22·23	27·13	47·55	**8**	26·00	31·57	55·32
7	22·31	27·22	47·70	**7**	26·07	31·65	55·46
6	22·38	27·31	47·86	**6**	26·13	31·72	55·59
5	22·46	27·40	48·02	**5**	26·20	31·80	55·73
4	22·54	27·49	48·18	**4**	26·27	31·88	55·87
3	22·62	27·59	48·34	**3**	26·33	31·96	56·00
2	22·69	27·68	48·50	**2**	26·40	32·03	56·14
1	22·77	27·77	48·66	**1**	26·47	32·11	56·27
0	22·85	27·86	48·82	**0**	26·53	32·19	56·41
·9679	22·92	27·95	48·98	**·9629**	26·60	32·27	56·55
8	23·00	28·04	49·14	**8**	26·67	32·34	56·68
7	23·08	28·13	49·30	**7**	26·73	32·42	56·82
6	23·15	28·22	49·46	**6**	26·80	32·50	56·95
5	23·23	28·31	49·62	**5**	26·87	32·58	57·09
4	23·31	28·41	49·78	**4**	26·93	32·65	57·23
3	23·38	28·50	49·94	**3**	27·00	32·73	57·36
2	23·46	28·59	50·10	**2**	27·07	32·81	57·51
1	23·54	28·68	50·25	**1**	27·14	32·90	57·65
0	23·62	28·77	50·41	**0**	27·21	32·98	57·80

Alcohol Tables—*continued.*

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9619	27·29	33·06	57·94
8	27·36	33·15	58·09
7	27·43	33·23	58·24
6	27·50	33·31	58·38
5	27·57	33·39	58·53
4	27·64	33·48	58·67
3	27·71	33·56	58·82
2	27·79	33·64	58·97
1	27·86	33·73	59·11
0	27·93	33·81	59·26
·9609	28·00	33·89	59·40
8	28·06	33·97	59·53
7	28·12	34·04	59·65
6	28·19	34·11	59·78
5	28·25	34·18	59·90
4	28·31	34·25	60·03
3	28·37	34·33	60·16
2	28·44	34·40	60·28
1	28·50	34·47	60·41
0	28·56	34·54	60·53
·9599	28·62	34·61	60·66
8	28·69	34·69	60·79
7	28·75	34·76	60·91
6	28·81	34·83	61·04
5	28·87	34·90	61·16
4	28·94	34·97	61·29
3	29·00	35·05	61·42
2	29·07	35·12	61·55
1	29·13	35·20	61·69
0	29·20	35·28	61·82
·9589	29·27	35·35	61·95
8	29·33	35·43	62·09
7	29·40	35·51	62·22
6	29·47	35·58	62·36
5	29·53	35·66	62·49
4	29·60	35·74	62·63
3	29·67	35·81	62·76
2	29·73	35·89	62·90
1	29·80	35·97	63·03
0	29·87	36·04	63·17
·9579	29·93	36·12	63·30
8	30·00	36·20	63·43
7	30·06	36·26	63·55
6	30·11	36·32	63·66
5	30·17	36·39	63·77
4	30·22	36·45	63·88
3	30·28	36·51	63·99
2	30·33	36·57	64·10
1	30·39	36·64	64·21
0	30·44	36·70	64·32

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9569	30·50	36·76	64·43
8	30·56	36·83	64·54
7	30·61	36·89	64·65
6	30·67	36·95	64·76
5	30·72	37·02	64·87
4	30·78	37·08	64·98
3	30·83	37·14	65·10
2	30·89	37·20	65·21
1	30·94	37·27	65·32
0	31·00	37·34	65·43
·9559	31·06	37·41	65·55
8	31·12	37·48	65·68
7	31·19	37·55	65·80
6	31·25	37·62	65·93
5	31·31	37·69	66·05
4	31·37	37·76	66·18
3	31·44	37·83	66·30
2	31·50	37·90	66·43
1	31·56	37·97	66·55
0	31·62	38·04	66·68
·9549	31·69	38·11	66·80
8	31·75	38·18	66·93
7	31·81	38·25	67·05
6	31·87	38·33	67·17
5	31·94	38·40	67·30
4	32·00	38·47	67·42
3	32·06	38·53	67·55
2	32·12	38·60	67·67
1	32·19	38·68	67·80
0	32·25	38·75	67·92
·9539	32·31	38·82	68·04
8	32·37	38·89	68·17
7	32·44	38·96	68·29
6	32·50	39·04	68·42
5	32·56	39·11	68·54
4	32·62	39·18	68·67
3	32·69	39·25	68·79
2	32·75	39·32	68·92
1	32·81	39·40	69·04
0	32·87	39·47	69·16
·9529	32·94	39·54	69·29
8	33·00	39·61	69·41
7	33·06	39·68	69·53
6	33·12	39·74	69·65
5	33·18	39·81	69·76
4	33·24	39·87	69·88
3	33·29	39·94	69·99
2	33·35	40·01	70·11
1	33·41	40·07	70·23
0	33·47	40·14	70·34

Alcohol Tables—*continued.*

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9519	33·53	40·20	70·46
8	33·59	40·27	70·57
7	33·65	40·34	70·69
6	33·71	40·40	70·81
5	33·76	40·47	70·92
4	33·82	40·53	71·04
3	33·88	40·60	71·15
2	33·94	40·67	71·27
1	34·00	40·74	71·39
0	34·05	40·79	71·48
·9509	34·10	40·84	71·58
8	34·14	40·90	71·67
7	34·19	40·95	71·76
6	34·24	41·00	71·85
5	34·29	41·05	71·94
4	34·33	41·11	72·04
3	34·38	41·16	72·13
2	34·43	41·21	72·22
1	34·48	41·26	72·31
0	34·52	41·32	72·41
·9499	34·57	41·37	72·50
8	34·62	41·42	72·59
7	34·67	41·48	72 68
6	34·71	41·53	72·78
5	34·76	41·58	72·87
4	34·81	41·63	72·96
3	34·86	41·69	73·05
2	35·90	41·74	73·14
1	34·95	41·79	73·24
0	35·00	41·84	73·33
·9489	35·05	41·90	73·43
8	35·10	41·95	73·52
7	35·15	42·01	73·62
6	35·20	42·06	73·72
5	35·25	42·12	73·81
4	35·30	42·17	73·91
3	35·35	42·23	74·01
2	35·40	42·29	74·10
1	35·45	42·34	74·20
0	35·50	42·40	74·30
·9479	35·55	42·45	74·39
8	35·60	42·51	74·49
7	35·65	42·56	74·59
6	35·70	42·62	74·68
5	35·75	42·67	74·78
4	35·80	42·73	74·88
3	35·85	42·78	74 97
2	35·90	42·84	75·07
1	35·95	42·89	75·17
0	36·00	42·95	75·26

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9469	36·06	43·01	75·37
8	36·11	43·07	75·48
7	36·17	43·13	75·59
6	36·22	43·19	75·70
5	36·28	43·26	75·80
4	36·33	43·32	75·91
3	36·39	43·38	76·02
2	36·44	43·44	76·13
1	36·50	43·50	76·24
0	36·56	43·56	76·34
·9459	36·61	43·63	76·45
8	36·67	43·69	76·56
7	36·72	43·75	76·67
6	36·78	43·81	76·78
5	36·83	43·87	76·88
4	36·89	43·93	76·99
3	36·94	44·00	77·10
2	37·00	44·06	77·21
1	37·06	44·12	77·32
0	37·11	44·18	77·42
·9449	37·17	44·24	77·53
8	37·22	44·30	77·64
7	37·28	44·36	77·75
6	37·33	44·43	77·85
5	37·39	44·49	77·96
4	37·44	44·55	78 07
3	37·50	44·61	78·18
2	37·56	44·67	78·28
1	37·61	44·73	78·39
0	37·67	44·79	78·50
·9439	37·72	44·86	78·61
8	37·78	44·92	78·71
7	37·83	44·98	78·82
6	37·89	45·04	78·93
5	37·94	45·10	79·04
4	38·00	45·16	79·14
3	38·06	45·22	79·25
2	38·11	45·28	79·36
1	38·17	45·34	79·46
0	38·22	45·41	79·57
·9429	38·28	45·47	79·86
8	38·33	45·53	79·79
7	38·39	45·59	79·89
6	38·44	45·65	80·00
5	38·50	45·71	80·11
4	38·56	45·77	80 21
3	38·61	45·83	80·32
2	38·67	45·89	80·43
1	38·72	45·95	80·53
0	38·78	46·02	80·64

Alcohol Tables—*continued.*

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9419	38·83	46·08	80·75
8	38·89	46·14	80·86
7	38·94	46·20	80·96
6	39·00	46·26	81·07
5	39·05	46·32	81·17
4	39·10	46·37	81·26
3	39·15	46·42	81·36
2	39·20	46·48	81·45
1	39·25	46·53	81·55
0	39·30	46·59	81·64
·9409	39·35	46·64	81·74
8	39·40	46·70	81·83
7	39·45	46·75	81·93
6	39·50	46·80	82·02
5	39·55	46·86	82·12
4	39·60	46·91	82·21
3	39·65	46·97	82·31
2	39·70	47·02	82·40
1	39·75	47·08	82·50
0	39·80	47·13	82·59
·9399	39·85	47·18	82·69
8	39·90	47·24	82·78
7	39·95	47·29	82·88
6	40·00	47·35	82·97
5	40·05	47·40	83·07
4	40·10	47·45	83·16
3	40·15	47·51	83·26
2	40·20	47·56	83·35
1	40·25	47·62	83·45
0	40·30	47·67	83·54
·9389	40·35	47·72	83·64
8	40·40	47·78	83·73
7	40·45	47·83	83·83
6	40·50	47·89	83·92
5	40·55	47·94	84·02
4	40·60	47·99	84·11
3	40·65	48·05	84·21
2	40·70	48·10	84·30
1	40·75	48·16	84·39
0	40·80	48·21	84·49
·9379	40·85	48·26	84·58
8	40·90	48·32	84·68
7	40·95	48·37	84·77
6	41·00	48·43	84·87
5	41·05	48·48	84·96
4	41·10	48·54	85·06
3	41·15	48·59	85·15
2	41·20	48·64	85·24
1	41·25	48·70	85·34
0	41·30	48·75	85·43

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9369	41·35	48·80	85·53
8	41·40	48·86	85·62
7	41·45	48·91	85·71
6	41·50	48·97	85·81
5	41·55	49·02	85·90
4	41·60	49·07	86·00
3	41·65	49·13	86·09
2	41·70	49·18	86·18
1	41·75	49·23	86·28
0	41·80	49·29	86·37
·9359	41·85	49·34	86·47
8	41·90	49·40	86·56
7	41·95	49·45	86·65
6	42·00	49·50	86·75
5	42·05	49·55	86·84
4	42·10	49·61	86·93
3	42·14	49·66	87·02
2	42·19	49·71	87·11
1	42·24	49·76	87·20
0	42·29	49·81	87·29
·9349	42·33	49·86	87·37
8	42·38	49·91	87·46
7	42·43	49·96	87·55
6	42·48	50·01	87·64
5	42·52	50·06	87·73
4	42·57	50·11	87·82
3	42·62	50·16	87·91
2	42·67	50·21	88·00
1	42·71	50·26	88·09
0	42·76	50·31	88·18
·9339	42·81	50·37	88·26
8	42·86	50·42	88·35
7	42·90	50·47	88·44
6	42·95	50·52	88·53
5	43·00	50·57	88·62
4	43·05	50·62	88·71
3	43·10	50·67	88·79
2	43·14	50·72	88·88
1	43·19	50·77	88·97
0	43·24	50·82	89·06
·9329	43·29	50·87	89·15
8	43·33	50·92	89·24
7	43·39	50·97	89·33
6	43·43	51·02	89·41
5	43·48	51·07	89·50
4	43·52	51·12	89·59
3	43·57	51·17	89·68
2	43·62	51·22	89·77
1	43·67	51·27	89·86
0	43·71	51·32	89·95

Alcohol Tables—*continued.*

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9319	43·76	51·38	90·03
8	43·81	51·43	90·12
7	43·86	51·48	90·21
6	43·90	51·53	90·30
5	43·95	51·58	90·39
4	44·00	51·63	90·48
3	44·05	51·68	90·56
2	44·09	51·72	90·64
1	44·14	51·77	90·73
0	44·18	51·82	90·81
9309	44·23	51·87	90·89
8	44·27	51·91	90·98
7	44·32	51·96	91·06
6	44·36	52·01	91·14
5	44·41	52·06	91·23
4	44·46	52·10	91·31
3	44·50	52·15	91·39
2	44·45	52·20	91·48
1	44·59	52·25	91·56
0	44·64	52·29	91·64
·9299	44·68	52·34	91·73
8	44·73	52·39	91·81
7	44·77	52·44	91·90
6	44·82	52·48	91·98
5	44·86	52·53	92·06
4	44·91	52·58	92·15
3	44·96	52·63	92·23
2	45·00	52·68	92·31
1	45·05	52·72	92·40
0	45·09	52·77	92·48
9289	45·14	52·82	92·56
8	45·18	52·87	92·64
7	45·23	52·91	92·73
6	45·27	52·96	92·81
5	45·32	53·01	92·89
4	45·36	53·06	92·98
3	45·41	53·10	93·06
2	45·46	53·15	93·14
1	45·50	53·20	93·23
0	45·55	53·24	93·31
·9279	45·59	53·39	93·39
8	45·64	53·34	93·48
7	45·68	53·39	93·56
6	45·73	53·43	93·64
5	45·77	53·48	93·73
4	45·82	53·53	93·81
3	45·86	53·58	93·89
2	45·91	53·62	93·98
1	45·96	53·67	94·06
0	46·00	53·72	94·14
·9269	46·05	53·77	94·22
8	46·09	53·81	94·31
7	46·14	53·86	94·39
6	46·18	53·91	94·47
5	46·23	53·95	94·55
4	46·27	54·00	94·64
3	46·32	54·05	94·72
2	46·36	54·10	94·80
1	46·41	54·14	94·89
0	46·46	54·19	94·97
·9259	46·50	54·24	95·05
8	46·55	54·29	95·13
7	46·59	54·33	95·22
6	46·64	54·38	95·30
5	46·68	54·43	95·38
4	46·73	54·47	95·46
3	46·77	54·52	95·55
2	46·82	54·57	95·63
1	46·86	54·62	95·71
0	46·91	54·66	95·79
·9249	46·96	54·71	95·88
8	47·00	54·76	95·96
7	47·05	54·80	96·04
6	47·09	54·85	96·12
5	47·14	54·90	96·21
4	47·18	54·95	96·29
3	47·23	54·99	96·37
2	47·27	55·04	96·45
1	47·32	55·09	96·53
0	47·36	55·13	96·62
·9239	47·41	55·18	96·70
8	47·46	55·23	96·78
7	47·50	55·27	96·86
6	47·55	55·32	96·95
5	47·59	55·37	97·03
4	47·64	55·41	97·11
3	47·68	55·64	97·19
2	47·73	55·51	97·27
1	47·77	55·55	97·36
0	47·82	55·60	97·44
·9229	47·86	55·65	97·52
8	47·91	55·69	97·60
7	47·96	55·74	97·68
6	48·00	55·79	97·77
5	48·05	55·83	97·85
4	48·09	55·88	97·93
3	48·14	55·93	98·01
2	48·18	55·97	98·09
1	48·23	56·02	98·18
0	48·27	56·07	98·26

ALCOHOL TABLES—*continued.*

Sp. Gravity at 60° F. = 15·5° C.	Absolute Alcohol by weight; per cent.	Absolute Alcohol by volume; per cent.	Proof Spirit; per cent.
·9219	48·32	56·11	98·34
8	48·36	56·16	98·42
7	48·41	56·21	98·50
6	48·64	56·25	98·59
5	48 50	56·30	98·67
4	48·55	56·35	98·75
3	48·59	56·40	98·83
2	48·64	56·44	98·91
1	48·68	56·49	99·00
0	48·73	56 54	99 08
·9209	48·77	56·58	99·16
8	48·82	56·63	99·24
7	48·86	56·68	99·32
6	48·91	56·72	99·41
5	48·96	56·77	99·49
4	49 00	56·82	99·57
3	49·04	56·86	99·64
2	49·08	56·90	99·71
1	49·12	56·94	99·78
0	49·16	56·98	99·86
·9199	49·20	57·02	99·93
Proof **8**	**49·24**	**57·06**	**100·00**

GENERAL INDEX.

APPENDIX.

By Authority: Robt. S. Brain Government Printer, Melbourne.