A

[illegible]UAL

[illegible]F THE

ART OF MAKING AND REFINING

SUGAR FROM BEETS,

INCLUDING THE

CULTIVATION OF THE PLANT,

AND THE

VARIOUS IMPROVEMENTS IN THE MANUFACTURE.

TRANSLATED

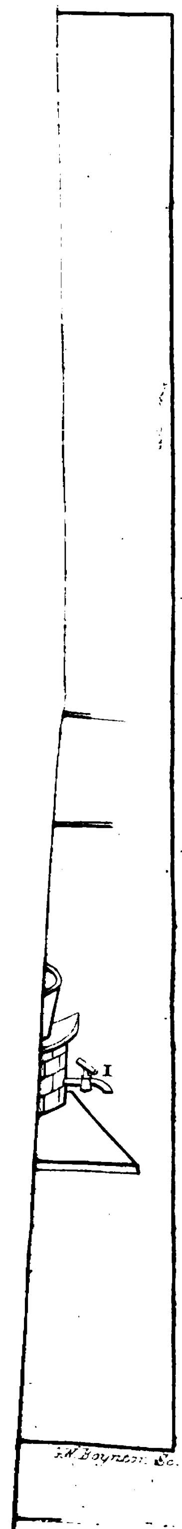
FROM PORTIONS OF THE TREATISE OF

M. M. BLACHETTE AND ZOEGA,

AS PUBLISHED, WITH ADDITIONS BY

M. J. DE FONTENELLE.

BOSTON:
MARSH, CAPEN & LYON.
1836.


I
J.W. Boynton Sc.

A

MANUAL

OF THE

ART OF MAKING AND REFINING

SUGAR FROM BEETS,

INCLUDING THE

CULTIVATION OF THE PLANT,

AND THE

VARIOUS IMPROVEMENTS IN THE MANUFACTURE.

TRANSLATED

FROM PORTIONS OF THE TREATISE OF

M. M. BLACHETTE AND ZOEGA,

AS PUBLISHED, WITH ADDITIONS BY

M. J. DE FONTENELLE.

BOSTON:
MARSH, CAPEN & LYON
1836.

SUGAR OF BEETS.

MARGRAFF, a celebrated Prussian chemist, was led toward the end of the last century, by the sugary savor of the radish beet, and by the crystalline appearance of its interior, when examined with a magnifying glass, to suspect that a substance analogous to sugar, existed in it. Herein is the detail of the researches, made to ascertain the nature of this substance, as he himself gave it in a memoir, read before the Academy of Berlin, in 1747.

After having cut the beets in thin slices, Margraff dried them carefully, and reduced them to powder. On eight ounces of beet thus pulverized, he poured six ounces of alcohol rectified as highly as he could obtain it, and placed the mixture over a gentle fire, in a sand bath. As soon as the liquid came to the boiling point, he withdrew it from the fire, and filtrated it into a flagon, which he stopped, and left to itself. After some weeks, he perceived that it had formed crystals, which presented all the physical and chemical characteristics of the crystals of sugar, from the cane. The alcohol which remained, contained sugar, in solution, and also a resinous matter, which he abstracted by evaporation.

Having subjected to a like treatment the root of the white beet, of skirret, and of some other plants, they all furnished sugar, but in different proportions: the radish beet gave the most. The existence of the sugar being once established, Margraff sought to extract it by processes more economical than those he had first used, and by approaching more nearly the processes in use, for extracting sugar from the cane.

After having pounded in a mortar, and reduced to paste, a certain quantity of beets, he enclosed it in a cloth bag, and subjected it to the action of a press, in order to separate all the liquid part. The pulp thus expressed was moistened with cold water and pressed again. Having put together the different liquids, he left them in a cool place, during twenty-four hours: the liquid then had become clear, and a deposit was formed. Margraff perceived that it would not be possible to extract sugar from the juice of beets, till this deposit was completely effected.

The liquid thus transparent, was put over the fire, first evaporated, and afterward skimmed, and clarified with the white of eggs, or ox blood, then brought to the consistence of sirup, and placed in a stove, where it was left during six months. It formed a great quantity of crystals, on the sides of the vessel, and the whole mass was not more than half fluid. He warmed it slightly, to give to the sirup more liquidity, and the whole was poured into a colander, pierced at the bottom with many holes, through which the sirup percolated, leaving the crystals in the colander. These crystals retained yet some moisture: to dry them completely, he pressed them between two leaves of brown paper.

As imperfect as were the means, used by Margraff to extract the sugar from beets, this celebrated chemist, nevertheless, perceived the importance which his discovery might have; and he recommended it to the attention of agriculturists, to whom he represented it as capable of being made a source of a new branch of industry. The moderate price of sugar, at the time of the experiments of Margraff, the expensive process, impracticable in manufactures, which he pointed out as proper to extract the sugar from the beet; the condition also of the chemical science, which was then only cultivated by a few scholars, were undoubtedly the causes why this discovery then appeared interesting only in a scientific point of view, and that it did not come into the conception of any person that it might ever present sufficient advantages to make it the object of manufacturing speculation.

These researches of Margraff, and the consequences he had deduced from them, were yet almost unknown, when Mr. Achard, of Berlin, having repeated and varied these experiments, succeeded in extracting, on a large scale, the sugar from the radish beet, by processes sufficiently economical to remove all doubts of the possibility of extracting with advantage the sugar from indigenous plants.

The direction given to mind by the brilliant discoveries of chemistry, nearly at the moment when the results of Achard become known, in France, contributed powerfully to fix on them the attention of the learned, and by consequence to extend the knowledge of them. They repeated and varied the experiments, in order to simplify the method, and to find one which should present a labor more easy, and results still more advantageous.

The result of this manufacture, as adopted in France with eagerness, did not answer, in the beginning, the hopes of those who expected to draw from it immense benefits. The manufactories established at great expense, for the most part, in places now ascertained to be least suitable for them, directed by men who had no acquaintance with agricultural business, to which the manufacture of beet sugar, must be necessarily allied; the imperfection of the apparatus first used; ignorance also, or at least the want of practical skill, about the different operations, to which the beets must be submitted—were so many causes that concurred to the ruin of these establishments. Thence arose an opinion, almost universal, that the extraction of sugar from beets might be correct in theory, but was altogether impracticable on a large scale and that a business of this kind would necessarily bring the ruin of all those who should undertake it.

Men of sagacity did not partake of this opinion, and no longer doubted, from this moment, of the success of this industry, when experience should make known the way most suitable to follow. Political events must hasten the time of the development of this branch of industry. The continental system, equivalent to an actual prohibition of colonial commodities, carried back attention to the means of obtaining sugar, from indigenous plants. The government at this time, made every effort that the researches which were making should be with profitable results.

Encouragements were promised; instructions were sent into all the départmens; rewards were decreed; a decree of 15th January, 1812, established five schools of chemistry, for the manufacture of sugar of beets, in the towns of Paris, Wachenheim, (département of Mont Tonnere,) Douai, Strasbourg, and Castelnaudry. By this same decree, the erection of four imperial manufactories was ordered, disposed in such manner as to make, with the product of the harvest of 1812 and 1813, two million *killograms of crude sugar.

Such were the state of things, at the time of the events of 1814—which destroyed, in France, all the sugar factories that had been established and had begun to prosper. At this time, the conviction which a great many persons had entertained of the inutility of the attempts to extract sugar from indigenous plants, gained ground from the apparent impossibility, that this manufacture could in future, sustain a competition with the sugar of the colonies. Instead of the acknowledgments, which those industrious men deserved, who had sought to diminish the privations we had been obliged to lay on ourselves, to give to agriculture, as M. Chaptal well remarked, more than 80 millions annually, we sought to turn them into ridicule, and it was, so to speak, agreed by general consent, that we should not recall the remembrance of beet sugar, without accompanying it with an ironical smile; that we should consider it very paltry.

Some men, accustomed not to allow themselves, to be governed by the reflected opinions of others, did

* A killogram is about 2 lbs.

not despair of overcoming the prejudice, which the vicissitudes, to which this industry had been subjected, had brought upon it. Endowed with a strong will, with a perseverance of full proof, animated with a desire to be useful,—they will not be repelled, neither by the difficulties they have to surmount, nor by the sacrifices they are often obliged to make; but finally, thanks to the knowledge which a long practice has obtained for them, to the improvements made in the processes and the apparatus, they have the glory to see, created in France, in Europe, a branch of industry altogether new, of having established it on bases that insure its existence forever, since it may compete on equal terms with the products of India and the colonies. In the number of learned and enterprising men, to whom France is more particularly indebted for the advantages that she may derive from this industry, we must reckon in the first rank, M. le comte Chaptal, who has made for many years the beet sugar at his proprietary, of Chanteloup, in Touraine, and who has published, in his Chimic appliquèe a l'Agriculture, an excellent memoir on this manufacture ; M. Matthieu de Dombasle, a distinguished writer on agriculture, so well known by his numerous applications of the physical and chemical sciences to agriculture, the improvements made in the construction of tilling implements, and other agricultural instruments, the establishment of an experimental model-farm, at Roville, who united precept with example in the publication of his work, entitled "Facts and Observations on the Manufacture of Beet Sugar," which has had two editions; and M. Crespel Delisle, of Arras, who by his example and advice has contributed to the erection of many manufactories at Arras and the environs, and whose zeal, and success, the society of encouragement at Paris rewarded by decreeing him a gold medal, in recompense of the services he had rendered to the manufacture of beet sugar.

There are now numerous factories, at different points, in the territory of France: large quantities of the sugar are used annually; it is all in a prosperous condition; and there is no longer a doubt now of the advantage of this business, when it shall be directed by skilful and intelligent men.

It is not to the Abbe de Commerell that we are indebted in France, as some persons have thought, and as M. Dubrunfaut has lately written, for the importation of the beet, since Olivier de Serres made mention of it; but only for the introduction of a variety, and of the knowledge of the advantages of this culture on a large scale. What led to this error, was, that until the publication of the memoir of M. de Commerell, in 1784, we had not considered this plant suitable to supply fodder for cattle, and that its cultivation was very little extended.

M. de Commerell gave to the variety which he made known, the name of *racine de disette*, which is only a translation of one of the names which it bears in Germany, (mangel würsel,) whence he had brought it. The botanists substituted for this name, first that of *betterave champetre*, and more lately that of *betterave commune*, *common* radish beet, (beta vulgaris, Lin.)

In the memoir of M. de Commerell, we find instructions in detail on the racine de disette. He shows the use of which it may be as an article of food, both for man and for cattle. Most of the writers who have treated of the beet have scarcely done more than repeat the work of M. de Commerell, without naming the source whence they had drawn it; as if it depended not on them to take from this estimable citizen the only glory of which he was ambitious, that of being useful to his country.

The *radish beet* is a plant of the tribe beet, of the family atriplices, species of biennial plants, of the height of one to four feet, branching, and with furrowed stalks; they have leaves single and alternate, flowers without corolla, hardly visible, collected in small groups, and forming, toward the summit of the stalk and the branches, long, leafy ears: its generic character is to have a calyx with five folioles, bearing five stamens, and an ovary furnished with two styles and two stigmas, half buried in the substance of the calyx, and becoming a kidney-shaped seed in which the calyx takes the place of the capsule.

The number of known varieties exceeds twenty. We find in the third volume of the Dictionnare Technologique, under the word *betterave*, a list of varieties and sub varieties known or cultivated in France. The following note was written by M. Payen, the compiler of the article mentioned, from documents that had been furnished him by M. Vilmorin-Andrieux. We give it here.

"First variety. Disette (beta silvestris) betterave champetre or commune, country or common radish beet, white inside and outside, white petioles.

Sub variety. Rose colored outside, and presenting, (if cut perpendicularly to its axis,) concentric circles, rose colored and white.

Second variety. Silesian white radish beet, (beta alba) rounded, pear-shaped, white petioles, pulp white and of strong texture. This is the variety recommended by Achard as the best and most productive.

Sub variety. Petioles veined with rose color, with concentric circles, rose colored and white in the interior of the root.

Third variety. White radish beet, long and spindle-shaped, with white pulp; it resembles the roots of succory in its length and form. This is known in some parts of France, under the name corne de boeuf, ox horn. We do not cultivate it, because it requires a very deep soil: it appears, beside, that it yields very little sugar.

Fourth variety. Red radish beet, (rubra romana,) oblong, well shaped, petioles of the leaves red: this, as well as its sub varieties, is not much cultivated except for the table.

First sub variety. Yellow, petioles of the leaves yellow.

Second sub variety. Small, red, spindle-shaped, petioles and pulp red, very deep, and mixed with yellow.

Third sub variety. Small, red, round like a turnip, early, (from twelve to fifteen days,) is cultivated in gardens: it is used to dress, to be eaten as a salad.

Fifth variety. Yellow radish beet, (lutea major) pear-shaped, elongated, of a middling size, pulp yellow, petioles of the leaves greenish yellow.

First sub variety. Red, with red petioles: it is always mixed with the preceding, although the seed, when sown, comes up only yellow. Of four kernels collected in one seed, it comes up, sometimes, three yellow and one red.

Second sub variety. Small, yellow, spindle-shaped, like the carrot, with yellow petioles: it is not cultivated.

Third sub variety. Yellow externally, and white internally, pear-shaped, rounded, petioles white."

M. Dubrunfaut adds to this enumeration a subvariety of the second variety. It is rose colored, pear-shaped, with white pulp, sometimes slightly rose colored, petioles white.

This plant may be considered under four different relations of utility:

1st. As an alimentary substance for man.

2d. As proper to supply fodder for cattle.

3d. Relatively to the sugar it contains.

4th. For the pot-ash that may be obtained from it, by the incineration of its leaves and top.

In the end we have proposed, we have only to examine it in reference to the sugar that it furnishes. It is only incidentally that we shall treat of its importance for the nourishment of cattle. This question, purely of rural economy, is, however, allied to the manufacture of beet sugar.

Studied under this point of view, the first question presented, relative to the beet, is to know if all the varieties furnish an equal quantity of sugar, or if one is to be preferred.

At first, when we cultivated the beet for the extraction of the sugar it contained, we attached much importance to the variety; each one took that which had given him the most advantageous product. Now that it is known, that the variety does not always reproduce itself, and that the quantity of sugar depends chiefly on the soil, or atmospheric conditions, and on cultivation, all varieties are sown almost indifferently. However, it is generally agreed to give the preference to the second variety—Silesian white radish beet, (beta alba.) The celebrated writer on agriculture, M. Mathieu de Dombasle, assures us that it is this which gave him the best success. Next comes the fifth variety, called yellow Castelnaudary beet, (lutea major.) But different circumstances may have so much influence on the products we may obtain, that the same variety may be the most advantageous in one department, and the poorest in another. It is, above all, the perfect knowledge of these local influences, which can insure success in the business of making beet sugar; and this knowledge cannot be acquired except by practice and repeated experiments. However, experience has shown that the smallest beets, generally speaking, furnish a quantity of sugar greater, in a given weight, than the larger. Also the juice of large roots does not mark scarcely from 5° to 6° on the hydrometer, while that of the small may go to 8° and sometimes 10°. The small roots also present less difficulties in the manufacture. It is more economical, since the juice being more rich, has less water to evaporate. These advantages, it is true, may be balanced by the mediocrity of the harvest. It is still a subject of research for the sugar maker—a subject which we can only indicate to him, in the impossibility of fixing general rules which may govern him.

The physical characters that may serve to make known a beet of good quality are, to be hard, brittle, to make a noise under the knife, and to be perfectly sound. The savor, more or less sugary, may also show the richness of a beet.

Color does not appear to have any influence on the quality and quantity of the product. However, according to M. Chaptal, the sugar obtained from red beets retains a tint which makes it more difficult to whiten.

Considerations on the Nature of the Soil, and the Climate which are suitable to the Beet.

The soil, its exposure, its nature, the climate to whose influences it is subjected, are the first considerations to which an agriculturist must give his attention for all culture in general, and which cannot be neglected when he acts on that of the beet in particular.

As a plant, having pivotant (single perpendicular) roots, the beet requires a light soil, of good depth. Thus we must give preference to alluvial rich and sandy lands, or which may be inundated naturally every year, and thereby covered with a coat of slime, which will impart an artificial richness to it. Lands having natural or artificial meadows, after having, however, first taken from them a crop of grain, in order to give to the turf and the roots, which would impede the growth of the beets, time to be decomposed, are equally suited to this culture. Lands thus prepared may furnish two good crops of beets consecutively.

The product of high lands, in dry years, is inconsiderable; the roots not being able to attain all the growth of which they are susceptible, furnish, it is true, much sugar, in proportion to their size, but little, if we take into consideration, the surface of ground they occupy, and the quantity of sugar they would have given if they had attained only a middling size. The contrary happens in rainy years. It is altogether otherwise in low lands. The volume of beet is very great in rainy years, but the sugar that comes from it is very watery, and the quantity of sugar that may be extracted is very small. It is therefore necessary, in order to establish a constant relation, as nearly as possible between the volume of beet and the sugar, it will furnish, to cultivate this plant in grounds which are neither too dry nor too moist.

We may now draw this conclusion from what goes before, that it is not always the largest beets that present the most advantages in the extraction of the sugar.

The beets giving so much more sugar in proportion as the season has been more warm, it would be natural to think that it would be much more advantageous to cultivate them for this purpose in southern countries. But experience seems to have proved the contrary. In fact, though the beets cultivated in the south of France have a more sugary taste than those of the environs of Paris, they, however, furnish less crystallizable sugar, and even a few days after their maturity it is transformed into uncrystallizable. The reaction of these principles is with so much more rapidity in proportion as they are exposed to a high temperature. The 45th degree * seems to be the limit where we must cease to cultivate them with

* There is a difference of about 6 degrees of temperature in the same latitude of Europe and America, which would allow us to cultivate it a little south of the above limit in this country.—But see note, next page. [Trans.]

a view to the production of sugar. We have supposed the existence of these different facts from the time when the experiments of M. Achard, were repeated in France. As much care as had been given to it, with all the variety of experiments used, we could not obtain from the same weight of beet a quantity of sugar equal to that which this chemist reports himself to have extracted from the white Silesian beet. The product which the factories of the northern departmens now obtain from the beet, with the improved process of extraction, and apparatus, have nearly approached, but have not, however, attained to the results announced by the Prussian chemist.

Notwithstanding all these facts, the conclusion which the learned anthor of the article *beet*, in the Nouveau Dictionnaire d'histoire naturelle, has drawn, of the impossibility that this kind of manufacture could prosper in the south of France, and to attribute to that cause the ruin of all those that were established there, does not appear to us strictly exact. * To the causes that we have mentioned in

---

* Not only is this assertion not exact, but it is erroneous and anti-scientific. Experience has demonstrated to me that beets cultivated in the south of France and in Spain, follow the same laws of vegetation as other plants which are so much more rich in oily, aromatic and sugary elements, &c., as they grow in the warmer climates.

In this the beet does not depart in any manner from the general rule. I have in fact tried a great number raised at Narbonne, Perpignan, Carcassonne, Castilnaudary, Toulouse, &c., and I have always found them more rich in crystallizable sugar than those raised at the north. I think, therefore, that we must attribute the want of success of the experimental schools of the south of France to the inexperience of those placed at their head, without having made any particular study of this kind of manufacture.

the preceding chapter as having exercised an unfavorable influence on this rising industry, perhaps must be added one that has been felt in the most disastrous manner in our southern departments: we allude to the deplorable system of fallow grounds.

The same variety, as we have said, does not always reproduce itself. It seems that in the act of vegetation it effectuates changes of the variety. These changes, it is ascertained, consist in alterations of the petioles and collets.

In a field sowed with the seed of the yellow beet only, there are always found some stems of the red and white. The seed of beet is sown in beds, or we sow it in sets to transplant. We shall describe the manner in which these operations are done when we treat of sowing.

Some maladies frequently discover themselves in the beet during the course of its vegetation: they are generally of little importance, except the rickets which is known by the smallness and contortion of the leaves, by the discoloration of the roots, and by the complete absence of every savor in the pulp. The roots that are attacked with it must be pulled up. Insects do not appear to cause any sensible damage to it.

Mr. Harlsteadt is, I think, the first who has advanced, it is not known on what foundation, that the sugar beet appears to succeed better in northern climates, and that of consequence the manufacture of sugar appears to suit better these climates. This opinion appears to me to have something of the spirit of nationality. This is more probable, as M. Wagenmann has undertaken to combat this assertion by positive facts to which my experience brings a new support. J. F.

The Preparation of the Soil.

It has long been ascertained that no ground can receive, many years in succession, the same plant, without destroying gradually the power of vegetation of this plant in it, by enfeebling it each year: thence came the belief that the ground was exhausted, and, in consequence, the absurd system of fallow grounds. The most reasonable doctrine to which experience has given support, establishes the fact that this exhaustion is only relative to the particular plant which had been cultivated on it, and even that only temporary; so that by alternating in the same ground the cultivation of different plants, we may, at the end of a certain time, cultivate upon it again, and with the same profit as at first, that which, sown without the intermediate culture of other plants, would present but a sickly vegetation.

The culture of the beet must necessarily make a part in a system of rotation of crops. It is perhaps to this necessity being too often neglected, that we must attribute the ruin of different articles. The beet requires a very loose soil. Its preparation will depend on the crop that preceded it. Thus, when the beet is to be sown after a crop of grain, it is necessary to give it two and even three deep ploughings—the first in winter, the third at the time of sowing.

M. Dubrunfaut, who gives many examples of a succession of crops, proposes one of a three years rotation, in which he makes the cultivation of the beet to follow a crop of potatoes. This plant, having the effect of breaking up the ground, may save one ploughing.

The rotation most suitable for the culture of beets, according to M. Mathieu de Dombasle, is one of four years, as follows: corn, beets, barley or oats, and clover.

The observation made a long time since, that beets manured grow larger than those raised without manure, while, under the same volume, they contain less sugar, has led some persons to think that manure diminishes the quantity of sugar which was supplied by nitrate of potash, which is found sometimes in the beet, especially when the ground in which it sprouted is mixed with plaster. But this belief was evidently erroneous: there is no longer a doubt on this point, now that we know that the largest beets do not always contain the most sugar.

It is unnecessary to remark that manures do not all act in the same manner, but will vary according to the nature of the soil on which they are spread. The state of decomposition in which the manure that we use, is, at the time, and the property they have of becoming decomposed in a longer or shorter time, should also have an influence on the time at which we spread them.

Among manures, those which are considered best are those taken from the stable and poultry yard. We must take care to use them fresh. They should be put on the ground before winter, and spread over it between two ploughings. These manures which are commonly mixed with straw, make the soil light, break it up, and render it more permeable to the roots, and have beside the advantage of acting on the soil, by reason of their slow decomposition, during many years.

We use with advantage, to manure cold and sluggish lands, the residuum obtained by the manufacture of sugar, such as animal-charcoal, and skimmings. The pasturing of sheep on lands of this kind, also furnishes a very fertilizing manure.

When at harvesting beets we cut off their collets on the ground, as we call it, in speaking of the manner of harvesting them, the leaves, thus separated, make a considerable mass. It is customary to leave them on the ground as manure, and they are generally considered as supplying a good demi-dressing. It is the same with the waste of the manufacture, such as the radicles, the pieces of the neck, and the pickings which are taken from the beets in cleansing them for the rasp.

In Flanders they use a particular kind of manure, known under the name of Flemish, which is a mixture of solid and liquid substances. This sort, which is used in a state of complete decomposition, must not be put on the ground till the time of sowing, sometimes even a little after. It hastens in a remarkable manner the vegetation of the beet, retarding, however, its maturity. The green of its leaves is very deep; they are more abundant and larger; they dry and fall off very late. The roots themselves grow larger, but they are always more watery.

Experience has shown that in France the greatest product of a good soil may amount to 50,000 kilograms * to the hectare. In a poor soil it will not be

* The kilogram being a little more than two pounds and the hectare a little over two acres English, it may be called 50,000 lbs. an acre, the kilogram to the hectare being about as the pound to the acre.

more than from 5 to 10,000 kilograms. The medium product, according to a table given by M. Dubrunfaut, from the amount of the product of ten different harvests, was nearly 24,000 kilograms.

The Sowing.

The choice of seed, says M. Chaptal, requires much caution. A good cultivator ought to raise them himself. The most vigorous and healthy plants must be selected for seed-bearers: they must be transplanted at two or three feet distance from one another, in a good exposure, and sheltered from the winds, which may break their stems. In the month of September when the seed is ripe, we cut the stalks, and when dry, the seed is detached from them with a stick or with the hand. This seed is to be spread on cloths in the open air, to complete the drying, without which there is risk of its being heated. The fragments of stalks are separated by fanning, and the seed is preserved by keeping it safe from all moisture.

Each plant furnishes from five to ten ounces of seed; but only half will be good—those on the extremity of the stalk rarely coming to maturity. We preserve only the best, the bad seed giving nothing but grubby plants, and not even coming up commonly but in part.

The plants furnishing the seed also contain sugar in sufficient quantity to be used with the others.

The sowing is to be done in the first pleasant days of Spring, when there is no longer any danger of frost, which in our climate arrives commonly at the end of March, or the beginning of April. It may be sown much later. Thus it happens, sometimes, that the seed is put in the ground in the month of May, or even in the first days of June; but this is only when the first sowing has failed, and the cultivator determines to take the chances of a second. Sown too soon while the earth is yet cold and moist, the seeds are apt to rot: on the other hand, too late, they are in danger of suffering by drought. In that case, the leaves of the beets, as they develope, cannot pierce through the crust which is formed on the surface of the soil. The time above mentioned is mostly free from both these inconveniences: the earth, in fact, retains yet a sufficient degree of moisture, and the action of the solar rays becoming every day more lively, the seed is in circumstances most favorable to germination. Too early sowing, besides, presents another inconvenience, in giving rise to the production of a crowd of parasitical plants, which impede the development of the beet, make numerous hoeings necessary, and thus increase the expense of cultivation. If a frost happens after the plant has sprouted, it becomes indispensable to plant anew, the seed being destroyed by a temperature below zero.* It will be the same if by a series of too abundant rains the seed rots in the ground. These accidents, which occur very frequently, are the cause why we ought to count in each crop the half in a given quantity of the seed at least necessary to be added.

M. Chaptal fixes the quantity of seed necessary to a hectare at five or six kilograms, which will make, by computing as above, fifty per cent. addition, seven

* Zero in Reaumur's thermometer is the point at which water freezes, corresponding to 32° Fahrenhait. [Trans.]

and a half to nine kilograms. M. Dubrunfaut puts the quantity of seed for the same space of ground at fifteen kilograms.* Both of these are by the mode of sowing broadcast. The difference between these two quantities is so great that there must be an error in the computation of one of them. There are three methods of sowing the beet, viz. broadcast, in nursery beds, and in drills.

The mode of sowing broadcast is most known and most generally practised. It is the same used for sowing grain. The soil having been suitably prepared, and smoothed by the roller, a laborer bearing before him an apron full of seeds marches in the way of the length of the piece to be sown, throwing the seed before him by pinches, so as to make it as uniform as possible. It may easily be conceived how imperfect this mode is, and also it is that which requires the greatest quantity of seeds.

The seed thus thrown is scattered at very unequal distances, which makes it necessary to pluck them up where they are too close, and to replant them in those places where they are very scattered. This is called thinning and transplanting. These operations are done simultaneously, about a month and a half after

* Kilogramme, a thousand grammes. The dictionary of Laveaux says the kilogramme "contient 1000 grammes, and revient au poids du marc, a 2 livres, 5 gros, 49 grains,"—is 1000 grammes, and, in poids du marc, 2 lbs. 5 drachms, 49 grains. The poids du marc has 16 oz. to the lb. The French ounce contains 2 drachms more than the English, and the livre therefore more than our lb., that is 18 oz. English. The kilogramme is therefore 2 lbs. 4 oz. 5 drachms, 49 gr.—1 gr. (Fr.), is 1-62 of a drachm.—30 grains of English weight to a drachm, (60 apothecaries) gives 17 43-100 grains to a gramme—which is 1-27 of an oz. a little over 2-3 of a dwt.

the seed has come up. The laborers, who are commonly women and children, employed in this labor, pluck up with one hand the superfluous plants; the other hand holds a planting-stick with which they make a hole where there is a vacant space, in which they insert one of the plants they have pulled up. Care must be taken in pulling them up not to break the roots. We must also take care not to crowd them in replanting. The distance we preserve between the plants varies according to the size we wish them to attain, and, of consequence according to the richness of the ground. They are generally placed from fifteen to eighteen inches apart.

The operation of transplanting has the inconvenience of retarding the vegetation of the root, which has never the same vigor as those that have not been removed. M. Mathieu de Dombasle does not think, however, that the beets when replanted are less rich in sugar than those which have not been removed; and after comparative experiments made with much attention he has adopted almost exclusively the plan of transplanting.

The method of sowing in nurseries consists in sowing all the seed at first on one seventh or one tenth part of the ground which they are afterward to occupy. This ground must have been well prepared and manured. About one month and a half after the beets have come up, they are to be taken up and transplanted in the field destined to receive them. For this purpose, a man having a planting-stick pierces holes with it, in each of which the women deposit a plant, closing them again with their feet. Before transplanting them it is necessary to cut off the leaves about three inches from the neck. Plants that have not been so treated die much oftener than the others by the effect of drought.

The inconveniences of this method are to increase very much the labor, it being unavoidable, at the moment when the plant is putting forth its greatest force of vegetation, to break the greater part of the ends of roots, which prevents their elongating to a point, and makes them forked: they afterward grow out in radicles, which increase the difficulties of clearing.

For the two preceding methods of sowing we have substituted, in almost all the large plantations, that of sowing in drills, which is done by tracing with a harrow, the teeth of which are at suitable distances, drills of an inch nearly in depth, in which women, who follow the harrow, deposit the seed at intervals of sixteen inches. We then pass over the whole surface of the field a harrow upside down, to smooth the ground and cover the seed. In less extended plantings this mode of sowing is improved by using a seed-bag, or sower.

This instrument, which is made in different forms more or less complicated, is composed of a sort of box, in form of a hopper, in which is put the seed that is to be sown: the bottom of the box is formed of a wooden cylinder, the surface of which has cavities in which the seeds lodge. The whole is moved on two wheels. In moving this machine, the motion of the wheels is communicated, by means of a feeder, to the cylinder, which in its rotary motion carries the seed from the box into the cavities, and sheds them uniformly in furrows traced by shares placed before the machine. We may readily conceive that the distances in which the seed will fall into the ground will be regulated by that which they had in the cavities of the cylinder.

In England they have adopted, says M. Chaptal, a process which must have great success. They open a deep furrow, and put the manure in the bottom: they then trace a second, which covers the first. The seeds are sown in the length of the furrows, so that they will be always placed perpendicularly to the manure, which retains its freshness and furnishes its nourishment to the seed.

It is also necessary, when sown in drills, to thin the plants in parts where they are too near, and to replant them, on the other hand, in the vacant spaces. For the rest, this labor is performed with great facility by reason of the regularity of the lines.

Hoeing.

The cares which the beet requires during its vegetation are very numerous. There come up at the same time with it a host of weeds, which impede its growth, and in the end will choke it, if they are not carefully rooted out. That is the end we propose in hoeing. In the cultivation of beets the hoeing must be repeated three times: the first is to be done at the time of transplanting; the second and the third at about one month's interval. When the beets have been sown broadcast, the weeds are to be rooted out with the hand, or with a pick. A man roots out with a pick all the weeds, which are then carried away and laid in a heap, to be converted into manure.

The sowing in drills gives the facility of doing the first and even the second hoeing with the horse-hoe, which is the most expeditious. It is true the workmen must afterward pass over it, to till about the roots, and to pull up the weeds which the machine has left.

Besides the advantage that hoeing gives in clearing the ground of weeds that impede the vegetation of the beets, it has that also of turning up the earth, and giving light upon it. Thus we see, after each hoeing, the plant assumes a new vigor. The product of a field that has been well hoed is at least double that where the hoeings have been neglected.

Some cultivators have proposed to hill the beet. This method is more hurtful than useful. The roots do better when their upper part enjoys the direct action of the air, and of the rays of the sun. Thus, in Germany they often plant them mixed with a species of potatoes which it is necessary to hill: the earth taken from the beets is put about the roots of the potatoes.

We must guard against plucking the leaves of the beets designed for the manufacture of sugar, during their vegetation. It is an error to suppose that by plucking the leaves the roots will grow larger. There is no doubt that the plant cannot supply the leaves of which it has been deprived, except to the injury of the substances which serve to increase its volume, and among these substances is the sugary matter, which is most developed.

Harvesting.

As the beet approaches maturity, its leaves, which have been up to this time hard, erect, and of a handsome green tint, become marked with reddish spots, flag down upon the ground, and grow yellow. These marks, which appear toward the month of October, announce that the beets have come to their full growth, and that they have nothing more to attain. We must then proceed to pluck them. We must choose fine weather, after some days without rain, for it has been observed that the quantity of sugar which the beets furnish, varies much with atmospheric circumstances. Thus the sugar from the beets, plucked after some days of rain, is always more watery than that from beets gathered in a dry time. The beet must not, however, be suffered to remain long after its maturity; for from this time the saccharine element, by a new elaboration of the juices, goes on daily diminishing, and finally disappears altogether. M. Chaptal relates an instance of this, too remarkable not to be mentioned here.

M. Darracq, in concert with M. Lecomte d' Angosse, prefect of the department of Landes, had every thing prepared to establish a sugar factory. From the month of July to the end of August, he made an experiment with beets in all the eight ways, and constantly extracted two and a half to four per cent. of good sugar from them. Assured by these results, he discontinued his experiments, to give himself up to the cares which his establishment required. What was his surprise, when, toward the end of October, the beets would furnish him nothing but sirup and saltpetre, and not one atom of crystalizable sugar.

Another inconvenience presents itself: if they are gathered before maturity, they wither, become soft—the extraction of the juice is a more difficult operation and the sugar has less consistence. However, if the sugar is extracted immediately after they are taken from the ground, it appears that it may be done a little before their maturity without any bad result. So, at least, M. Mathieu de Dombasle assures us, who says, that he had extracted as much sugar, and even, as it appeared to him, more, from beets of the same ground plucked in June, than from those gathered in the month of October. It is commonly women and children who do the business of gathering them. For this purpose they are divided into couples of two women, or of one woman and one child. The first with a spade takes up the beet, and leaves it on the soil: the child who accompanies her takes a root in each hand, and shakes them, beating one against the other, to detach the earth that is adhering to them; after which he ranges them one by the side of another in a line, the necks on one side. A laborer with a sharp spade passes over the lines, cutting off the necks. This is done by striking down the spade vertically, as if to fix it in the ground. This operation requires in the laborer who is charged with it a certain degree of adroitness, to cut off the neck without injuring the body of the beet. The principal object in cutting off the necks of the beet is to arrest the vegetation, which, without this operation, will continue many days to the injury of the sugary matter.

When the weather is favorable, the beets, after being pulled up and beheaded, are left some days spread on the ground, in order that the air may take from them a part of the water they contain. When it is supposed this drying is effected, they are put in heaps, and carried on carts to the magazines where they are to be kept.

We have already said that the leaves and the necks should remain on the ground, and that they may be considered a good demi-dressing for the harvest of the following year, which is commonly grain. Sometimes they fodder on the spot with these leaves, which are very abundant, the oxen, cows, sheep, and pigs.

It is computed that sixty workmen, women and children, may pluck up, behead and put in heaps, the roots from a hectare and a half of ground in a day.

Preservation of the Beets.

The manufacture of the sugar of beets being prolonged through part of the winter, one of the most important cares is to provide for the keeping of this root, and preserving it from the different influences which might alter its composition and diminish the sugary matter, that it contains at the moment of harvesting.

These causes of alteration may be reduced, first to the influence exerted on all organized matter by a secret power, according to which they perform all their functions, the action of which continues even after the vegetable has been separated from the soil, and to which the name *vital power* has been given. Second, to temperature and humidity.

All plants retain then, as we have said, a remainder of life which continues longer or shorter, and with more or less force to elaborate the elements of which they are composed. Different circumstances may suspend, destroy or favor this action. A temperature below zero* has the first effect, and in that cir-

---

* See above, p. 20.

cumstance beets may be preserved almost indefinitely. When subjected in this state to the operation of extracting the sugar, it furnishes a quantity equal to what it would have given before being frozen, only the work of rasping becomes more laborious. But it is altogether different if the operation is attempted in time of a thaw. The beets are then soft, wrinkled, and go on rapidly in the process of putrefaction. The mean time for the congelation of beets seems to be between the third and fourth degree below zero by the thermometer of Reaumur. But this degree may vary according to the quantity of water they contain; the least watery being sometimes able to support from one to two degrees below that above indicated.

A temperature a little raised destroys the vital power of the beet; but in a root completely dried, the proportion of crystalizable sugar that may be extracted will be considerably diminished, either by a change which may be caused by a too rapid drying or by the difficulty of working it.

However, Mr. Nosarzewski advises to preserve the beets by drying, and afterward extract the sugar by the aid of water or alcohol. His opinion is not founded on any positive experiment. Admitting, however, that it was based on facts, this method will be too expensive to be adopted in the manufactories.

The action of the vital power is singularly favored by a mean temperature of twelve or fifteen degrees; especially if accompanied with moisture. It is always at the expense of the saccharine element that this action is effected. Beets placed in such circumstances are changed very quickly. A fermentation takes place, at first acid, but which before long becomes putrid. Their interior then presents a number of cells, very apparent, filled with a viscous, stringy liquid. Their pulp is black, soft, and their surface is covered with mould.

Now in beets collected in a large quantity without the air having a chance of being renewed, the vital power is sufficient to develope a heat capable of producing these different effects. It has even often happened that fermentation progresses with so much violence, that it is exhaled from the mass in abundant vapors. M. Dubrunfaut relates, on the testimony of several manufacturers, that beets which at one time would not give any sugar, being left to themselves for some time, have afterward furnished some very fine. The writer abovementioned, although finding it was very singular, did not seem to think it impossible—and we are of his opinion. He supposed, in order to explain it, that there was an elaboration of the juices of the plant, which at the first time had not taken place, and which was afterward effected.

The means at first used to preserve beets, that which naturally presented itself, was to put them in heaps in the yard of the factory or in the neighboring enclosures, or sometimes even on the field where they had been gathered. These heaps were made in the form of an oblong square of ten or twelve feet high. The top, disposed to a sharp ridge, was covered with straw to shed the rain. This mode of keeping, otherwise very economical, had the inconvenience of not protecting the beets from frost, from which it is especially necessary to guard them—nor from the varieties of temperature, the effect of which as has been above mentioned is always very hurtful.

In many establishments they have attempted to preserve the beets by burying them. For this purpose they dig in the field, or in a ground near the factory, ditches three or four feet deep, and of various breadth. The roots are thrown at random in these ditches, the middle is raised to a sharp ridge, and the whole is covered with a bed of earth, a foot thick, at least.

In cases where the earth is very moist, M. Dubrunfaut advises not to make the ditches designed to receive the beets more than twelve or fifteen inches deep; to make two similar parallel ditches, and to dig between them a deep trench of two or three feet, for the rains to flow in. The earth taken from this trench will serve to cover the heaps of beets, which will then be raised about two feet above the soil. This is the method in use in Germany to preserve potatoes. M. Mathieu de Dombasle has practised it with advantage for preserving the beet. M. Chaptal recommends to line the bottom and sides of the ditch with straw. It is now well established that this is more hurtful than useful. For the straw decays, and draws after it the decay of the roots.

In this mode of preservation, which otherwise offers great advantages, the chief difficulty against which we have to guard is to prevent the action of moisture, as well of the ground as of the natural moisture of the beets.

Of all methods of preserving beets, the best undoubtedly, because it is calculated to guard them from extrinsic dangers, is to store them in cellars, or, better still, in magazines. The beets are piled in heaps of twelve to fifteen feet or more. By making them higher, the lower tiers which support the weight of the whole mass will be infallibly crushed. A passage must be left through the length of the store-room, in order to be able to examine them from time to time, and to remove from the heap any portions in which any decay appears.

To prevent the heating which may result from the heaping up of the beets, it is necessary to change often the air of the store-room. For this we must take advantage of a day when the weather is dry and fine. The preservation of the beets in a store unites all the advantages that are desired. It has only the disadvantage of being expensive by the necessary size of the building.

The medium weight of a cubic metre* of beets is about 800 kilograms. It will be easy from this given quantity to calculate the dimensions of a store designed to receive any certain quantity of beets.

We will add that it will be for the advantage of manufacturers to work, through the season, as many beets as they can. For Hermbstaedt has ascertained that they generally give more and better sugar at the beginning of the season than at the close. This is also the opinion of Wagennann.

Mode of determining the Saccharine Richness of Beets.

The process proposed by M. Pelouze for estimating the quantity of sugar contained in the different species of beets, consists in making them ferment in a place sheltered from the air, and then distilling the spirituous liquor that results from it. By the quan-

* About four feet—cubic metre! about one half cord, wood measure.

tity of alcohol produced he estimates the proportion of sugar which was in the roots.

He first ascertained that thirty-five grammes* of pure sugar perfectly dry dissolved in 450 grammes of water, to which had been added a little yeast or beer well watered, had given by distillation a spirituous liquor representing 22.5 of pure alcohol.

Starting from these premises, M. Pelouze extracted the juice of 500 grammes of beets, the pulp reduced very fine; and in order to extract all the sugary part which remained in the pulp after expression, he exhausted it by repeated washings and compressions. This liquor mixed with a small quantity of pure yeast, is left to itself, in a temperature of about 18° or 20°, and at the end of 15 days the action is finished. He distilled then the fermented liquid, and ascertained its degree by the hydrometer of M. Gay Lussac.

To know the quantity of sugar in the 500 grammes of beets he had only to compare the quantity of alcohol obtained, with that furnished by the pure sugar.

Repeated experiments proved to M. Pelouze that generally beets contained a proportion of sugar double that which was separated by the processes used in the manufactories, that is to say, about 10 per cent.

According to this author, beets the most rich in sugar are those having a rose-colored skin and white pulp. The small are always more sugary than the large; which was known before the experiments of M. Pelouze.

---

* The gramme is the unit of the new French weights and 1000th part of the kilogramme. 35 grammes about 1 1-4 oz. English. See note, p. 21.

The process of M. Pelouze is certainly accurate for the estimation of the quantity of sugar, and to clear up a mass of questions of great interest concerning the culture of the beet. But will it be practicable on all occasions? We think that an experiment that demands from twelve to fifteen days to be tried, and which requires some care to be done well, is not susceptible of being put in practice in all the factories where beets are worked to obtain sugar.

EXTRACTION OF BEET SUGAR.

Cleaning.

The first processes to which the beets are subjected are to clean them of the earth and gravel which may be left adhering to them, and of the small filaments and the parts of the neck attached to it. This is the object of the cleaning, which is done in the following manner. A woman with a very sharp knife, the blade of which is about ten inches long and two or three broad, cuts off the radicles, takes up the parts of the neck which have been left in the beheading, and scrapes the root lengthwise, to clear it of the earth. When the beet is too large to be fixed upon the rasp, the operator splits it lengthwise and divides it in two or more pieces. Two women, accustomed to the work, cut and clean three thousand roots when small, and double when they are larger. The loss of weight by the cleaning is about six to seven per cent. of the gross weight.

Washing.

The factories which can command a sufficient supply of water, commonly make a washing follow this first operation of cleansing. The washing is economically done in a large cylindrical box, the circumference of which is formed with slats of wood at intervals of an inch and a half. This cylinder is enclosed in a cistern full of water. About two quintals of beets are put in it at a time, and they are perfectly washed by some turns of the machine. This washing is not indispensable, only when it is omitted more care must be given to the cleansing of the beets. For if it were done negligently, and any earth were left attached to the roots, the teeth of the rasp would be injured. The only use of washing is to give the beets to the rasp in the best condition for it.*

---

* We give here a view of the washing cylinder of M. De Dombasle, which is that of M. Achard of Berlin, with some slight changes.

Fig. 47 shows the cylinder seen at the end.

Fig. 48 shows the cylinder seen on the side with its two handles and the cord which serves to raise it. The circumference of the cylinder is formed of slats of wood, leaving between them intervals an inch and a half broad, and nailed on two boards that form the two ends of the cylinder. A door which opens the whole length of the cylinder, to which it is fixed by hinges, serves to put in the beets, and withdraw them.

Fig. 49 the cylinder mounted on the cistern.

a, oblong cistern of wood.

b, cylinder resting on cletes fixed on the two sides of the cistern.

c, cletes fixed by bars of iron on which the cylinder is supported to empty it.

d, box of wood which receives the washed beets.

e, pulley by which one man raises the cylinder, while two workmen, taking it by the handles, place it on the cletes c.

The pulpy roots are, properly speaking, spongy masses, the holes or cellules of which are filled with juice. The spongy tissue, which commonly makes but three or four per cent. of the weight of the root, is wholly composed of parenchyme or woody fibre. Compression merely, however strong we may suppose it, is not sufficient to break this tissue and extract the liquid matters contained in it. To effect this, it must necessarily be subjected to the action of a machine which shall cut it up, and open the greatest possible number of these cellules. Experiments have in fact shown that the greatest pressure will not obtain more than 40 or 50 per cent. of the juices of beets, whilst the pulp obtained, by the action of the rasp on these roots furnishes from 75 to 80 per cent.

Rasping of Beets.

The mode which was first thought of to facilitate the best division of the beet was to boil it. This also was the same M. Achard had invented, who, after having boiled the beets in vapor and reduced them to paste, tried to express them. But the minute division of the pulp, which in this state was nothing but a clear paste, presented another inconvenience. It was then impossible to separate the juice from the parenchyme, this passing through the bags in which the paste was enclosed to be submitted to the press. It was therefore necessary to return to rasping the raw root.

The apparatus, which, in the factories of beet sugar, and in those of the feculae of potatoes, bear the name of rasps are composed of a plane surface, cylindrical or conical, according to the particular disposition of the apparatus, armed with rows of teeth set perpendicularly. This surface, revolving on an axis, receives from a moving power a very rapid rotary motion, by which means it tears the substances subjected to its action. In some cylindrical machines the swiftness is so great that it makes 800 revolutions in a minute.

The form of these rasps and disposition of the blades is very various. The teeth are sometimes placed on the inner, sometimes on the outer surface. When the surface is cylindrical, we give it a horizontal position; when its form is conical, the axis of the cone is vertical.

The object that we must endeavor to obtain in the rasp is the greatest possible division of the beet; for the more perfect this division is the more juice is obtained, and of consequence more sugar, in a given quantity of roots. But it is also necessary that this operation be executed in a short time, and by the waste of the least power. Among all the rasps which have been tried hitherto, those which seem to unite in the greatest degree these different advantages and which we ought particularly to mention are those of M. M. Burette, Thierry, Molard, Jr., and Odobbel.

The rasp of M. Burette, uniting to perfection of work, a great simplicity and a moderate cost, which makes it suited to small establishments, the price being but 400 francs,* we will give a short account of it borrowed from the report made on this machine, by M. Pajot Descharmes, in the name of the committee on the mechanic arts.

"A solid stick of oak, oblong, mounted on four

* 75 dollars.

legs, supported above and below by traverses, constitutes the frame which bears the different parts of the new mechanism nearly all disposed on the length of the upper traverses. These parts are composed of a cylinder of wood, suitably prepared; it is 18 inches diameter, and 8 inches broad, and armed on the circumference with 80 teeth 7 inches long. The axis of the cylinder bears at one end an iron pinion furnished with 16 teeth, which fit into those of a wheel, also of iron, having 120 teeth. A handle 18 inches long is placed at each end of the axis of this last wheel. Under this cylinder is placed a sort of box, inclined so as to send back the pulp obtained into a trough used as a recipient. On the same end of the stick, and before the circumference of this cylinder, is added, on a moveable centre, a sort of wooden flyer which receives from the axis of the pinion, and, by the aid of a see-saw, a traversing motion to and fro, in such a way that the space between the cylinder and this flyer for the passage of the substance to be rasped is alternately closed and open. The opening always is limited by a small bar, on which the flyer in its recoil is stayed. All the parts of the machine which are without the stick are covered with a box surmounted by a hopper capable of containing at least a quintal. By this machine the contact of the beet with the rasp is effected very quickly, without any splashing or waste.

Expression of the Sugar.

The beets reduced to a pulp by the action of the rasp must be then pressed, to separate the liquid part from the pulp or vegetable fibre. To this end they are put under a press. Any kind of press may be employed for this purpose. Thus in these labors it often happens that one and the same press is used for the pulp of the beet and the produce of the vineyard. However, the object in submitting the pulp of the beets to the press being to extract the greatest quantity possible of the juices they contain, it is necessary to subject them to considerable power of pressure, which it is hardly permitted to hope for with such an apparatus.

The presses most generally used are strong screw presses which only differ from the wine presses in being constructed with more care. These machines are too well known to make a detailed description necesssary.

We have tried a cylinder press of M. Lauvergnat, which has also been adopted in some factories. It is composed of two superposed cylinders. They are in a plane slightly inclined. The lower cylinder is cast-iron with a wrought iron axis. The upper cylinder is wood, its axis also of iron. These two axes turn in copper pads, which are moveable in a vertical direction, in order to be able to close the upper cylinder more or less on the lower one by two compressing screws. These cylinders receive a movement equal, and in opposite directions. Between the two cylinders is placed a cloth without end, made of strong canvass. This cloth is extended over several points of the machine by four wooden rollers, which keep it in place, and one of them is so disposed that it supports one part in a horizontal position. On this part of the cloth the substances about to undergo the compression, come, by passing through the cylinders. For this purpose, a box without bottom is placed on the horizontal part of the cloth, designed to receive the matter to be pressed. Beneath the cylinders, is a second box or tray, into which the expressed juice flows. The pulp thus enters one side of the cylinders and goes out at the other, exhausted of its liquid. This machine, which on the whole is very ingenious, has the disadvantage of not pressing the paste sufficiently to extract all the liquid; so that the pulp must be submitted to a second pressure under a screw press. This happens for the reason that the cylinders cannot be closed upon one another but to a certain point. If they are too near, but a small portion of pulp passes, very thin, which makes the operation much too long.

Some manufacturers have used the double press of M. Isnard. In this kind of press, the screw, instead of being vertical, is placed horizontally. At each end of this screw is fixed a plate, against which it is supported. The nut is in the middle of the screw, which receives a rectilinear motion to and fro, in such manner that when loosed from one plate it exercises a pressure on the opposite one. The position of the screw, and that of the matter to be pressed, render the working of this machine very convenient. It produces otherwise but a moderate effect, and seems to be generally given up.

Of all the methods to obtain a strong pressure, the most effectual is, doubtless the hydraulic press, which, as is well known, is founded on the hydrostatic principle, so that a pressure exerted on a liquid is transmitted through the whole mass with a force equal to that on the surface. We will give an idea of the manner in which the application of this principle is made to the hydraulic press.

To make this explanation more easy, we will imagine two hollow vertical cylinders of very different sizes, communicating with one another by any means whatever. A moveable stopper, which we suppose to have the form of a solid cylinder, enters into the larger cylinder, exactly fitting it. In the interior of the small one is a piston, having an arm of a lever. If, the two cylinders being full of water, a pressure is exerted by means of the arm of the lever and the piston on the surface of the fluid in the small cylinder, this pressure will be transmitted to the fluid of the larger, increased in proportion to the volume of the two cylinders. Thus, if the contents of the larger cylinder is one hundred times that of the small, the pressure on the surface of the first will be one hundred times that which was exerted on the other. This being well understood, it is easy to calculate the action of a hydraulic press. If the two cylinders being full, a new quantity of water is made to enter by means of a small forcing pump put in play by the same lever which gives the pressure to the small piston, this water, pressing from all sides, will raise the moveable stopper in the large cylinder which raises to the upper part the plate of the press.

This kind of press, which offers great advantages, has been adopted in all the factories where considerable pressure is required.

Whatever press, in fine, any one has at his disposal, one of the most important points is, that it work quick, and that the interval between the rasping and the pressure should be the shortest possible, so that the juice should not undergo any change.

The pulp, in order to be passed through the press, is enclosed in bags of strong cloth, but not too close for the liquid to escape easily; for if it should not escape, the bags would break under the pressure. The dimensions of these bags is to be determined by that of the plate of the press, leaving an excess of length sufficient for the fold that is to form the bag. The quantity of pulp put into each bag should be such as to form, when spread, a bed not exceeding an inch and a half or two inches thick. For this, a workman after having put the pulp in the bag, bears it on a hurdle of ozier placed on a tray, there, with his hands he spreads this pulp in a bed in the inside of the bag, the end of which open below, he fills with it. He places a hurdle on it, and above a second bag which he disposes like the preceding. When he has thus formed a pile of ten bags, a second workman raises it, and places it on the plate of the press. When the press has received its quota of twenty or thirty bags, varying according to its height, it is put in play.

We give to the whole of the bags which are put to the press, and which should be the same at each time, the name of a set of bags. Thus there are many sets, and some bags for change, in case of accident.

While one set is in the press, the workmen prepare another, in order that there may be no interruption in the labor. The tray on which they are arranged is designed to receive the juice that flows from the pulp when it is spread in a bed on the bags. The hurdles rest on two traverses of wood placed parallel on the length of the tray, in the direction of its breadth.

By the effect of the pressure, the juice running out of all parts, falls on the plate, and thence is conducted by a gutter into a reservoir of wood lined with copper. As it is necessary that the pressure should be made gradually, a single workman at first works the press, a second, third, and so on, coming successively to join him, to produce the greatest pressure. Then they leave the press, which, after remaining a quarter of an hour, is loosed, the bags taken out, and carried to the place destined to receive the pulp, where they are emptied, turned and beaten, in order to detach the matter adhering to them.

The bags and the hurdles should be washed at least every twelve hours with boiling water, to which should be added a little salt of soda. It should be the same also with the trays, the plates of the press, and generally all the utensils used in the operations above described. The washing of these should be done with cold lime water. In some factories where the screw press is used, they are accustomed to slack the press, to put the bags below, to remove the pulp, and then to subject it to a second pressure. This is intended to supply the defect of power, which cannot be otherwise obtained by these presses.

With a hydraulic press, capable of receiving each time thirty bags of twenty-two inches long, and fifteen broad, filled each with an inch and a half thick, the whole weight being about 800 pounds, may be made in twelve hours, ten or twelve pressings, which at the rate of 70 parts of juice for 100 of pulp, will produce from 2800 to 3400 litres * of juice.

* Litre is a French measure, which, under the new system of measures, supplants the old pint. A litre of juice would be two pounds, by the above calculation. [Trans.]

Observations on the extraction of the Juice of Beets.

The extraction of the juice of beets is one of the most important operations in the manufacture of sugar. In fact, it is in the proportion more or less great of this matter obtained from an equal quantity of beets that the advantages are to be calculated. Now, as the proportions of sugar are in direct ratio with that of the juice which is extracted, it is very evident that it is of particular importance to the manufacturer to extract from the beets as much as possible of the juice they contain. A complete desiccation made by successive dissolutions in water has demonstrated that they contain not more than ninety-six to ninety-eight per cent. of solid matter, according as they have been more or less watered, or cultivated in land more or less moist. It is well known that it is not possible to extract from beets all the juice they contain: but what is of much importance to the manufacturer is, as we have before said, to extract all that it is possible to separate from it, seeing that it is in part on the proportion of the juice that the prosperity of the manufacture depends. It is, in fact, evident that a person, who, from 100 parts of beets shall extract 90 lbs. of juice, will obtain 3 lbs. of refined sugar, while a person who shall extract but 60 lbs. will have but 2 lbs. of sugar, and of consequence a profit less by fifty per cent. This quantity of 60 lbs. of juice to 100 lbs of beets is that which is most commonly obtained. M. de Dombasle never extracted more in this manufacture, till he worked upon watery beets, harvested from a very rich soil. The proportion then rose to seventy-five per cent. But it is well to remark that this last juice was nearly one half less rich than that of good beets not watery. Thus 60 lbs. of juice of these last gave him four and a half to five lbs. of brown sugar, while the 75 lbs. of juice from watery beets furnished only 3 lbs.

The entire extraction of the juice of beets is a problem not yet solved. Experience has however shown that we may extract so much more of it according as, first, the rasping has been more complete: second, as the pulp is finer: third the pressure stronger: fourth, and that the pulp is pressed in smaller masses. M. de Dombasle thinks that the object is not attained till we shall be able to extract eighty-five per cent at least of juice from beets. We think we have reason to believe that by means of some chemical processes, and with improved presses we shall be able to extract from ninety to ninety-five per cent. The author above named gives himself to particular researches, the object of which was to extinguish the vital principle, which before existed in the beets, after they are taken from the ground, and which seems to be opposed to the emission of their juice. The desiccation and dissolution of the beets offered to him difficulties and obstacles so great that he was obliged to renounce them. This process also, after having been tried by M. M. Gotling, and Fouques had been abandoned. M. de Dombasle then devoted himself to destroying the vitality of beets as he called it, by means of the vapor of water. If it is permitted to us to give an opinion, it is not to the vitality of beets that the difficulty experienced of separating all the juice is to be attributed, but to the union of the sugar with albumen, green rosin, fat and azotic matters, &c., which M. Dubrunfaut has found in the juice. It is this adherence or affinity over which the vapor of water must completely triumph. M. de Dombasle worked in the following manner. Let him speak for himself.

"If beets are exposed to the action of the vapor of boiling water in slices of two to three lines* thick, one hour will be sufficient to destroy the vital principle, (according to us, one minute is enough,) and the small quantity of liquid which is condensed is also charged with sugary matter, as well as the juice contained in the roots. If then we pour on the slices a quantity of water equal to their own weight, keeping the mass at the temperature of boiling water, the division of the soluble matters is accomplished in less than a half hour, and the infused water is charged with half the sugary matter contained in the slices; so that if we work upon beets the juice of which is equal to 8, we shall obtain a liquid equal in weight to the beets signified by 4. By means of a second infusion with an equal quantity of water, we extract again half the sugary matter which remains in the roots. It is the same with the dissolutions, or rather infusions following; so that after four successive infusions, the slices being dried do not give more than about three per cent. of the original weight of the beets. I suppose that we have worked on beets which, dried whole, and without previous infusion, will be reduced to 14-100; we have then taken from them, by four infusions, 11-100 of soluble matter, the residue dry and insipid. On the other side, if after

* A line is one twelfth of an inch.

having obtained by the first infusion a liquid equal to 4, we pour it on new slices already submitted to the action of vapor, this liquor will equal 6 at the end of this infusion; at the end of a third, on new slices, 7. It will be the same, if instead of making the infusion of the slices by the vapor of water, it is made to undergo the action of heat in the water itself."

After these experiments, M. de Dombasle preferred, in the manufacture, in order to obtain the product in the most economical manner, to work as they do in the saltpetreries. Thus, having arranged several tubs by the side of one another, the infusion of the first tub was poured into the second, and successively into the third and fourth tub, &c., the fresh boiling water being turned on to the first, from that went to wash the others. By this means the author thought he could extract 90 for 100 of juice. He founded his opinion on a great number of experiments, which he did not try, it is true, but on a small scale, but which have inspired him, however, with sufficient confidence to take out a patent for his invention. We are ignorant to what purpose this patent can be available; for the process of submitting vegetable substances to the action of vapor, and of boiling water to extract their essences has been known a great many years. If this method succeeds, the pressing of the pulp of beets will become almost useless.

The Juice of Beets—the spontaneous change it experiences—and its composition.

The juice of the beet, in the state in which it comes from the press, has a milky tint, approaching to a yellowish white, (or a rose color more or less deep, according to the color of the beets:) exposed to the air, it immediately takes a bright violet color, which becomes more and more deep when let to stand, and afterwards turns to a dingy brown, (and ends by acquiring an oily and stringy consistence, of which we shall speak presently.) Lime in small proportions, and the strong acids, such as sulphuric acid, preserve it, at least for some time, from discoloration.

This juice enters very readily into decomposition; especially at a temperature of 12 to 15 degrees.* It then gives a blackish precipitate, and is changed into a slimy, and stringy substance, which gradually increases like the oiliness of foaming wines. It ends by acquiring the consistence of the white of eggs, and becomes sometimes even more thick, and more ropy. It is ascertained that the intensity of this consistence is in direct proportion to the saccharine richness of the juice, which is decomposed in great part, and gives place to the formation of an acid, which, Braconnot who discovered it, named nanceic, and which has much analogy with lacteous acid. The juice which has undergone this decomposition still retains a sugary savor. Potash caustic colors this viscous matter green, and disengages from it ammoniac gas, without destroying its viscosity. Lime water gives it the same color, destroys its viscosity, and produces a pre-

* The degrees of temperature in this volume are referred to the thermometer of Reaumur. One degree of Reaumur is equal to 2 1-4° of Fahrenheit, and is to be counted from 32°, that being the freezing point of Fahrenheit, and 0 the freezing point of Reaumur.—12° Reaumur, is 27° counted from 32°, or 59°.—15 Reaumur is 65 1-4 Fahrenheit. The boiling point of Reaumur, equal to 212° Fahrenheit is 80°.

cipitate. Cold nitric acid destroys its viscosity, colors it a bright fawn, and produces a woolly, greyish precipitate: it cannot be diluted in water, and does not mix with alcohol: but this dissolvent takes a deep red color, and a sugary savor; it deposits a substance having peculiar properties, some of which seem to approach those of gluten. We refer to the work of M. de Dombasle for a more full knowledge of the properties of this substance. This skilful husbandman has also ascertained it to be in the molasses of beets, drawing it out by alcohol. He has seen it also produced in a mixture of one part of rye meal with 32 of molasses of beets, and 130 parts of water which had been exposed to a temperature of 24: at the end of 36 hours the liquid began to be ropy: this condition increased during four hours, and became very considerable. We have often seen barley syrup diluted with water, (in the Bavarian mode,) and preserved in a glass bottle, acquire also this viscosity, and become stringy. M. de Dombasle considers this substance as existing in the juice of beets, and thence he advises the manufacturers to clear the juice well of it, because that by making the crystalline particles of the sugar clammy it prevents their union. We do not adopt this opinion in the whole. We think the viscous matter does not exist in the juice, and that it is only produced by the alteration. The separation of the sediment of the juice must then be prompt and complete, in order to deprive it of all the matters tending to produce or develope this formation.

The composition of the juice does not seem to differ much from that of the juice of the cane. Like that it contains water, crystallizable sugar, and sugar uncrystalizable; these two last substances, however, in very small proportions, albumen, ferment, salts, which vary according to the earth, and the manuring, pith, and beside, a little malic or acetic acid.

The following is the result of an analysis of the beet placed by M. Dubrunfaut at the end of his work. He found,—

1. Water.
2. Woody fibre.
3. Crystallizable sugar identical with the sugar of the cane.
4. Liquid or uncrystallizable sugar.
5. Colored vegetable albumen.
6. Gelée, (or jelly.)
7. Black azotic matter, precipitable by acids, and decomposing sugar in the viscous state.
8. A fat matter, solid at the common temperature.
9. A fixed oil.
10. An essential oil.
11. A green bitter rosin.
12. A gummy matter.
13. One or two coloring elements, yellow and red.
14. An active acid, the nature of which has not been determined. It is developed in conserves, and preserves roots when cut from alteration, which is manifested in the fresh root by a black color.
15. Oxalate of ammonia.
16. Oxalate of potash.
17. Oxalate of lime.
18. Hydrochlorate of ammonia.
19. Sulphate and phosphate of potash.
20. Silex.
21. Alumine.

22. Traces of oxydes of iron and of manganese.
23. Traces of sulphur.

However numerous were the matters which M. Dubrunfaut found in the beets, he did not think, however, that he had indicated all. He did not give his analysis as very exact. He proposed to resume it for the remainder.

There is reason to think that the juice of beets contains nitrates, which M. Dubrunfaut did not mention. In fact, M. M. Descroisillez and Tilloy, &c. have ascertained that nitrous gas is disengaged during evaporation of the sirup of beets, which the first attributes to the reaction of sulphuric acid on the nitrates, and the last to a reaction of organic products on the nitric acid.

Separation of the Sediment.

From the reservoirs where the juice has been received, it passes into a cauldron to undergo the separation of the sediment; that is, to be deprived of the solid matters which it has drawn mechanically, and of some soluble foreign substances which dispose the juice to spontaneous alteration, which will be mentioned hereafter. The capacity of these cauldrons varies in the different manufactories, according as the manufacturer thinks more or less advantageous. Thus, in some establishments, they have them of a capacity of twenty-five hectolitres,* while in others its capacity is only ten. The cauldrons which M. M de Dombasle used, only contained two hectolitres. In the case of a smaller content, capacity is supplied by a greater number.

* A hectolitre is a little more than thirteen gallons.

The amount of work to be done daily in a sugar factory, being regulated by that which the rasps can accomplish, the dimensions to be given to the cauldrons are to be calculated by the proportion of pulp they furnish, so that the different operations may follow immediately, and the juice may not remain in the troughs. It is the best rule we can follow to determine the progress of the operations of a sugar-house, and the amount on which we may work at a time. In the large establishments, where the quantity of juice is such that more than ten or twelve hectolitres must be worked at a time, perhaps it will be preferable to have two cauldrons. These cauldrons are of copper, of a cylindrical form, with a flat bottom: their diameter should be greater than their depth. The proportion between these two dimensions, that experience has shown to be most suitable, is about 5 to 8. They are furnished with two cocks, one at the bottom, the other some inches above. The height at which the last is placed is determined by the volume of the deposit which is formed by the separation. This deposit varies from the sixth to the eighth part of the whole volume of the liquid.

During the separation, the froth that is produced rising to the surface and forming a large cap, the cauldron must not be filled but to five sixths of its capacity. Sometimes the masonry is extended, following up the opening above its edge, and furnishing the rim with a sheet of copper to retain the foam that may pass over.

The furnaces for taking the cauldrons and all those used in a sugar factory have nothing particular in their construction. The only condition to be fulfilled is to give them the form most suitable to economize the greatest portion of the heat produced.

Process of Achard.

In announcing the practicability of extracting sugar from beets on a large scale, M. Achard published the proceeding which he employed to come at it. This process put in practice did not appear to give the results which its author had announced; and each manufacturer made those changes which seemed to him most proper to obtain the most advantageous results. Some renounced it entirely, substituting for it a method analogous to that in use in the colonies for the treatment of cane sugar. For some years, however, experience has led manufacturers to adopt nearly the same means indicated by Achard: it would seem, then, that if these means do not succeed in the first applications, it is because one has neglected to adhere to an exact execution of the operations and the proportions recommended by the Prussian chemist. The following is the manner of separating the sediment according to Achard:—

The juice running from the press is received into large earthen vessels. There is added to it sulphuric acid in the proportion of two grammes * and a half of acid for each litre of juice. Thus acidified the juice was let stand twenty-four hours. After this lapse of time the surface of the liquid must be clear and limpid: but the bottom was disturbed by a deposit of

* 27 grammes to one ounce. 2 1-2 grammes is 1-11 of an oz., the litre of the French measure adopted in lieu of the old pint. See note, p. 21.

albuminous matters coagulated by the acid and by some other impurities. The whole is thrown into a cauldron, at the bottom of which there is spread uniformly a bed of chalk in the proportion of 5,826 to a litre of acidified juice. The cauldron is to be filled but two thirds, to leave a place for the foam which is formed by the effervescence caused by the decomposition of the calcareous carbonate. The juice is stirred up with the chalk, that the combination may be made thoroughly. The sulphate of lime which results from this decomposition being not easily soluble, is precipitated, and forms the greater part of a deposit, which falls to the bottom of the cauldron.

The proportion of chalk mentioned, says M. Achard is much more than is necessary to saturate the sulphuric acid mixed with the juice; but it is better to use this matter in superfluous quantity than to risk that all the acid should not be saturated.

It is necessary that only very pure chalk should be used in this operation, the substances with which it is sometimes mixed, being hurtful to the clarification.

In the action of the sulphuric acid on the chalk there is a disengagement of carbonic gas, a part of which remains in dissolution in the liquid. The author recommends to saturate it by the addition of one gramme and six tenths * of quick lime to a litre of juice. It is now known that this addition is useless, the carbonic acid gas being easily disengaged by heat; and we may be certain that none of it remains in solution in the liquid at the temperature to which it is carried for the separation of the sediment.

---

* One seventeenth part of an ounce. See note, page 21.

This first operation being finished, the fire is lighted under the cauldron, the liquid heated to the temperature of 30°, which is indicated by a thermometer plunged in the cauldron: there is added cream, in the proportion from ten to fourteen pints, for one thousand of juice. The mass then is well stirred, and the cauldron covered. When the thermometer marks 79° the fire is extinguished, and the liquid suffered to fall to the temperature of 50 to 60 degrees. The cauldron being then uncovered, the scum which is collected on the surface and floats on the liquid in a black crust, is taken off with a skimmer.

M. Crespel, of Arras, who follows yet to this day the method of Achard, has made some changes which experience has pointed out to him, and which require the use of animal charcoal.

For the earthen vessels which received the juice, and in which it was acidified, M. Crespel substituted large receivers of nearly 1800 pints (litres) capacity; the milk was replaced by ox-blood, and the carbonate of lime by slacked lime. It is also ascertained that the continued contact of the acid with the juice is not necessary. This is the way in which M. Crespel works.

Having put the juice into the cauldron containing 1800 pints, he poured on it, cold, 2600 grammes * of sulphuric acid at 66 degrees, diluted with three times its weight of water. It is then well stirred. The mass being well mixed, there is added four kilogrammes † of lime, weighed quick, then slacked and boiled:

* A little more than 6 lbs.

† 1 kilog. is 2 lbs. 4 1-2 oz. nearly—4 kilog.—9 1-2 lbs. See note, p. 21.

after having stirred it anew, the fire is kindled. The liquid being heated to about 70°, is tempered with the animal charcoal, which was used in a previous clarification. The ox-blood diluted with water is added: the whole is strongly worked, in order to mix it well, and taken from the fire to allow the liquid to settle; then it is drawn off clear by the cock placed at some inches above the bottom.

The manufacturers of beet sugar with whom the method of Achard has not succeeded, and who have substituted for it that used for the cane sugar, must necessarily give it the modifications required by the difference in the nature of the liquid. This is the process they use.

Process of the Colonies.

The cauldron being filled and the fire lighted, they wait till the liquid is heated to 60° or 65°, then compound lime mixed with water is thrown in, in proportion of 5 grammes* of lime to a litre of juice. The liquid is then well stirred with a spoon or spatula. The mass being well mixed, is let to stand some minutes, and then a small quantity of the liquid is taken in a ladle to examine. The quantity of lime is considered sufficient, when we perceive a collection of lumps to be floating on the liquid, separate, which precipitate rapidly, leaving the liquid very clear, transparent, and light amber colored. If, on the contrary, the lumps are much broken, do not precipitate, and the liquid remains thick, it is a proof that enough lime has not been put in. In this case a determinate weight is added, such as the above

---

* M. de Dombasle says 2 1-2 to 3 1-2 grammes to a litre.

indices manifest. It is well to put in a small excess of lime. It seems now well established that the presence of a small quantity of this alkali facilitates the operations which the juice must undergo, above all when crystallizing. The quantity of lime that has been used being well known, these same proportions may serve for a whole season. However, as it is known that the juice of beets newly gathered requires a little larger proportion of it, than the juice coming from beets kept for some months, it will be well to assure ourselves, from time to time, of the quantity of lime strictly necessary.

M. Mathieu de Dombasle points out a mode of making this separation of the sediment, which ought to be mentioned here. After having put into a cauldron the necessary quantity of lime, he put into it the juice to be defecated, and kindled the fire. When the liquid has nearly come to ebullition, a workman stands at the side of the cauldron having a bucket filled with the juice cold, and a tin vessel of the capacity of about a pint. As soon as he perceives the bubbling to come through the scum in any part of the surface, he pours, from as high as he can, a pint of juice exactly on that spot; the bubbling is immediately stopped, and he waits, till it appears again, to repeat the same operation. At each time, before pouring the cold juice, the workman takes in a ladle a little juice, in the same place where the bubbling appeared, to ascertain if the defecation is completely accomplished. Then he extinguishes the fire, taking care to continue in the same manner to stop the boiling each time it appears, and not permit the juice to rise through the scum and spread over the surface. It is left to settle, and drawn off clear, as we shall say presently.

M. de Dombasle thinks that this sudden addition of cold liquid has the effect to facilitate the separation of the matters in solution, which are then coagulated in large flakes.

The variable proportions of the substances composing the juice of beets, make considerable differences in the quantities of lime necessary for the defecation of different lots of juice. Some persons add but two and a half grammes * of lime to a pint of juice; others put even seven grammes. The situations, the seasons, and the time of manufacture, may have such an influence that it is scarcely possible to fix the proportions. It will be always better to assure ourselves directly of those which are most proper.

However it may be, when we think we have attained the proper point for a perfect defecation, we extinguish the fire, leave the liquid to settle, which, during these various operations will have become heated to 70° or 75°, and draw it off after about an hour of rest.

Third operation.

The alterations that the lime has made the sugar to undergo, when it is used in excess, has induced the manufacturers to seek the means to protect it from losses caused by its presence in the juice after its clarification. It was conceived it might be neutralized by an acid; and they chose sulphuric acid, because it is cheap, and it forms with lime a salt easily soluble.

---

* See note, page 21.

After having treated the juice, as above mentioned, by lime put in the defecating cauldron, the clear liquid is drawn off in the evaporating cauldrons. Into the liquid which is then more or less alkaline, according to the quantity of lime that has been used, is poured the sulphuric acid, diluted with water, till the lime is nearly neutralized—taking care, however, that the liquid preserves a little of its alkaline quality, an excess of acid being still more injurious than an excess of lime. The point of saturation is easily known by means of blue paper dyed in tournesol, which is turned to red by an excess of acid. Paper colored yellow with saffron, (curcuma,) which the alkalies change to red, or the syrup of violets which they color green, serve to show the excess of lime.

Some manufacturers, (and this method is preferable,) add the sulphuric acid in the defecating cauldron, after the lime has worked. In this manner the two deposits, occasioned, one by the action of the lime, the other by that of the sulphuric acid, form but one. The operation is thus simplified, and in the evaporating cauldrons we have only to concentrate the liquid.

The third process which we have described is most generally used in the French manufactories. It is the same, with some slight differences, which is used by M. Chaptal, and which M. M. de Dombasle recommends.

The scum obtained by the defecation, in the several modes, is thrown at once into a filter of strong cloth, then enclosed in bags, as the pulp is, and is passed through a press specially constructed for this purpose, in order to express the juice it may yet retain.

On flowing from the defecating cauldron the juice falls into two cauldrons, the surface of the bottoms of which is equal, in each, to that of the defecating cauldron, but which are not more than half the depth of that.

Evaporation and concentration of the Juice.

By the defecation, the juice separated from a part of the foreign matters with which it was combined, has lost something of its density; so much so as to mark from 1° to 2° at least on the hydrometer. It is therefore in this state, that it comes into the evaporating cauldrons, and in which, after having neutralized the excess of lime, if any, by means of a sufficient quantity of sulphuric acid,* it is made to undergo an evaporation that carries it to 20° or 25° of the hydrometer, boiling, which answers to 24° to 29°, cold; that is to say, it experiences a reduction of volume equal about to 4-5 or 5-6 of its whole volume. In proportion as the water is evaporated, are the flaky matters separated which the liquid holds in solution, and which affect its clearness. These matters collect in a white foam on the surface of the liquid: to favor their formation, we husband the fire at the beginning, adding also sometimes a little blood or white of egg beat up. The workman takes care to remove all the

*It is best not to neutralize the lime entirely. It is necessary to allow a small portion of it to remain, which should be such that in immersing in the liquid some blue paper of tournesol reddened by a very weak acid, the paper shall resume its blue color very slowly. We will add that it is also essential, not to redden the paper till the moment of using it, because of the ammoniae gas diffused through the atmosphere of sugar-houses. J. F.

scum; when it no longer forms, he increases the fire to hasten the evaporation. During this evaporation the juice rises in froth, mounts and seems about to flow over the edge of the cauldron, which often happens if this rising is not prevented. For this, a small quantity of some fat substance is thrown on the surface of the liquid; butter is commonly used. When the action is not very great, the workman contents himself with beating the surface with the back of a skimmer. It is necessary to prevent as much as possible this rising of the liquid, and to keep the boiling low. The bed of liquid which settles at the bottom of the cauldron becoming then very thin, may easily be caked, as it has been remarked that this takes place whenever the liquid has not a certain height in the cauldron. This height varies, from two to four inches, according as the surface of the cauldron is larger or smaller. The bed of liquid to be evaporated, must not be made very deep, because the evaporation being proportional to the surface directly submitted to the action of the fire, and not to the height of the liquid, the time necessary to bring a given mass to a determinate point of concentration, will be shorter, as the surface is large and the bed thin.

The workman knows that the juice has come to a point suitable for concentration by the reduction of volume, which is scarcely more than 1-5 or 1-6 of that which it was at first. The liquid must then mark, boiling, 26° on the hydrometer, or 30°, cold. The juice of two evaporating cauldrons is now poured together into one, to proceed to the clarification; that is to say, to the separation of foreign matters which the juice yet contains.

6

The first thing to be done before beginning the clarification is, as we have said, to be assured of the state of the liquid, to know if it contain an excess of acid or of lime. In the first case, it will be necessary to neutralize it by adding lime. If the liquid, on the other hand, contain an excess of lime, it is equally necessary to saturate this with sulphuric acid diluted with water, so that the sirup shall be but very slightly alkaline, as we have already said.

This being ascertained, and the sirup suitably prepared, we pour on it for each hundred pints (litres) five kilogrammes of animal charcoal;* the liquid is stirred, to mix well the charcoal; care is taken to divide with the skimmer the collections that may be formed; we bring to the surface that which is precipitated, and continue thus to stir it, till, by the ebullition, the charcoal shall be maintained in suspension in the liquid. The sirup has then the appearance of a muddy and black mass. It is kept in ebullition some minutes, to leave the charcoal time to act. During this time, we dilute one pint of blood or two pints of milk in water, or, better still, five eggs to a hundred pints of sirup, and pour this solution on to it, taking care to mix well the mass till the ebullition that was

* M. M. de Dombasle advises to put the animal charcoal into the liquid after its saturation, in the proportion of 1 1-2 pound to a quintal of juice, and to proceed then to the evaporation till the sirup marks, boiling, 20° of Beaumé on the hydrometer. Having gone thus far, he leaves it 24 hours in wooden settling vessels, where it deposits, in cooling, a large quantity of calcareous salts, particularly malate of lime. When this sirup is very clear, he concentrates it rapidly to 32, and adds then 12 oz. of animal charcoal to a quintal of juice—that is, half of the first dose. When the sirup has fallen to 75, he clarifies it again with ox blood. This means seems to us preferable. [J. F.]

arrested by the addition of this cold liquid is produced again. We then cease to stir it, and leave it to boil for some minutes. We know that the quantity of blood or eggs that were added were sufficient, by plunging a skimmer into the cauldron and withdrawing it. The sirup that flows from it, seen through the light, must present a great transparency, and the charcoal swim in lumps. If the sirup does not have this appearance, blood or eggs must be added anew, till we perceive these indices of a perfect clarification.

Filtration.

When this operation is finished, we pass to the filtration of the liquid. For this, it is put on filtres, varying in form in the different factories. In the most they are paniers of ozier, furnished interiorly with a strong cloth or stuff of wool, in which the sirup is poured, which leaves on the filtre the matters that foul it, and flows clear into the receiver placed below. These paniers are sufficiently large to receive each the product of one clarification. The filtration progressing with so much more rapidity as the sirup is more warm, we have been obliged to seek means to continue its temperature a long time. There have been therefore substituted in many factories, for the paniers, wooden cubical chests, lined in the interior with hurdles of ozier, covered with a cloth or a woollen stuff, and furnished with a wooden cover. The liquid flows through a cock placed at the bottom of the chest. in this apparatus the liquid less exposed to the contact of the air, retains a longer time its fluidity, and the filtration is continued without interruption—an inconvenience frequently occurring in the paniers by the gluing up of the filtres.

The deposit which remains on the filtres, and which is composed of animal charcoal, of the albuminous matters that have been used and become coagulated by the effect of the heat, and the matters taken off the sirup, is impregnated with a considerable quantity of sugar sufficient to make it advantageous to extract it. This is done by repeated washings. The animal charcoal which has been used the first time in the clarification is useful again, either in entering anew for a part in that of a following clarification, or being added in the defecating cauldron, from which it goes out with the scum.

We ought to mention the differences that exist between the methods followed in some factories and that above described. Thus M. Chaptal, whose defecating cauldron contained 1800 litres, used only one evaporating cauldron for each defecation. This cauldron was 15 inches deep. When the juice in it marked 5° to 6° of concentration, he commenced throwing in the animal charcoal, and continued it, increasing the quantity by degrees till the juice was concentrated to 20°. He used in this manner 25 kilogrammes of charcoal for each operation of 1600 to 1800 litres of juice. Once come to 20°, he sustained the evaporation till the boiling sirup marked 27° to 28°; then he filtrated it in paniers of ozier of two feet in diameter placed over a cauldron and furnished with a cloth bag of a diameter equal to the panier. When the sirup, thickened by cooling, flowed more slowly, and finally stopped, he folded the edges of the bag toward the interior of the paniers, and put above a plank of wood which he loaded gradually with iron weights to work a suitable pressure. The filtration was finished in two or three hours.

We will remark, in the detail of these operations M. Chaptal does not say that he used ox blood or white of eggs.

Achard concentrated his sirups by means of the heat disengaged by the condensation of vapor. He had for this two low cauldrons for one defecation, under which he conducted the vapor. He filled the cauldrons only to six inches at most, seeing that in this mode of heating he had not to fear that the sirup, reduced to a very thin bed, would become caked, since the temperature of the liquid could hardly go beyond 70°, Reaumur. This mode of evaporation had the inconvenience of being very long, the vapor that Achard employed being produced simply under atmospheric pressure. They have made in England a very good application of this method of evaporation, using the vapor formed at a high pressure, and having, by consequence, a temperature much more elevated than that formed under the ordinary pressure. Farther mention will be made of it when we shall treat of the new processes used in the refining of sugar.

M. Crespel, whose name always presents itself, when we treat of improvements in the manufacture of beet sugar, used formerly six evaporating cauldrons for one defecating cauldron. Each of them was seven feet long, and three feet broad. He poured in each cauldron 280 to 300 litres of this juice, which made a bed of liquid of 4 inches to 4 1-2 inches high. He kindled a smart fire till the liquid marked 20° on the hydrometer, which happened commonly after 5 hours' ebullition. The juice was then reduced, according to its richness, to the 7th or 8th part of its volume. For these cauldrons, fixed, M. Crespel substituted a like number of vibrating cauldrons, placed in a line, and following the defecating cauldron. The charge of one of these last is immediately poured equally into these six cauldrons to be subjected to a quick evaporation. When the juice has acquired a density of 20°, he puts the liquid of the six cauldrons into one to be clarified.

Baking the Sirup.

The sirup that flows from the filtres bears the name of clairce, (or clairée).* It goes into reservoirs which in the ateliers are called avaletout (receive all.) In this state the cold sirup marks nearly 30°. This density is not sufficient to crystallize it. It must then be again concentrated, to remove the water that holds the sugar in solution. This is the object of the baking. When this avaletout has received a quantity of sirup sufficient for one baking, and the sirup is very clear, we proceed to this operation in cauldrons like the evaporating cauldrons, only of smaller capacity, or in the vibrating cauldrons, which have many advantages over the others. These cauldrons are commonly circular and with flat bottoms. Their diameter is about three feet, their depth one foot. They have a nose, under which is a solid axis, on which the cauldron turns: on the side opposite to the nose, is a ring to which a chain is attached, passing over a pully. The workman drawing the chain, raises the cauldron, and makes it swing so as to pour out of the nose the liquid it contains.

* That is, sirup clarified, and prepared for baking. [Trans.]

The upper part of the furnace has a circular opening, of a diameter a little less than that of the cauldron itself. This is placed over the opening so that the greater part of the surface of its bottom is exposed to the direct action of the fire. This is for the purpose of obtaining a quick ebullition, throughout the cauldron; and it is especially necessary to obtain this, if we wish the sirup to bake rapidly.

After having put into the baking cauldrons fifty pints nearly of clarified liquid each, the fire is kindled, and a thermometer placed with the bulb wholly immersed in the liquid in the cauldron. The sirup coming into the cauldron at a temperature already very high, which it has on flowing from the filtres, quickly enters into ebullition. But before coming to this point, the sirup makes yet a little white froth. It is so arranged that for some minutes the boiling is produced only in the centre of the cauldron, to make it more easy to take off the scum, which is then passed toward the circumference.

When a little thick sirup has flowed into the avaletout, we add a white of egg beat up, to the sirup in the baking cauldron, and take off with the skimmer the impurities that rise to the surface.

The skum being taken off, a brisk fire is made, till the thermometer goes to 85° or 86°. It is prudent, at this time, to look well to the fire; for the nearer it approaches the point of baking, the greater is the liability of burning the sirup.

During all this first operation, if the sirup is of good quality, it presents over the whole surface a good jelly broth, and white, which rises fast. This is called dry broth; on the contrary, it is called a fat broth, when it has a frothy and viscous appearance. In the last case scum is produced abundantly, the sirup rises very much, and the baking becomes difficult.

When, during the baking, the sirup tends to rise, we throw into the cauldron, as we have before said, as is practised when the same phenomenon is produced in the concentration, a little butter, or any other fat substance, the effect of which is to smooth immediately the surface of the liquid, to disperse the lumps that cover it, and to clear the broth. This going down of the ebullition is so much more prompt as the sirup is of better quality, the addition of butter having but little, and sometimes no effect on a fat liquid.

At the moment the workman perceives that the thermometer indicates 85° or 86°, he must lessen the fire, and prepare to take the proof, that is to say, to ascertain the state of concentration of the sirup. This he does when the thermometer announces 89°. The proof is made in two ways, by the thread, and by the breath.

The proof by the thread is made by plunging a skimmer in the sirup, withdrawing it, and taking on the thumb some drops of the liquid. The sirup thus placed, is left to cool an instant. Then the fore-finger is brought near to the thumb, so as to put the two in contact. When the sirup interposed between them is reduced about to the temperature of the hand, the fore-finger is to be suddenly raised; in this separation it forms a thread. If the thread is weak, if it breaks near the fore-finger, the baking is called weak; which means that the concentration is not pushed to the point to which the solution will be in the most favorable condition for forming crystals. It is found on the other hand, and is then said that the baking is good, when the thread is lengthened out an inch or two, breaks toward the thumb, and turns up toward the fore-finger in form of a hook. This point passed, the thread is lengthened more, breaks equally toward the thumb, bending into a hook; but it retires but slowly into the drop adhering to the fore-finger. The baking is then called strong.

For the proof by the breath, after having plunged the skimmer into the boiling sirup, it is withdrawn, shaken over the liquid to throw out the greater part of the sirup it bears, and is placed vertically before the mouth. Then a strong expiration is made through the holes of the skimmer, by which will be detached a collection of small white lumps, like lumps of soap. According as these lumps are more or less numerous, and remain a long time, we judge that the baking is strong or feeble. Before and after the point of baking, there are no lumps produced.

The thermometer, the use of which has been frequently mentioned, may also serve to determine accurately the point of the baking. To make it the better understood, let us recall some of the circumstances that accompany the boiling of liquids holding matters in solution. Pure water under the pressure of the atmosphere boils at 80° Reaumur: if there be added to the water, a body which has an affinity for it, that is to say, that is easily dissolved, such as sugar, the point at which it will boil will be so much higher, as the quantity of this body and its affinity for water shall be greater. In fact, the boiling of a liquid taking place when the elastic force of the vapor is equal to the pressure it sustains, the addition of a body that has an affinity for it will delay the time when the elastic force of the vapor will counterbalance this pressure; so that to bring it to the point at which it will overcome the resistance of the atmosphere, it will be necessary to raise the temperature of the liquid higher, the tension or elastic force of the vapor increasing with this.

In applying this principle to the case before us, we see that the temperature necessary to keep the sirup boiling must be raised in proportion as the water will be vaporized, and the sugar will be in larger quantity in the liquid.

The point of the baking being the moment when the relative proportions of the water and sugar which constitute the sirup will be most suitable for making the crystallization easy and abundant, this point once determined by comparing it with the thermometer, will always be known by that means. Thus it is found, that the weak baking answers to 89° or 89 1-2° Reaumur, and the strong bake to 90 1-2° or 91°.* As different causes may make these indications of the thermometer vary sensibly, perhaps it will be better only to consider them as announcing the approach of the point of baking, and the moment to take the proof by the ordinary means.

A thermometer for the sugar-house ought to be graduated to 100° Reaumur, at least, it should be mounted on wood, and its degrees marked on a cop-

---

* 89° Reau.=232 1-4° Fahr. 90° Reau. 234 1-2° F.—91° R. 236 3-4° F. [Trans.]

per scale. It should be large enough to mark the half degrees. A thermometer of this kind will be about two feet long.

The hydrometer may also furnish some indications, less exact, however, than that of the thermometer, of the approach of the point of baking. Thus the sirup at the point of baking marks 44° to 45° on the hydrometer.*

When come to the point of baking, the sirup has lost 40 per cent. of the weight it had when put into the cauldron for baking.

As soon as the workman has ascertained the baking point, he draws the chain to raise the cauldron, and pour the sirup into the cooler. Thus emptied, the cauldron must be immediately filled. If the reservoir of the clairée is not placed so that it runs through the cock into the baking cauldron, the workman, before emptying it, takes good care to fill a bucket that he pours into the cauldron as soon as he has taken out its load. If, in the baking, the sirup had been burned, or if there were attached to its bottom any matters that adhered to it, it would be necessary to wash them, and remove them carefully, before exposing them to a new fire.

Bleaching the Sirup.

The bleaching of the sirup presents a problem, the solution of which is interesting to the sugar-works and refineries. M. Pajot des Charmes has been occupied with this solution in relation to the refineries, and has published the means by which he succeeded.

* M. de Dombasle prefers the proof by the thread to all others. [J. F.]

He devoted himself to a series of experiments which he gave to the public in the "Journal de physique de chimie et d'histoire naturelle," in July, 1822. Before entering on the matter, this learned man thought he ought to give a summary of the processes followed thitherto in the refineries to clarify the sirups, before he spoke of those which he offered to replace them. The processes employed consisted in dissolving at a heat below 80° Reaumur, a given quantity of some sugar, in about half of the whole weight of the sugar, either of pure water, or of the washing of the scum, or a mixture of common water, and that resulting from the washing, and to add to this solution a determinate portion of albumen or ox-blood, and of vegetable or animal charcoal, or solely of this last, to take off the scum which comes to the surface of the sirup, then to pour the whole into a filtre suitably disposed. The liquid filtrated, cleared of the refining matters, ought to mark on the hydrometer of Reaumur from 28° to 32°. It varies in color according to the sugars used to make the solution; but it is clear and transparent. Evaporated by a lively fire kindled so as to make the liquid boil, we carry it to the 43° of the same hydrometer, and pour the sirup, carried to this degree into the forms, where it is left twenty-four hours, to crystallize. At the end of this twenty-four hours, we open the opening placed at the lower part of these forms, in order to let drop the sirup not crystallized, which is called green sirup, or shaded sirup, according as it is clayed or not. These sirups are always much colored, and of a shadowing more deep, as they have undergone more bakings, to be deprived of the crystallizable sugar; so that they are totally deprived of it. The mother water left after all these operations, is nothing but a blackish, gluey, viscous, uncrystallizable substance, known under the name of molasses.

After having spoken of this mode of working, the author enters on the subject and describes his bleaching matters, which are charcoal, and oxy-muriatic acid, (chlorine.)

Use of charcoal. According to M. Pajot des Charmes, vegetable or animal charcoal, or a mixture of the two may be used. However, he only speaks of animal charcoal, this being preferable. It is therefore with this, at the different temperatures, that M Pajot des Charmes operates.

Experiment of the Bleaching of the Sirup of Brown Sugar by Charcoal, with the aid of Heat.

From the experiments M. Pajot des Charmes has made, he recommends, before working the decoloration of the sirup at a heat of 50° to 60°, and by the aid of an equal quantity of pure water or the product of the washes, or of a mixture of pure water and washings, to separate by means of dissolution and filtration the insoluble and strongly colored matters, which, sometimes, are about six kilogrammes to a quintal measure.

The solution being filtrated, there is added five kilogrammes of animal charcoal, ground as fine as possible. It is mixed with a wooden spoon, in such way that it shall not run over. The liquor is heated to a simmer. The fire is put out, and the whole poured on a filtre. The filtrated syrup is removed and carried into a cauldron which has been already used, or in any other, and four kilogrammes of animal charcoal again added to it: it is heated, removed as the first time, and the mixture poured on another filtre. The filtrated liquid is carried again into the same cauldron cleaned, or into any other, and three kilogrammes of animal charcoal again added. The operation is repeated as in the preceding way, and it is poured on a new filtre. The decoloration is continued farther by a quantity of charcoal in a dose of one kilogramme: it is heated to a simmer, and poured on another filter. This filtration finished, the sirup then presents a color like water, and marks on the sirup proof 30° to 32°. This process consists, first, in a filtration of the solution of sugar to separate the insoluble substances: second, in five successive decolorations of this liquor by the use of 32 per cent. of animal charcoal, with the aid of heat.

A similar experiment made on clayed sugar, but which had only received one claying, gave very advantageous results. Three decolorations with animal charcoal in the proportion of twenty-four to a hundred of sugar, using for the first decoloration five kilog., four for the second, and three for the last, produced the same effect.

The author remarks, that the number of decolorations is more or less according as the process is applied to brown or clayed sugar.

Experiment made on the Sirup, cold, of Brown Sugar of poor Quality.

Fifty kilogrammes of brown sugar of poor quality were dissolved in an equal weight of common water, at the temperature of the atmosphere. There was put to it one fifth of the weight of sugar of animal charcoal powdered (10 kilog.) The mixture of charcoal and dissolved sugar was stirred for ten minutes; it was then left to rest the same time. After this repose, the stirring and rest were repeated during ten minutes, it was then thrown on a filtre. This operation was repeated five times in the same manner, taking care to change the filtre each time, and to use the second time 1-7th of the weight of sugar of charcoal, (7 kilog.) the third time 1-10th of the weight of sugar, (5 kilog.) the fourth time 1-10th, (5 kilog.,) and the last time the same, (5 kilog.) The sirup obtained after the fifth filtration was as clear as pure water.

This process requires, without fire, five passages of the charcoal, 32 kilog. of this substance, double the quantity required by the same sugar to be decolored with the aid of heat.

The same experiment made on a clayed sugar in the same circumstances, has demonstrated that for 50 kilog. of this sugar, the charcoal is required three times, 20 kilogs. only for the entire decoloration. The first mixture was 10 kilogs., the second and third, 5 kilogs.

A new experiment made by the same process, cold, on some brown sugar, considered to be of middling quality, established that 50 kilogs. of this sugar was entirely decolored by three passings of charcoal: the first of 10 kilogs. the second and third of 8 kilogs.

One other decoloration (always by the same process) has demonstrated that 50 kilogs. of sugar that had received two clayings, did not require but two passings of charcoal: the first with 10 kilogs., the second with 6 kilogs. The sirup coming from this operation had the transparence of water.

M. Pajot des Charmes having observed that by the common process of our refineries, there remained in the decolorants, the filtres, and several skimmings about the fourth part of the dissolved sugar; that by the process above with heat, there remained the third, and by that in cold, one half; that beside, the number of filtrations of the same sirup by these processes requires, whether operated in warm or cold, a great loss of time, which it was important to diminish, he sought the means to remedy this double inconvenience, by the particular disposition of the filtres, which he placed one over another, in form of columns, and which would work with or without heat.

The filtres in columns have the advantage, being placed one above another, to spare hand labor; since the sugar in dissolution falls on the first filtre of charcoal, passes successively on the others, and arrives at the last decolored and transparent, like water. This economy of time is equal to six-eighths of that employed by the filtration worked by filtres placed horizontally.

There is an economy beside of fuel, since there is need only of one fire, if the process is by heat, and that to sustain this in the interior of the column or coffer which contains the filtres, we may place a stove there, or direct into it a funnel, similar to a stove.

To economize the heat of the stove, or of the column containing the filtres, the author sought to supply the place of both by a particular process, in order to obtain a permeability equivalent as near as possible to that produced by the heat, making use of fine silex well washed, and mixing it with charcoal in the proportion of two to three times the weight of this last, (a proportion which may be modified.) Then to supply a property which the charcoal has of acting more strongly by heat on the coloring substance of sirup, M. Pajot des Charmes increased the weight of charcoal, in order to increase the decoloring surface.

The placing of the mixture of carbon and silex, demanding a certain care, especially for the first and last filtres, the memoir of M. Pajot des Charmes contains the following description:—We spread over the linen that covers the webbing or cloth, the charcoal mixed beforehand, with two or three times its weight of silex washed, and only moistened. We must spread with this mixture the sides of the filtre to the height of several inches, in such a manner as to form a sort of chest, covered with linen, finer than that below. In this sort of chest the sirup is received fit to be filtred.

In the following filtres we place the silex immediately over the tricot, and above the quantity of charcoal, then a linen designed to receive the sirup.

These two ways of receiving the sirup are equally good. The essential thing is, that the beds be equally spread, and the edges be raised on the side of the filtre.

To separate as much as possible the liquid matters contained in the decolorants, they must be submitted to the action of a lever press, or, better still, of a hydraulic press. The washing will be more easy. It is convenient to put on a filtre the liquor obtained from this pressing.

The author repeats here, the recommendation he had given to filtrate the solution of the sugar that he is to refine: he insists on the advantage of this filtration, which is favorable to the bleaching. He asserts that the sirups, green, shaded, even the molasses, are benefited by the operation.

The part of this memoir which treats of the decoloration of sugar by charcoal, concludes with some observations on the importance that the author attaches to having the liquor mark 28° to 30° after the decoloration. He points out the disadvantage of having it at a lower degree; for it will be colored by a baking necessarily so much larger. But this inconvenience is not to be feared when the decoloration is made with the aid of heat, although the quantity prescribed scarcely allows to the solution more than 25° or 26°. This degree is enforced by the operation that follows. The process in the cold, not giving an increase of the sirup, we may from the beginning carry it to 30° and 32°: since the mixture of charcoal with the silex in contributing to the permeability of the sirup, facilitates also the loss of its viscous quality. Then to attain 32° of concentration, the proportion of sugar to that of water must be about two parts of water to three parts of brown sugar, of middling quality.

Employment of Chlorine.

In the gaseous state, this substance may be applied two ways, either on the sugar in the natural state, or in grain, or in a liquid state. These two modes according to the author have their particular advantages.

He applied this process to the liquid sugar, passing in proportion to the distillation, some chlorine in a solution of sugar previously filtrated. He facilitates the absorption of the gas by means of a valve. When he has obtained the tint of the desired color, even including that of purified water, he takes care to fix this tint by filtrating the liquor on chalk, in order to take away the muriatic acid, then on animal charcoal. The sirup, after the filtration, passes soon to the baking.

The advantage that results from this method depends on having the sirups constantly of the same specific gravity, of obtaining a gas endowed with all the strength proper to it, of directing on the sirup the whole quantity of it necessary to decolor it, and of requiring but one direct operation in decoloring it.

The chlorine gas may be applied to sugar in grain. For this, the sugar is spread on floors, or strong hair canvass, arranged in stages about a chamber, into which will be led the ends of the vessels from which the chlorine is disengaged.

When the gas is in contact, care must be taken to renew the surfaces, by using a rake, the handle of which extends beyond the wall or partition, where the substances are in contact. According to M. P. des Charmes, it is necessary that the súgar be well bleached; that it be in beds of not more than three or four lines * thick, in order that the gas act above and below the hair. The sugar must then be passed through lime, to separate the excess of hydrochloric acid, as in the preceding experiment.

The liquid chlorine may be employed in two ways; the first, putting into the sirup which has been filtrated one fifth in volume of liquid chlorine in a cask, and shaking it, then putting it into a cauldron with animal charcoal, filtrating it, putting it back in the

* Twelve lines to an inch. [Trans.]

cask, and adding anew one-sixth of the chlorine, putting it into the basin, with a new quantity of animal charcoal, filtrating it, and mixing it anew with one-tenth of its volume of chlorine. This operation is repeated, and the sirup added with some charcoal is finally thrown on a filtre. It passes then, clear and transparent like water.

We may also apply the chlorine to the decoloring of the sirup; but first, making the charcoal act as a decolorant, and, after this operation, adding the chlorine in the sirup, shaking the cask, putting it into a cauldron, filtrating it, and putting it again with a new quantity of chlorine.

This method, which succeeds in the decoloration of sirup made by a solution of sugar, may also be used in the decoloration of green sirup, shaded, sirups of lumps, of bastards, and vergeoises. The molasses may be brought to a white tint, so as to make them sought for uses to which hitherto commerce has not applied them.

Some experiments made by M. P. des Charmes have demonstrated that vegetable charcoal was a good decolorant; but he observed that the charcoal has the disadvantage of mixing badly with the sugar, and that a portion of the charcoal remains on the upper part of the sirup without mixing.

The author announces that the animal charcoal that has been used in the sugar refineries is an advantageous fertilizer to the plantation, or to the nurseries, and that already exportations are made of it from Paris to the environs.

M. des Charmes having tried if the charcoal used, but calcined, could be used anew as a decolorant, did not find any difference from the new animal charcoal.

Working the Moulds.

The sirup being baked to a suitable point, is poured into a large copper cauldron called a cooler. Its capacity should be such that it may contain at least four bakes. The most convenient disposition of the atelier is that by swinging the baking cauldron, the sirup flows into the cooler, placed in a part near to that where the furnaces are. This part bears the name of empli.*

As fast as the new bakes come into the cooler, they are stirred with a large iron spoon, to mix them together, and the liquid is then let fall to 70° or even to 60°. The bottom of the cooler is covered with a thick bed of crystals, having but little consistence: the sides also are covered with crystals, and the surface of the liquid soon forms a crust. When this takes place we must take care to make an opening, and pour the bakes with caution, as the liquid flows by the opening below this crust, and raises without breaking it. It goes thus from the opening to the cooler, and the cooling takes place very slowly.

To determine the crystallization, or, as it is called, the formation of the grain, when the sirup is thin, we put sometimes in the cooler, before pouring in the first baking, a light bed of brown sugar. It is known, in fact, that a solid body placed in a solution is a true nucleus, about which are collected the molecules of a crystallizable substance.

The temperature of the sirup being fallen to a

* That is, a fill of moulds, or place to hold all the moulds to be filled from one cooler.

suitable degree, we proceed to filling the moulds. These are large conical vessels commonly of earthen ware, the point of which is pierced with a hole about nine lines in diameter. Their content is 45 or 50 litres of sirup. They are the same moulds that we shall mention presently in treating of the refining, under the name of grand bastards, or moulds in vergeoises. M. Mathieu de Dombasle who has proposed to substitute for the earthen moulds, wooden vessels of a similar conical form, says, that he used these last with advantage.

Some hours before filling them, we immerse them in a large basin full of water called the mould trough, (bac á formes,) whence they are taken and left to dry a short time before the moment when we are to pour in the sirup. We cover their opening with some old linen, or, better, with a cork.

Thus prepared, the moulds are put in the fill, (empli,) and ranged in two lines,the lower part against one of the walls of this atelier, this is what is called the plantation. They are sustained in this position by other moulds placed on their base. A workman now detaches with the iron spoon the sugar which is attached to the bottom and the sides of the cooler, and stirs it, to mix it with the mass which remains fluid. He continues to stir it till the cooler is wholly empty.

The workman charged with the business of pouring the sirup into the moulds brings to the cooler a copper basin which he holds by the two ears. This basin has a nose, in the form of a large gutter, very broad, by which the sirup is poured into the moulds without danger of spilling. It will contain 12 or 15 pints of sirup. Another workman takes the sirup in the cooler, and with it fills the basin two thirds. The basin thus filled, the workman pours it into the moulds, taking care to divide this first charge between two or three. It is the same with the second, which he pours into the next moulds, and so on successively till all the moulds have nearly an equal quantity of sirup. This is what is called a round. A first round finished, he makes a second; that is, begins again to pour new charges into all the forms, as he had done the first time, and continues in this manner till they are all filled, or the cooler is empty. Some hours after the work of filling the moulds has been performed, a crust is formed on the surface of the liquid presented at the upper part of the cone. When it has acquired a certain consistence, we pierce it with a wooden spoon about two inches broad, which we dip into the mould, and with which we stir the sirup for some minutes. Care must be taken in this operation to detach the crystals adhering to the sides of the mould, and to bring them as much as possible into the centre. The crystallization is then left to itself, and is quickly formed through the whole mass. Through all these operations the temperature of the fill (empli,) must be maintained from 15 to 20°.

The characteristics which serve to show if the sugar is of good quality, if it is well baked, if the fill has been made at a suitable temperature, are the following:—The surface of the crystallized mass must be dry, and present a brilliant aspect. By the effect of the contraction of the sirup in solidifying, a slight depression of this surface must be produced: crevices will be formed in it. About 36 hours after the fill, the temperature of the mould not being more than about 20 degrees, we transport them to a part of the factory called the bleachery (purgerie.)* We have previously arranged in this place a number of pots equal to the moulds that have been filled. These pots are of earthen ware. They must have a broad base, and their opening large enough to receive the point of the mould some inches deep. They must contain about two thirds of the molasses which must flow from the loaves; that is to say, 15 or 20 pints.

After having withdrawn the stopper which closed the usual opening at the point of the mould, we place this on a pot. The molasses which flows at the first instant is so abundant that it will be necessary to visit the pots frequently, to change those that are full. In the five first days the loaves give nearly two thirds of the molasses they contain. To facilitate their flowing by preserving their fluidity, we maintain the temperature of the room at 12° or 15°.

To hasten the separation of the last molasses, which takes place rather slowly, we bring the moulds into another place which we can raise to a temperature of 40 or 50°. There they are placed on new pots, after having thrust into the point of the loaf an iron bodkin, to pierce it, make an opening, and facilitate the flowing of the molasses. This operation is repeated as often as it is perceived that a mould does not flow. After having remained again five days in this second place, the loaves are dry and are taken away. For this, after having detached with a knife the base of the loaf from the sides of the mould, we take these

* Place so called, where the sugars are put to whiten, and to drain off the molasses.

from the pots and place them on the floor, their point upwards, and leave them in this position for a couple of hours. Then, seizing the point of the mould, we give it a jerk, which detaches the sugar and makes it fall by its own weight. This is what is called to loose the loaves, (locher.) The mould is then taken away.

The aspect which the loaf presents is of a cone of a red color, whose tint goes gradually deepening from the base to the point. All the heads of the loaves which retain always some humidity and a portion of molasses which colors them and makes them viscous, are cut and thrown into one mould to dry. They are put in the sirup in clarification. The molasses that flows from the moulds is put together, to be concentrated and baked again, in order to obtain all the crystallizable sugar in it, and which sometimes amounts to a sixth part of the sugar already obtained. In some factories they rebake the molasses immediately on its flowing; in others they preserve them to use after the work is gone through. For this they are put in reservoirs, or in casks placed in the cellars or cool places, to be taken up afterward. This last method has the advantage of not requiring particular apparatus, and of not interrupting the course of operations; but it requires vessels to contain the molasses and magazines to keep them. Beside, according as the season is more or less favorable the molasses run the risk of undergoing alterations. In all cases they are treated in the same manner that is to say, they are evaporated to bring them to the same condition as the sirups of the first baking. Their baking must be pushed a little farther than that of new sirup. The loaves made from them also require a little more time for their refining. Some factories are in the custom of clarifying them with a small quantity of animal black. But then, if they mark more than 24° of the hydrometer, water must be added to reduce them to this density. Without this precaution it will be very difficult to filtrate them. The molasses obtained from a second crystallization has an acrid taste, and can only be used for distillation.

The mode of crystallization that Achard pursued is so different from that above described, we think readers will be pleased to have it repeated here.

Achard, as we have already said, concentrated his sirups by heating the cauldrons that contained them with vapor. He thereby prevented the change of a portion of crystallizable sugar into incrystallizable, as happens by a too long exposure over the fire; but it was altogether impossible by this mode to push the baking to the point that we have said is practised, that is, to mark 90° on the thermometer, as the point of concentration to which the sirup must be carried. Achard obtained but a very small quantity of crystals. To supply this defect of sufficient evaporation, he put his sirups in vases, which presented a large surface. The sirup concentrated to 28° of the hydrometer, was distributed in these vessels in very thin beds, then exposed on a stove to warm air. He produced a slow evaporation of the liquid, and the bottom and sides of the vessels were covered with a bed of crystals nearly like those that form sugar candy. He broke these cakes as soon as formed, and when he had a sufficient quantity of crystals, he cast them into moulds, like those above described, to drain off the molasses. This operation required a considerable time, numerous evaporating vases, and very large stoves. It would be impossible to follow this method in a large establishment. We have only spoken of it, to tell what has been done.

M. M. de Dombasle used, a long time, an apparatus warmed by vapor, to concentrate the sirups, at a density of 32°. The apparatus was as follows:—

On a horizontal copper sheet of 15 feet long and 4 feet broad, the edges of which were raised, he placed a bed of sirup at 32°, about one inch and a half thick. This sheet was fixed on a wooden leaf, and supported by iron bars 6 inches long. The whole was fixed over a cauldron that supplied the vapor, on masonry. The author, who accords to this mode great advantages over all others; acknowledges, however, that it requires a large space and a great number of cauldrons, since the sirup must remain quiet eighteen and sometimes twenty-four hours, to come to the point of concentration at which it will crystallize.

Refining of Sugar.

The colonies supply us first with brown sugar, or muscovado; second with sugar cleaned, or gray refined sugar, gray cassonade; third, with clayed sugar, or white cassonade; fourth, with refined and powdered sugar. That which the domestic manufactories give, which is extracted from the beet, is brown sugar.

In these different states the sugar will not be proper to all the uses for which it is employed. It is mixed with some foreign matters, and thickened by a quantity, often very considerable, of molasses, which colors it with a tint more or less deep, and gives it a disagreeable taste and flavor. The sugars of the colonies which are always made with a great excess of lime contain almost always a great proportion of this alkali, so that it will be easy to recognize its presence by their acridity. Beside the necessity of separating these different substances, it will be also necessary that the sugar acquire a perfect whiteness, a fine and sugary grain, hardness, and a crystalline brilliancy. These qualities do not make a sugar more perfect than another, but they are much sought by the consumers; and it is in the manipulations to which it must be subjected to acquire them that the art of the refiner consists.

The operations of refining are much simplified by the application of animal charcoal in the purification of sugar. Before it was used, all the kinds of sugar coming from the colonies could not enter into the manufacture of loaf sugar, and they took care to work separately the muscovadoes and the white cassonades. It was necessary, on their reception, to open and separate as exactly as possible the different qualities of sugar, to put each in a particular tray. Now this operation has become altogether useless, and we do not know that it is practised in any refinery. They are content, when they work brown and clayed sugars to do it separately, the first always requiring proportions a little stronger of clarifying agents, and a longer time for separating the sirup from the crystals of the loaf sugar. For the rest, the refiner can judge what qualities of sugar he may mix, and in what proportion he must mix them to obtain a sugar of a particular quality. A little practice will make it easy to decide in this point, and to be able to know with precision the results before-hand.

Before describing the processes now employed for the refining of sugar, it is proper to mention those formerly followed. The clarifying cauldron, in which the sugar underwent the first operation, was cylindrical, with a flat bottom. It was about four feet and a half in diameter, and an equal depth. They increased the capacity of this cauldron nearly double by a slope or border of sheet copper rivetted to it with iron cramps.

After having nearly two-thirds filled the cauldron with lime-water, they added the brown sugar brought by two workmen in tubs with handles. The mixture was stirred to hasten the dissolution of the sugar, and prevent its precipitation to the bottom of the cauldron. They used for this a large wooden spoon of the form of a paddle. This paddle was at least eight feet long. The fire was kindled while the cauldron was filling. When the liquid began to be hot, that is, after about an hour, they poured into the cauldron about two pints of ox-blood, and continued for some minutes to stir it with the spoon, and then left the liquid to repose, the surface of which began to be covered with a bed of scum. At the moment it was perceived the cauldron was coming to the point of ebullition, the fire is abated in order to allow the scum to be separated; for by the boiling motion it will be carried into the mass of liquid, and the clarification cannot be easily effected. The earthy matters accidentally mixed with the sugar, will be precipitated to the bottom of the cauldron. When it is thought that all the scum is collected on the surface of the liquid, and it appeared black and dry, a workman with a large skimmer took it off carefully and threw it in a tub at the side of the cauldron. After having taken off this first scum it satisfied him if the clairee was well clarified. For this, the workman having plunged his skimmer in the liquid, withdrew it, and, holding it to the light, he observed if the sirup that run from it presented a perfect limpidity—if the liquid showed yet some small parcels of scum; if it appeared thick, he finished the clarification, and gave it some coverings,* that is, added anew a pint of blood diluted in six to eight pints of water. They sometimes also examined the liquid, taking a little of it in a silver ladle or one of some other suitable metal.

When they wished to relieve the whiteness of the sugar by a light tinct of azure, they threw at this moment into the cauldron a little superfine indigo reduced to impalpable powder, which had been strained with water through a woollen stuff to separate the grosser parts. In some factories, instead of indigo they used blue cobalt. The sugar brought to a perfect transparency had to pass into the cauldron for settling. For this purpose there were placed on it two iron bars, traversing it, which supported an oblong chest or a large panier of ozier, called a strainer. This strainer was lined inside with a cloth of woollen stuff, through which the sirup passed, being brought to it, by a gutter, into which it was poured with buckets. The sirup left on the surface of the cloth the earthy matters and impurities that remained after the skimming. At this moment were added, pouring them equally over the cloth, the fine sirups that were to come into the sugar. The matters

* The effect of adding this blood is to raise a second scum, and it is thence called a covering. [Trans.]

deposited by the sugar soon encrusted the cloth, which must then necessarily be changed. In some refineries they used a large piece of cloth of five quarters in breadth, folded zig zag in a box. When one part was encrusted, it was moved a little to bring another to the bottom of the panier, and the whole length of the piece was thus made to follow. The lime-water employed in this first operation was not indispensable; it was frequently supplied by pure water. It was remarked, however, that the presence of a small quantity of lime in the sirup facilitated the operation by contributing to the formation of the grain.

The sirup taken from the settling cauldron, either with a pump or with basins, was carried into the baking cauldron. This cauldron, the dimensions of which were equal to the clarifying cauldron, except it had no border, was half filled with clarified sugar. The fire was then kindled and made to burn briskly, in order to carry the liquid to ebullition as quickly as possible, and render the evaporation more rapid.

The liquid being brought to the point of ebullition, the fire is moderated in order that the sirup which rises very much should not spill over the edges. If the sugar rise too much, the workman threw in a little butter to reduce the ebullition; for it was necessary to keep the boiling low, and the sugar rising above the bottom of the cauldron, more directly exposed to the action of the heat, necessarily retarded the evaporation, and the sugar remained longer over the fire, while the baking was finished in a half hour at most. When the refiner judged that the sugar had come to a suitable point of concentration, he assured himself by taking the proof. This proof is the same that has been already described under the name of proof by the thread, when speaking of the baking of the sugar. The sugar baked was put into the coolers. The subsequent operations not having undergone any changes, we shall resume them after having described the processes now used for the clarification of sugar.

The scums taken off by the skimmer in the clarifying cauldron, and those which adhered to the filtre, were collected, put again into the cauldron with lime-water, and then thrown into a filtre of strong cloth. That which remained on the filtre was pressed, to get out all the liquid, and the water served in the following clarificaticn to dissolve the brown sugar.

Clarification according to the New Process.

The cauldrons we use in this mode of clarification are like those we have described in speaking of the ancient process, only they have not glacis nor border. We pour pure water in them to about two-thirds full, and add a quantity of brown sugar, sufficient to make a solution which will mark 30 or 32° of the hydrometer. This density of the solution varies according to the quality of the sugar. The rich sugars cannot be carried beyond 30°, while we can give 32° to dry sugars. These cauldrons have a cock at their bottom, which will empty them wholly. Having put in the cauldron the proper quantities of water and sugar, animal charcoal is added in the proportion of four to five per cent. of sugar, and the fire is lighted. We stir the liquid carefully and with many repeated strokes, to mix the charcoal uniformly in the whole mass. After the sirup has come to ebullition, we keep up this temperature for about one hour. There rises to the surface of the liquid a large bed of scum. Care is taken to moderate the fire, so that it shall not overflow the edges of the cauldron. During this time we have diluted in a tub some pints of ox-blood, which we throw into the cauldron, taking care to stir it briskly for some minutes. The ebullition, arrested by the addition of this liquid, soon begins again; we maintain it for about a quarter of an hour, after which we turn the cock and let the whole out on the filtres, and fill the cauldron anew for a second clarification.

The filtres are large rectangular chests, fifteen feet long, and about three feet high, the sides of which are covered with sheet copper. Their bottom is of open work. These chests are furnished inside with a woollen stuff, strong and well laid. They are placed at a level with the ground over a cistern or reservoir intended to receive all the clarified sirups, and which on that account is called the reservoir of the clear. The number of filtres varies according to the importance of the refinery.

A workman raises, by means of a pump, the cleared liquid from the reservoir into an upper basin, whence it may flow into the baking cauldrons. They have generally adopted in the refineries, vibrating cauldrons to bake the sirup. They have three great advantages over the old fixed cauldrons. Thus, when they draw the baked sirup from one of these old cauldrons, the part of the vessel which the liquid has left in subsiding, is covered with a bed of sugar which is subjected to a temperature sufficient to decompose it; beside, the succeeding operation is disturbed by this burnt sugar. The cauldron itself, in a very short time, experiences a very sensible deterioration. These inconveniences cannot take place with a vibrating cauldron, which has none of its parts exposed to the fire, when the sirup is withdrawn.

The vibrating cauldrons used in the refineries, are in all respects like those we have described in speaking of the baking of beet sugar. We refer our readers, therefore, to the description already given.

The workman charged with the baking, fills his cauldron by opening a cock, which brings the cleared from the reservoir in which it had been raised. This cock is placed so high as not to prevent the vibrating motion of the cauldron, and in order that the sirup in falling from this height shall not fly back, it is made to flow in a cloth tube, which descends from the cock into the cauldron. The cock may also be placed very low, by giving it the form of a swan's neck, which is closed by turning it vertically. The height of the baked sirup must not exceed four inches.* The point of baking is sometimes ascertained as in

* M. de Dombasle says, that he obtained the greatest advantages from a graining made by vapor in the following manner:—He made some plates of copper of 80 or 110 square feet of surface, having an edge, and being fixed on a frame of wood which was set in a foundation of masonry over the cauldron, preserving a sufficient inclination. The sirup placed in an upper reservoir and concentrated to 32°, falls on this plate, and forms there a bed of an inch and a half thick, which in a short time comes to the point of concentration necessary to crystallization, and forms on the surface a bed of crystals, which it is often necessary to break and take off. It is proper to observe, that the sugar obtained by graining by vapor has not so good and pleasant a savor as that prepared by the immediate action of fire.

[J. F.]

the preceding mode, by the proof by the thread, but oftener by that of the breath, the signs of which we have already mentioned.

The chief merit of a workman charged with baking the sirups is to seize precisely and regularly the suitable point of baking, according to the different qualities of the sugar. He must have much skill, tact and attention, in order not to be deceived therein; the formation of the grain being altogether dependent on the perfection of the baking. Thus when the sirup is not sufficiently concentrated, the grain will not form but in very small quantity, and the sirup which will flow will be so much more abundant. If, on the contrary, the baking is too strong, the sugar will form in a mass, and the liquid part be separated with great difficulty, and may be even so shut up in the interior as not to be separable.

We must repeat here the observation already made in the course of this work, on the advantage it will be to determine the point of baking by means of a thermometer, or at least to make use of one to announce the approach of the baking point, and that it is time to make the proof.

However this is, the sugar when ascertained to be baked, flows from the vibrating cauldron into the fill of moulds. The animal charcoal mixed with the albuminous matters, and with the impurities in the sugar, and of which it has been deprived, is washed in water, and cast on an appropriate filtre. The water that flows from it, is used in the operations following the clarification to dissolve the brown sugar. The charcoal itself, enters for one part into that which is used in this operation.

It is easy to see, that this method has great advantages over the old. It dispenses with the laborious, and nearly always imperfect work of skimming. We have no longer need to go through the processes with masses of scum, as has place in the refineries. The brown sugar on its arrival in Europe, contains a quantity, larger or smaller, of acetic acid, which is developed in it during its passage by the fermentation, at first vinous, and afterward acetous of a part of the molasses. This acid does great hurt to the operations of the refinery. The carbonate of lime, which makes a part of the animal charcoal of commerce, perhaps also the ammoniac that is found in it when this charcoal is not finely broken, appear to act in saturating this acid. This last substance acts equally on the viscous matter, rendering it more fluid. In some refineries where they have distinctly recognized this acidity of sugar and the property that lime has of making it disappear, they have retained of the old process, the habit of dissolving it in lime-water, instead of using pure water. But this method is nearly useless, now that it is known that animal charcoal has the property of saturating the acid. We know, beside, that it has power to precipitate the salts and alkalies of liquids that hold them in solution, so that it acts equally on the sirups that may hold lime in solution. The decoloring properties of charcoal contribute also to diminish the number and duration of the operations, and give us the facility of obtaining very handsome loaves of sugar, from sugars which formerly furnished only a very inferior quality.

We have said that the sirup when baked flows from the cauldrons into the cooler, which is placed in the room designated under the name of the fill. They sometimes have many coolers. This depends on the quantity of sugar on which they operate. These are large copper basins which will take several bakings. When the first baking comes into the cooler, we stir it strongly with a spoon, to determine and facilitate the formation of the grain. There is, in fact, quickly formed on the surface of the liquid a crust, several lines in thickness. The bottom and sides are also covered with crystals. When the second baking is poured in, it is stirred to work a mixture of the two. This stirring is repeated to each new baking, in order that the liquid mass may be entirely homogeneous. In the space of time which elapses between one baking and another, there is almost always formed a crust, which, by the different stirrings is broken, and which, being precipitated, serves as a nucleus for new crystals. When the last baking is poured in, we detach, with the paddle or iron spoon, the sugar attached to the bottom and sides of the cooler: we stir it carefully, to mix it with the sirup, and to maintain it in suspension while we are filling the moulds.

The beauty and perfection of the products depend very much on this stirring of the sirup in the cooler. If the liquid has not been properly stirred, the grain of the refined sugar will be coarse and porous. Its color even will not always be of so brilliant a white. The grain, on the other hand, will be broken if the agitation has been violent and too long continued. The sugar, although very pleasant, will not have closeness of grain nor brilliancy.

It is indispensable to have in the refineries moulds of different sizes, according to the quality of sugar we wish to have in the loaf. Thus, there are six kinds of moulds known, viz.—

The small two, eleven inches high, and five in diameter at the base.

The large two, eighteen inches high, and six in diameter.

The three, seventeen inches high, and seven and a half in diameter.

The four, nineteen inches high, and eight in diameter.

The seven, twenty-three inches high, ten in diameter.

The bastards, or vergoises, thirty inches high, and fifteen in diameter.

The size of these moulds is regulated by the quality of the sugar they are to receive; the larger serving for the more inferior sugars, and the smaller for the sugars of best quality. However, the smallest moulds are not now much used, the *four* and the *seven* being those most commonly used for the finest sugars, and the bastards never receiving any but the sirup produced from rebaking the molasses.

The size of these last moulds was not taken arbitrarily: it belongs to the necessity we are under of pushing the point of baking so much farther, as the sirup is more poor, and it must then be put to crystallize in larger masses, because that in the small moulds, it will be formed in a thick mass, that will not be drained of the molasses, which remains still in it.

Two or three days before filling the moulds, they are put to soak in the mould-trough. The new ones have even need to remain a longer time, in order to let them be saturated entirely with the water. When this precaution is neglected, the loaf adheres strongly to them, and can only be drawn out by breaking them. To guard the moulds against shocks, they are fitted on the outside with hoops, which serve also to support them when they are cracked. Each mould must be accompanied with a pot with a broad bottom, the opening or neck of which will be able to receive the mould. The size of these pots must be proportioned to that of the moulds they have to hold. Some hours before filling the moulds, we take them out of the water, and set them to drain, and stop with old linen, or with a peg, the hole at the point. They are then carried to the fill. There they are placed in two or three tiers, according to their size, through the whole length of the fill. All being suitably disposed, the workmen bring to the cooler the pitcher in which they put the sirup to be poured into the moulds, taking care not to fill them all at first, but to one third of their capacity. This is the first round. For a second round, they add a like quantity, and fill them two thirds. They are arranged in such manner as, at the last round, to distribute in each mould a nearly equal quantity of the grain formed in the cooler, and which being precipitated notwithstanding the agitation is drawn up last.

The moulds thus filled are left to themselves till a crust is formed on their surface. Then a workman takes an instrument called a knife, a wooden spatule, four feet long, an inch and a half broad, and five lines* thick in the middle, the edges being slightly scolloped. The workman holds the knife by one of the ends, which is rounded: he thrusts it in quite to

* Nearly half an inch.

the bottom of the mould: he moves it round two or three times on the inside, to detach the crystals adhering to it: he repeats this a half hour, or three quarters, after the first. The object of this is to render the grain uniform and close through the whole mass. About twenty-four hours after the filling of the moulds we carry them into the upper story. There, after having taken out the linen stopper which closed the opening of the point, we introduce through it a bodkin, which we call a prime, to disengage and facilitate through it the flowing of the molasses. Then each mould is placed, point down, on a pot.

At the moment the moulds unstopped are placed on the pots, the sirup which is not crystallized begins to flow, and the upper part of the loaf or paste soon undergoes a change in its color. After some hours, ten or twelve or more, it has passed from a red to a clear yellow, drawing towards white. The weight of the moulds diminishes by reason of the flowing out of the sirup; but this leaves void interstices between the crystals; so that the volume of the loaf is the same in the solid state as that the sugar occupied when it was poured liquid into the moulds. We must take care to change the pots on which the moulds are fixed as they become filled.

To facilitate the flowing of the sirup, the temperature of the chamber is raised by making a fire in it. In summer, this flowing goes on very well at the ordinary temperature.

When we think this flowing is finished, which commonly is at the end of two or three days, we examine some loaves. For this, after having separated with a knife the base of the loaf from the sides of the mould, we place over it the palm of the left hand; with the right hand we seize the mould toward the point, and turn the point up. Then, knocking the base of the mould on a block of wood, the loaf is detached and falls into the hand. Nothing more is to be done but to take it from the mould.

If the loaf of sugar is very smooth at the surface, the grain very pearly, and the head where the sirup is collected is not too brown,—if the loaf presents a certain degree of consistence, it is judged to be in condition to receive the operation of claying, or taking off the syrup. But first the loaf must be detached from the mould. This operation is done for all of them in the same manner as we have said is to be done for the examination—with this difference, however, that they are not taken out of the mould. The sugar that is separated at the base with the knife, is thrown into a chest, and reserved for the operation which immediately follows.

As soon as they are separated, the loaves are replaced on the pots; and when this operation is finished, we proceed immediately to that, the object of which is to make the bottoms. For this, having pounded and passed through a fine sieve, the sugar coming from the lochage (or process of separating) or, in case there is not enough of this, some white cassonade, we fill the empty space at the base of each mould, to within half an inch of the edge, with a bed of this powdered sugar. It is united perfectly, being heaped on with a trowel, particularly made for this use. The loaf thus prepared may be submitted to the operation of claying or separating the sirup.

Claying the Sugar.

The operation of claying consists in placing at the base of the loaf, a bed of clay diluted with water. This water dripping from the clay slowly, descends by its weight, is infiltred into the loaf, increases the fluidity of the sirup that remains uncrystallized, and thereby facilitates its flowing out. All clays are not suitable for this operation. It is necessary that what we make use of should be very pure; that it should not be mixed with oxydes of iron or coloring matters. It must also not contain but very little sand, otherwise it will let the water escape too fast. About the environs of Rouen and of Saumur is taken the greater part of the clays employed in the refineries. Before being used, they are prepared by throwing them into large vases, in which they are repeatedly washed by decanting. They are passed through a colander to separate the gravel they contain, and diluted to the consistence of thin paste. In this state it is put with a copper spoon on the base of the loaf. The thickness given to this bed of clay varies according to the quality of the sugar. It is thinner on the fine sugars than on those of inferior quality.

We leave this first bed on the loaves to dry, which occupies six or eight days; then we cut out the clay all round the moulds, and take it off. At this time this bed has acquired the consistence, and bears the name of esquive. The clays are washed to separate the sugar attached to them, and worked anew, like new clay. They brush the surface of the loaves, to take off the clay that is adhering to them; and withdraw some of the forms, to see the effect produced by this first claying. They make new bottoms with powdered sugar, and over them put a second time a bed of clay precisely like the first, and leave it to dry. In these two operations care is taken the first days to keep the windows closed, so that the clay shall not dry too quick: they are afterwards opened, only that the clay may be separated more easily. After the second claying they make anew the visit of the loaves, to judge of the state of their purification.

The number of clayings they give to the sugar, depends on its quality, the finest being clayed two and three times, and the most common receiving even four successive beds of clay, except the bastards, that receive only two.

Drying the Sugar.

The hot-houses are buildings nearly square, high, divided in their height by lattice stages, on which the loaves are ranged. To warm it, there is a large cast-iron stove, in which the openings of the hearth and the ash-pan lead to the outside; and some feet above this stove is a form also of cast-iron, which covers it in manner of a screen, to prevent the too direct action of the heat on the loaves placed immediately above. The roof of the hot-house is pierced with large windows, which open in the manner of trapdoors, in order to give vent to the vapor which is produced in great quantity, especially at the commencement of the operations.

The loaves are placed on wooden platters, and ranged in the hot-house on the open-work stages. Care must be taken to give but a very moderate heat in the beginning, and to augment it gradually, carrying it finally to 50° Reaumur. This operation lasts, on an average, eight days.

In speaking of the hot-houses in which the sugar is dried in the colonies, we have said, that when we should come, in the order of the operations, to speak of the hot-houses of the refineries, we should make some observations on their dispositions, and on the principles on which they are established, calculated to correct the false ideas of the refiners about vaporization,—ideas which have led them to give to their hot-houses the dispositions least proper to attain the end they propose. We will enter on some explanations on this subject.

An error generally prevailing among those who have not made a particular study of physics, is, that heat is the only agent of use in drying, and they take no account of the circumstances that accompany the production of vapor; circumstances which, however, have the greatest influence on the dryings. Heat acts in fact only in a secondary manner, in increasing the property of the air to charge itself with a greater quantity of vapor. It is therefore the air that is the agent really useful in this operation, the heat being of no use, but as a means of transportation, to act on great masses of air. If we could, by means purely mechanical, establish a sufficient current of dry air, even at 0°, the desiccation would be none less,—while if we give 100° of heat to the air, if we do not have it renewed, it will have no effect.

One may well conceive how faulty is the construction of the hot-houses in actual use, in which, by the position of the stove in their interior, it is not possible to have a current, so that we can merely heat the bodies, both solid and liquid, which are placed within them: and the separation of the water that is fixed in the loaves, and which is evaporated, is only effected by the considerable increase of volume that it takes in passing to the state of vapor, which obliges them to keep open all the windows at the commencement of the work. However, they will say, they do dry in such hot-houses. This comes from the fact, that in spite of the care taken to close them entirely, there are some cracks, by which the warm air charged with the vapor, escapes. Thus the desiccation takes place very slowly. This mode of heating, has, moreover, great inconveniences, which it is well to point out, though the refiners are daily in the way of knowing them. The vapor formed in the beginning, and which fills the whole room, softens the loaves. This softening is even sometimes so great, that they sink with their weight, and are melted. It sometimes happens that the fire, pushed too briskly, makes some part of the loaves red: this is what is called heat struck. The length of the operation, which is prolonged for many days, makes great expense of fuel. It will be very easy to avoid all these inconveniences by changing this arrangement of the hot-houses, replacing the stove by a calorifere of warm air placed outside of the hot-house, into which we bring the current of air that is charged with vapor, and to which we give a vent, proportioned to the opening by which it is brought in.

On taking them from the hot-house, the loaves are carried to the store-house, to be put in paper and sent to market.

The quantity of sirup that flows from the moulds in the operations of refining exceeding much that of the sugar in loaf, this product is of great importance in the manufacture; and it is the portion more or less profitable that we draw from it, on which depends frequently the prosperity of a refinery. It is therefore necessary that we treat here of the uses that may be made of it.

The syrups obtained in the process of claying are of two sorts, to wit: first, the coarse sirups; these are they which flow first, when, after having unstopped the moulds, we place them on the pots, they are red, fat, and little suited to furnish sugar: second, the fine sirups that flow in the pots after we have changed the moulds, and during the different clayings. We give also the name of *shaded* sirups, (couverts,) to the coarse sirups, and of *clear* sirups (decouverts,) to the fine. These are scarcely any thing but melted sugar. They collect and preserve separately these two qualities of sirups. The first sometimes go into the clarifying cauldron, and the second are poured, as we have said, on the filter, and are mixed with the clarified in the avale-tout. At other times the coarse sirups are rebaked separately, and serve to make loaves of an inferior quality to those which have been moulded.

It is perhaps not unuseful to repeat that the baking must be pushed so much the farther, as these sirups have been more exhausted; for otherwise the sugar will not form but with great difficulty. Also we must not unstop the moulds of the bastards, till six and even eight days after they have been filled. Their purifying is also much longer, though they are accustomed to give them but two clayings. All the points or heads of the bastards are cut; for it will be necessary to wait too long for their complete desiccation. They are, beside, always colored. They also make them enter again into the clarifications. The sirups that come from the bastards bear the name of molasses. They are wholly exhausted, and can only serve for distillation.

It has been proposed to exchange the claying for a sort of washing with alcohol. It was found on the fact that concentrated alcohol dissolves very well the coloring principle, and does not act on the sugar. M. Chaptal, who has made many experiments on this subject, has settled the point, that the loss by the alcohol, which goes as high at least as a half kilogramme to a loaf of sugar of ten pounds, whatever precautions were taken, renders this process too expensive. The sugar retains, beside, a slight odor, which is developed more as it continues longer in the paper. M. Chaptal, who has also attempted to clay his sugars by substituting the sirup for water, says that the experiment satisfied him that in practice this substitution is disadvantageous. The loaves of sugar clayed in this manner were fat, without consistence: it was not possible to dry them; and they adhered so to the moulds, that when he attempted to loosen them, they were almost always broken in pieces. Changes have been introduced in latter years, in the refining of sugar, too important not to be mentioned in detail. We shall follow the order of the dates in which these changes have been introduced.

In 1812, Mr. Edward Charles Howard, of Westboro' Green, in the county of Middlesex, obtained a patent for a new method of refining. This is the detail he gave of his operations in the specification that accompanied his patent.

After having mixed, as rapidly as possible, in a cauldron lined with copper, quantities of water and sugar or of muscovado, so proportioned that the mixture had, at the common temperature, the consistence of thick mortar, he let it stand for one or two hours; then he raised the temperature of the cauldron to 70° or 75° Reaumur, by bringing vapor under it in a double bottom. As the mixture became liquified by the effect of the heat, he added sugar, to diminish its fluidity. He then filled some large moulds with this pasty mass, and waited to withdraw the stoppers that closed the openings at the point till they were completely cool. He then let the molasses flow out.

This flowing being finished, he took from the base of the loaf a bed of sugar, as far as to the point where it was colored. The sugar so taken off was mixed with cold water, so as to form a thick paste; and for this purpose he spread it in beds on the base of the same loaves from which he had taken it. When this bed begun to be dry, he covered it with a shield of woollen cloth or felt, over which he poured, cold, a solution of fine sugar saturated; or rather, he put on this sort of sugar claying; he kneaded it over again, with water, and spread it anew on the loaf. He repeated this operation many times, according to the quality of sugar he wished to obtain. Mr. Howard said, that on sugar thus treated, and perfectly dried, he could without injury pour a sugary solution, or even pure water, without its penetrating. When it happens that the loaf is too porous, the sugar used to make the bottoms, must be pounded very fine, so that the water may leave it more slowly, and may not be unequally spread, in the whole mass of the loaf. One may use, to make bottoms, any other sugar than that taken from the surface of the loaves, provided, however, it be always of a superior quality, or at least equal to that on which it is poured.

The color of the molasses that flows from the loaves, the rapidity with which the water is filtrated, serve to show the moment when this first operation approaches its end. We may, moreover, be assured of it, by withdrawing, from time to time, some loaves from their moulds, to examine them. It is necessary to have the temperature of the room, at the beginning of the operation, at about 12°, and to raise it afterwards to 22°, or even to 25°, when, after having poured the solution on them for the last time, the surface of the loaves begins to be dry. To promote the extrication of the fixed air from the loaves, it is proper, each time that we make new bottoms, to break the loaf at the base.

All this first operation, merely preparatory, being finished, he withdraws the loaves from the moulds, he breaks them, to separate from the parts perfectly purified those which still retain some molasses, which must be put into brown sugar to undergo anew the above operation. The pure sugar is dissolved in a cauldron with six parts of water, for five of sugar; he stirs it to facilitate the dissolution, and after having allowed time for the impurities to be deposited, he draws it off clear into a second cauldron, in which the sugar is to be acted on, by agents proper to take from it the coloring matter it may still retain.

He prepared, on one part, a solution of two pounds and a half of alum, in six pounds of water, for a quintal of sugar that he was to whiten; and on the other part, water of lime, perfectly pure. The water of lime is poured on the solution of alum, in such quantity that the mixture will not change the yellow color of saffron paper. It is then thrown on a filtre, to separate the deposit which it leaves in dropping through.*

He takes this deposit, dilutes it in some pints of the solution of sugar on which he is going to operate, and pours the whole on the clarifying cauldron, taking care to stir it, to facilitate the mixing, and the action of the clarifying agents on the coloring matters.

The solution thus treated is left to settle five or six hours; after which he draws off the clear liquid, and proceeds to the evaporation, which is produced by the heat of vapor at about 75° Reaumur, and is continued till the density of the liquid is equal to 1.37, that of water being 1. (1.) The sirup is then changed into the coolers, in which it is stirred in order to form the grain, whence it is again taken to be poured into the moulds. When these are cold, he withdraws the pins, and the sirup that has not crystallized flows in the ordinary manner.

When the base of the loaf is dry, he scrapes it, as we have said was done in the preparatory operation, and makes a paste that he puts on the base of the loaf,

* The patent prescribes a great number of washings and filtrations, all at least useless. The operation is reduced definitively to precipitating the alumine of the alum by lime. We have thought proper to suppress all these superfluous operations, and to point out only the simplest means of arriving at the same result.

(1.) Corresponding to 40° of the hydrometer.

if this does not appear to be white enough. If, on the other hand, he finds it to be perfectly purified, he leaves the loaf to dry without any claying, takes it from the moulds, and puts it in the drying-house.

The quantity of molasses that he obtains by this process is only ten pounds to the quintal of sugar, while there is thirty pounds by the ordinary process.

He pours on the deposits formed in the two cauldrons some boiling water, to dissolve the sugar they contain, and throws them on a filtre. The water that he catches serves to dissolve the brown sugar in the first operation.

The sirups that flow from the loaves of sugar thus treated, being nothing but pure sugar dissolved, have only need, in order to make crystallized sugar, to be concentrated without the addition of other sugar.

Mr. Howard remarked, that by treating, in the common mode of refining, the sugar with the clarifying agents he mentions, without having been submitted to the preparatory operation, we shall obtain a more perfect clarification.

A patent for an improvement on the processes above described was granted to Mr. Howard in 1813. The changes specified in the new patent were principally in the evaporating cauldrons, and in the temperature at which he was able to bake the sirups. While there was a question of the method of concentration recommended by Achard for the baking of the beet sugar, we had seen that this operation was too long. Achard using only the vapor produced under an ordinary pressure, he could not bring the sirups to a temperature above about 75 degrees. Mr. Howard experienced also this inconvenience; but he surmounted this difficulty by a very ingenious arrangement of the apparatus, which proved in its author a particular talent for the application of his physical science.

The apparatus of Mr. Howard is founded on this reasoning. All liquids under the common pressure of the atmosphere boil at a certain temperature peculiar to each of them. Thus, water boils at 80° Reaumur; rectified spirits of wine at 64° of the same thermometer; concentrated sulphuric acid at about 260 degrees. But the point of ebullition may be so much lowered as the pressure at the surface is diminished. Thus, under the receiver of an air-pump water may boil and be vaporized at a few degrees above zero. Accordingly, Mr. Howard thought that by reducing a part or the whole of the atmospheric pressure, the sirup would boil at a temperature much below that of boiling water.

It only remained to combine the different parts of an apparatus by which the result of this reasoning should be realized. This is the disposition Mr. Howard adopted.

The evaporating cauldron is spherical: the lower half is enclosed with a concentric sphere, so as to leave between them a void space, into which is brought the vapor from a cauldron filled with water. The evaporating cauldron has at its upper part a tube, that communicates with a pump, in which plays a piston put in motion by means of mechanism moved by vapor taken from the same cauldron which furnishes that which circulates in the space between the two concentric enclosures, and which will also warm the sirup. The spherical cauldron having a suitable quantity of sirup for evaporation, if the vapor is brought into the double bottom, the syrup will be warmed, the air contained in the cauldron at the beginning of the operation, and afterward the vapor that will be formed will pass into the pump, whence they will be continually thrown out by the movement of the piston. The vapor being thus taken off as fast as it is produced, we may suppose that the pressure at the surface of the liquid will be very feeble, and that it will boil at a low temperature. A thermometer whose bulb is fixed in the interior of the cauldron while its stem is raised without it, shows the temperature. By means of a tube open at both ends, which goes nearly to the bottom of the cauldron and comes out at the top, we can introduce a proof to withdraw a small quantity of the liquid, and be assured each moment of its point of concentration or baking.

The advantage that this method presents is to accomplish the concentration of the syrup with great rapidity, without a very high temperature, and to accomplish this concentration protected from the contact of the air; which seems to exercise, concurrently with the heat, an influence to make the crystallizable sugar pass to a state of uncrystallizable. The inconveniences are in requiring very expensive apparatus for the power to work the pumps, and a very active watchfulness of the operations.

In June, 1815, Mr. John, Taylor operative chemist of Stratford in the county of Essex, obtained a patent for a process of refining. Mr. Taylor says that this process is equally applicable to the manufacture of brown sugar in the colonies, which renders the subsequent operations of refining more simple and less expensive. This is wherein the process consists, according to the specification appended to the patent.

I have observed, says Mr. Taylor, that the molasses and other soluble matters which color the brown sugar may be separated from it by means purely mechanical without the necessity of the intervention of heat. After having poured on the sugar a quantity of pure water or of lime-water sufficient to moisten it, and which may vary from 1-8th to 1-10th of the weight of the sugar, it was submitted to a pressure capable of removing all the fluid parts. In the sugar-houses of the colonies, the water that the sugar retains in coming from the coolers in which it is crystallized will suffice for this operation without the necessity of adding any new quantity. In the liquid that will flow from it will be found the molasses and other soluble substances the sugar contained, and which the water will have drawn out. If the pressure used has been sufficient, the sugar will be dry, and its shade will be changed.

To submit the sugar to the pressure, Mr. Taylor enclosed it in bags, which he laid in a pile on the floor of a press, which may be indifferently a screw press or hydraulic press, remembering always that the force we can exert with this is very much greater than that we can obtain with the first. Mr. Taylor has made no change in the other operations of the refinery.

This simple and cheap operation is probably capable of exercising an influence on the sugar so important that it may be advantageous to put it in practice. There will in fact be separated by it a great part of the coloring matters, without the necessity of exposing the sugar to the action of fire. Its clarification will be more easy.

Messrs. Taylor and Martineau, wishing to preserve the sugar from the alterations to which it is exposed, by the prolonged action of fire during the evaporation of the syrup, conceived the idea of effecting this evaporation by means of heat emitted by the condensation of vapor produced under a high pressure in order to give it a higher temperature. For this they placed at the bottom of the evaporating cauldron, a spiral tube which communicated with a vapor cauldron. A discharging tube led into the cauldron the vapor condensed in the spiral. The vapor cauldron and tubes are furnished with safety valves and all the auxiliaries belonging to high pressure engines.

In an apparatus of this kind the evaporation is effected very well: it is even extremely rapid, and although the temperature obtained is very high, the sugar does not undergo any alteration. But this apparatus has all the inconveniences of high-pressure engines, since, in order to work with advantage it is necessary that the vapor have an elastic force of three or four atmospheres.

M. Clement Desormes, professor of chemistry applied to the arts, has given in his course of lectures to the Academy of Arts and Trades, in the year 1822, an account of the operation of a refinery worked by an apparatus of Messrs. Taylor and Martineau, in which vapor was employed, condensed to three atmospheres. We will repeat what this learned professor gave.

He takes for granted that a square metre of copper, 0. 0002 thick, may transmit a quantity of heat sufficient to vaporize 75 kilogrammes of water an hour, and that the apparatus ought to work 10,000 kilogrammes of brown sugar in a day.

Water to be vaporized, *(two thirds the weight of sugar,)* . . . . 6700 kilog.

Time employed in the baking twelve hours.

Vapor produced by the hour, $\frac{6700}{12}$ (1) $= 558$ kilog.

Surface of transmission to be given to the tubes in which the vapor circulates, $\frac{558}{75} = 7.40$ sq. metres.*

Charcoal consumed, $\frac{6700}{6}$(1) $= 1116$ kilog.

Including the clarifying and the drying house, 2000 kilog.

Charcoal used in the old process, 8000 kilog. Saving 6000 kilo. at 5 fr. the hun. 300 fr.

" 300 days, at 300 fr. a day, 90,000

Saving of sugar, 2 1-2 pr. ct. at 2 fr. 50 c.—625 fr., equal in 300 days to 187,500

Advantage, 277,800 fr.

Mr. Wilson conceived the idea of supplying the circulation of the condensed vapor, by that of a liquid that would not enter into ebullition but at a much higher degree than that at which syrup boils. He used for this purpose whale oil which he made to circulate in the tubes which pass through the bason containing the syrup.

---

* A metre is 4 feet. [Trans.]

(1) To know the quantity of charcoal to be consumed in changing a determinate quantity of water into vapor, expressed in kilogrammes we divide by 6, the quantity of water that experience has shown to be vaporized in practice by a kilogramme of charcoal.

His apparatus consists of a cauldron of strong iron plates, nine feet long, and five feet broad, and eighteen inches deep, capable of containing 400 litres of oil. This cauldron, sealed above with a common furnace of masonry, communicates by copper tubes with a bason of sugar, lined on one side with wood, in order to retain the heat for a longer time. One of the tubes of communication is twisted spirally at the bottom of the bason; its extremity fits into a second tube which enters into the cauldron by the opposite end. A cast-iron pump fixed above the first tube, raises the oil, and conducts it afterwards into the spiral part of the tube.

At the top of the cauldron is a mercury thermometer. The bulb of this thermometer is immersed in the oil, to show the degree of heat: its stem is elevated externally.

To use the apparatus, he begins by heating the oil to 140 degrees of Reaumur; then he conducts it, by the aid of the pump, into the spiral, where it circulates continually to enter afterward into the tube of discharge. The sirup entering into ebullition at 90°, we may conceive that so long as the pump will continue its action, the oil, whose heat is much greater, will maintain the sirup boiling, and this without difficulty or danger.

We have forgot to say that the cauldron bears on its upper part a small tube, opening by its lower extremity into the cauldron: it is surmounted by a long tube, called a steam flue. It serves to keep up a free communication between the interior of the cauldron and the outside, so as to avoid all internal pressure. It carries out the steam that may be produced, and, by the communication that it establishes with the exterior, gives the pump the power of raising the oil.

It has been supposed that the sirup heated to a certain degree in contact with the air, would be susceptible of spontaneous combustion. The author has made some experiments on this subject, from which it results that the sirup is decomposed at a temperature of 138° Reaumur, and lets escape a vapor, which, however, will not burn at 150°, 157°, and even at 160° Reaumur.

As to the oil, that has also been regarded as very inflammable. Mr. Wilson assures us that it will become inflamed at 250°, a temperature much above that which is required to make the sirup boil. M. Parthes has established that in truth it disengages steam at 140°, but does not burn at 250°, except with a very feeble flame, giving out but eight cubic inches in four minutes for four pints (litres) of oil, while at 250° the steam produces thirty-two cubic inches a minute, and burns spontaneously.

They have endeavored to lessen the time required for the operation of claying by accelerating the infiltration of water through the loaves. For this purpose they conceived the idea of making a void space at the lower part of the moulds. The air then exercising its pressure at the lower part of the loaves, forced the water to descend so much more quickly, as the void was more complete. The apparatus consisted of a large square conduit, the upper part of which was pierced with circular openings proper to receive the moulds. This conduit communicated with a pump in which a piston played with double effect. The base of the conduit had the form of a gutter, by which the sirups flowed into a common reservoir. This apparatus, used, it is said, in England, has not succeeded in Paris; we know not why, but we are inclined to think it owing to some faults in the construction. It may be that it only wants a skilful refiner, whom a first unsuccessful attempt would not discourage, to find the means of putting it in practice with advantage.

Sugar Candy.

To fulfil, without omission of anything, the task we have imposed on ourselves, it only remains to speak of the processes by means of which they obtain the sugar candy: but this manufacture, constituting, in France, at least, a part of the art of the confectioner, rather than that of the refiner, we shall only point out very summarily the labors by which they make it.

Sugar candy does not differ from sugar in the loaf except in this, that its crystallization instead of being produced by the stirring, must be effected by repose; and also, that it may be done more slowly, in order that the crystals be more regular, we have removed all causes of a too sudden cooling, and maintained the temperature of the place, where it is to a suitable degree for a time long enough. We have seen, on the contrary, that the operation known under the name of *clouding*,* in the manufacture of sugar in the loaf, has for its object to break the crystals, and to promote the cooling by renewing the surfaces. Thus they call *regular crystallization*, that by which they obtain sugar candy; and *confused crystallization*, that of loaf sugar.

* Fr. opaler, to break and confuse the crystals. [Trans.]

The sirup having been clarified and filtered, is taken again into the reservoir of the clairèe and carried into the cauldron, to be there baked to a suitable point. This is commonly, by the proof of the breath, weak or strong, according as we wish to obtain crystals larger or smaller.

We pour the baked sirup into copper basins, nearly hemispherical, the interior of which is perfectly polished. They are from fifteen to eighteen inches diameter at their edge, and six to eight inches deep. At about two inches below the edge, they are pierced on each side with eight or ten very small holes, through which a thread is passed, which goes from one edge to the other, passing through each of the holes. They stop these last either with paste, or by pasting paper on the outside of the basin, in order that the sirup, shall not flow through the holes.

The basins thus prepared are filled to an inch nearly above the threads, and carried immediately into a hot-house, the temperature of which is so high that the crystallization will not be complete till the end of six or seven days. After this time they remove the basins from the hot-house, and draw off the mother-water, that is, the sirup that remains liquid. They pour a little water in the basins, to wash the crystals which are spread over their bottoms. This water is put with the mother-water.

The bottom of the bed then presents a crystalline bed from six to nine lines thick. The threads which are covered with crystals have the form of garlands. They reverse the basins on a vase suitable to drain them well; after which they carry them again to the hot-house, that they may be well warmed. At the end of two or three days the sugar is dry; they take it from the hot-house, and remove it from the basins from which it is easily detached. It may then be put up for sale.

The mother-water enters into the manufacture of loaf sugar, like the bastards or lumps.

The tints more or less deep which many kinds of sugar candy exhibit, belong wholly to the purity of the sirup that has been used in making them. Sirup perfectly pure gives crystals entirely white.

Sometimes also they shade it in different manners by adding suitable coloring substances. It would lead us entirely from our subject to enter into the detail of these operations, which will be found, beside, in all works that treat of the art of the confectioner, into which they enter thoroughly.

11

APPENDIX.

[From the additions by M. J. de Fontenelle.]

Filtres of Mr. Taylor for the manufacture of Sugar.

One of the essential conditions of the sirup, is, that it should be very clear. When this clarification is made by means of animal black, the sirup retains a small quantity of it, of which it is important to deprive it by a new filtration, when the evaporation draws to an end. This operation is very important. When we operate on a concentrated sirup, it must be done rapidly, if not, the sirup by cooling passes with difficulty. The residuum which remains on the filtre must be as much exhausted as is possible. One of the conditions indispensable to making the filtration rapidly, that is, that the filtres be drained, is that the sirup be kept at a high temperature while this operation lasts. But, in order that the sirup be perfectly clear, it requires an apparatus well arranged, and filtering cloths well selected.

Some time ago, discussions arose among the principal manufacturers of beet sugar. Some, advocates for slow crystallization, by which the evaporation of the sirup was finished in the hot-houses, do not concentrate their sirup beyond the point to which the deposit of the animal charcoal is possible. They do not filtrate. They clarify their sirups by means of blood; and the portions which this substance does not take up, are readily deposited at the bottom of the cauldron. This sirup then drawn off clear, is carried immediately to the hot-house, where it is evaporated to crystallization. Those, on the contrary, who prefer a quick crystallization, concentrate their sirup very much, which obliges them to filtrate it, to separate the animal charcoal it retains. With these manufacturers, the filtres of Mr. Taylor are used, which are already in the French factories, to the number of more than 150. These filtres have the advantage, first, of giving the clarification more readily, and of passing it warmed to 33° or 35°: second, of economizing also the fuel: third, of dispensing entirely with the use of blood, or, reducing it to a very small quantity, (they do not use it in the beet sugar factories): fourth, finally, of making a saving of 20 per cent. in the animal black. The principle of these filtres is the same with those of our laboratories, which form a sort of tunnel, folded, contained within a glass tunnel. That of Mr. Taylor is made on this model. The first is a bag of cotton, and the second a bag of linen cloth. The last is of a diameter one half less than the cotton, which thereby forms numerous folds, and has a double filtrating surface.

M. Dubrunfaut thinks, that notwithstanding the encomiums given to this filtre, it has the inconvenience of filtrating too quick, and of not drawing part of the action of the charcoal on the filtre. The contrary is the case in the Dumont filtre, whose action is too slow.

We do not partake entirely the opinion of M. Dubrunfaut on one of these points. When we make the filtration of the sirup, the charcoal has already exercised on it its clarifying and decoloring action, and a continuance of some minutes more of the liquor on the filtre will hardly add to this action.

Improved process to boil and evaporate solutions of Sugar, &c. (English patent) by John Davis.

This invention, (says M. Boquillon,) consists in an apparatus fitted to the cauldron in which it produces a vacuum without the aid of the pneumatic machine hitherto used, by means of water, which, introduced into the apparatus, is partially raised in it. It is so constructed that the vapor rises from the cauldron, is divided into two parts, one of which drives the water into the conductor, and the other enters there to be condensed by the water which the first has introduced there, and which has been previously deprived of air. Here is the description.

Fig. 4 represents the cauldron with the apparatus fitted to it. Some parts are here delineated in the whole, others are only in sections, to make them more easily understood. We shall speak only of that which constitutes the new apparatus, which is fitted to the cauldron, and communicates with it by the tube G.

H is a cistern filled with water, which must always cover the cask I, and prevent the external air from communicating with the interior. The cask I contains a stirring stick, put in motion by a handle J, whose axis passes into boxes closed to prevent all communication with the external air.

K is a glass tube communicating by the two ends with the interior of the casks, and serving thus to indicate the quantity of water which it contains.

L is a cock for the discharge of the cistern H. M. is the tube for feeding the cask; it is supposed to lead to a reservoir of cold water.

N. Tube for feeding the cistern.

O. Cock to fill the cask by the intervention of the tube P. P.

Q. Cock by which the air escapes, when the cask is filled.

R. Cock designed to prevent all communication between the cask and the tube S, of which we shall speak.

T. Tube communicating with the cask by the condenser V to supply it with cold water: *r* is a cock designed to regulate the flowing of this water.

V. Condenser, a small cask placed in another cask full of water, to prevent all communication with the external air. The condenser is furnished in the interior with partitions of ozier, represented by punctured marks to divide the vapor and condensing water, and to act, consequently, as a cooler.

W. Partition of wood or iron pierced with holes, and projecting, entering, the better to resist the first action of the steam, into the condenser.

U. Cock designed to open and close the communication between the tube G and the tube X. This last conducts the steam from the cauldron to the tube S, which communicates by its lower end, with the condenser, and, by its upper end, with the cask I, by the intervention of the tube P and the cock Q. Its effect is therefore to divide the steam in two parts, one of which acts on the surface of the water in the cask I, while the other goes into the condenser.

y is a tube leading from the condenser to the vessel *z*, which is supposed placed in a well a little more than thirty-two feet deep, under the bottom of the condenser; for the length of the tube must have exactly the height of a column of water, equal to the weight of the atmosphere, (32 feet mean pressure.) Its use will be farther explained. This tube Y must be immersed some inches into the vessel *z* filled with water. This part of the tube *y* is shown in the section in the figure, in order not to give too large dimensions to the plate.

t, a small cord which is intended to open at the top of the well a valve g, which is kept in position by a weight, and opens when the weight is raised.

After the description of the apparatus, we will describe its operations. The first thing to be done is to fill with water the outer cask of the condenser, as well as the cistern H, to close the cocks N, L, and U, and also the valve g, and to open the cocks O, Q, R, and r. By this operation we shall introduce cold water raised from the reservoir by the tube M into the cask I, the condenser V, and all the works of the apparatus, while the air which this water will displace will escape by the cock R. When all the parts of the apparatus are filled with water, we close the cocks O and Q, and open the valve g. The water in the cask I and tube S flows out. When it is lowered eight or ten inches, which may be seen by means of the glass tube K, we shut again the valve, and turn the stirring-stick in the cask I, to disengage the air which the water of this cask may contain, and make it occupy the upper part. The cocks O and Q are opened again both to admit new water, and to permit the air disengaged by the stirring-stick to escape. In this manner the water of the cask I is as completely freed of air as possible, and fit for the use for which it is designed. We then close the cocks O and Q for the last time during the operation. All the apparatus being once more filled with water, we open again the valve g, and let a part of the water flow out, until the glass tube K shows that it is lowered in the cask I to the punctured line b, and that consequently the tube P P, the upper part of the tube S, and the same part of the tube K are empty. We then close the cock Z, to prevent the cask I being emptied more: the valve g continuing to remain open, it is evident that the water contained in the lower part of the tube S and the condenser V will continue to flow out till the atmospheric pressure on the surface of the water in the vessel Z shall make an equilibrium to the column of water in the tube y, whose length being 32 feet, this equilibrium will be established at the moment when the condenser will have no more water, which will produce in it a vacuum. In this condition the apparatus is ready to work. We kindle the furnace, and when the boiling begins we open a valve placed over the cauldron to let the air escape which is above the liquid. When no more of the vapor remains, we close this valve, and open the cock U. The vapor flies by the tube X into the tube S, where it is divided into two parts, of which one is raised by the tubes R and P into the empty part of the cask I, where it exerts its pressure on the surface of the water, while the other descends into the condenser, where it passes through the perforated partition W. At this moment the cock r is opened partly, which produces the following effect. The elasticity of the vapor which acts on the surface of the water, drives out the quantity necessary for condensation. The continued flowing of this water condenses the vapor, and falling thence to the bottom of the condenser flows successively by the tube y, where it cannot rise above the height determined by the atmospheric pressure on the water of the vessel z. The operation is thus continued till the liquid of the cauldron is sufficiently evaporated.

Pneumatic apparatus for baking the sirup, by M. Roth.

This apparatus is much more simple than that of Mr. Davis. It differs from that of Mr. Howard not only in its form and construction, which is of great simplicity, but also because it dispenses with the use of a stirring-stick, the vacuum being produced by the vapor. Founded on different principles, it has nothing in common with the English apparatus but the end, which is to draw the vaporized liquid from the action of the atmosphere. M. Roth announces that both in answering in a complete manner the desired purpose of effecting the vacuum, and the boiling at a low temperature, his process is more economical, more prompt, and that it offers a better plan of work than the English process.

His apparatus is composed of a copper cauldron with a double bottom, covered with a dome or top of the same metal and hermetically closed. The space included between the two bottoms is warmed by the vapor proceeding from a generator which distributes it equally under the dome to produce the vacuum, and in a spiral placed on the inner bottom, where it circulates constantly to effect the baking of the sirup. As soon as the cauldron is freed of the air, that the vacuum is made there by the condensation of the steam, the sirup contained in a contiguous basin is forced in, passing through a tube furnished with a cock.

As soon as the vapor is produced in the cauldron, it passes into a receiver, where it is condensed by a current of cold water, which falls in a shower in the interior of the vessel. The condensing water filled with the heat arising from the steam is useful for various purposes. The proof is made by the thread. A plummet very simple and convenient for use, fitted on the cauldron, permits us to draw out a small portion of the liquid without letting the air enter. After the sirup has been baked by the steam at the ordinary pressure, it is made to flow into a basin placed by the side of the cauldron, by simply turning a cock. According to the author it offers the following results:—

First, It works with great swiftness an apparatus of which the cauldron, six feet in diameter, is sufficient for a refinery which makes twenty-five millions of brown sugar a day. To bake this quantity we must have, using the English process, four cauldrons of the same dimensions.

The mean duration of a baking is fifteen minutes. This very important circumstance secures a great advantage in the mode of working by this apparatus over that of Mr. Howard in which the receivers require two hours. It is in fact demonstrated that the solutions of sugar, submitted to a prolonged ebullition, may, notwithstanding the low temperature to which they are exposed, lose more or less their property of crystallization. M. Roth has ascertained that even in the vacuum the sirups are not exempt from this kind of alteration when subjected to a long ebullition.

Second. The temperature at which the baking of the sirups is effected is 63° R. They may be baked above this degree, but this is without any real advantage. Three circumstances have an influence on the temperature of the baking. 1st, the quantity of matter forming the contents of the cauldron. 2d, the elastic power of the steam heating it. 3d, the volume of water admitted into the apparatus for heating the vapor. By diminishing, on one part, the quantity of sirup and the degree of pressure of the steam, and by increasing, on the other, the volume of water, we may lower the thermometer to 55° and even below: but the most proper limit is from 60° to 65° R.

Third. In this system we do not make use of heaters as in England, and after each baking we may leave the bake some seconds in the cauldron before taking it out to carry it to 70° or 72°. This temperature is necessary for filling the forms.

Fourth. The new apparatus working by steam at low pressure, (about a quarter of an atmosphere above the ordinary pressure,) we avoid thus all the inconveniences and dangers attached to the use of steam in the usual way of heating. The low pressure is never powerful. The apparatus moves by middling and even high pressure, without any change resulting from it in the essential conditions of the system: however the low pressure, is preferable, especially for the lower sirups. A higher pressure in the heating vapor produces an acceleration in the movement of the apparatus.

Fifth. We may bake in it matters which, by reason of their low quality, and their chemical condition, (sirup of beets) present insurmountable difficulties to baking in the open air. It permits also to be extracted from the crystallized sugar the sirup or residuum, which is no farther susceptible of furnishing it by cauldrons in the open air.

Sixth. The author announces that his system is economical in respect to fuel. He founds this assertion on several considerations. 1st, the production of heat is concentrated in one fire-place: 2d, this production is infinitely more advantageous in furnaces where the flame has a long circuit to run, than in those of cauldrons over a naked fire, where it strikes only one small surface before being lost in the flue of the chimney: 3d, the quantity of water that may be reduced to steam, with a given quantity of fuel, is larger in the warming at low pressure than in that at high pressure; and the loss of heat through the warmed surfaces is less in the first case, than in the second.

Seventh. The condensation of the steam arising from sugar in ebullition warms a considerable mass of water. This water may be used for clarification, for the feeding of the generators, for the washings, &c.

Eighth. From this fact that all the vapors are condensed it follows, that the system has the advantage of a grand unity. Beside, by carrying off this mass of steam, which inundates the refineries and sugar-houses, we preserve the building from the deterioration it makes them suffer.

Ninth. With the new apparatus it is never necessary to cleanse the cauldrons inside. After the temperature at which the baking of the sugar takes place, nothing can be attached to the heating surfaces in contact with the liquid. The introduction of steam into the interior of the cauldron suffices to wash these surfaces, and to keep them always in order.

Tenth. Finally, the fundamental advantage which results from the evaporatory system of M. Roth applied to sugar works is that all the products we obtain are of a handsomer shade and better taste; and that the mass of incrystallizable residuum is diminished and reduced in very great proportion.

The quantity of water necessary in the work is about four pints (litres) to each pound of sirup to be baked. The apparatus of M. Roth is susceptible of receiving various applications in the useful arts, among which the most important is that which has been made of it, in the refining and manufacture of indigenous sugar.

EXPLANATION OF THE FIGURES.

Fig. 5, lateral elevation of the apparatus and section of the receiver, for condensing the steam.

A. Copper evaporating cauldron. It is formed of the following parts.

a, a, inner bottom. b, b, double or outer bottom. The two bottoms curve in an opposite direction, one from the other, and unite in the centre.

c, cupola or dome. These three parts are united by a common joint.

d, head furnished with a cap, well fitted.

In the interior of the cauldrons is placed a spiral, formed of a copper tube e, fig. 6. This spiral rests on the inner bottom a, a, at the height of the plane of junction of the two bottoms and the dome.

B, receiver of sheet-iron.

f, head of the receiver g, g, a sort of colander, formed of a copper cylinder, pierced with holes on the whole surface. In its interior are seen a series of plates or diaphragms, h, h, superposed one over another, and also pierced with a great number of holes.

i, water level.

k, barometer for the open air.

C, copper ball.

D, receiver of a known capacity and equal to the content of the cauldron.

E, reservoir of cold water.

G, wood-work serving for the support of the cauldron.

H, masonry on which the wood rests.

I, tube with three branches for the admission into the apparatus of steam from the generator.

J, tube conducting the steam from the cauldron A into the receiver B.

K, tube immersed into the receiver D.

L, tube descending into the reservoir E.

M, thermometer which enters into the cauldron.

N, plummet to take the proof of the liquid.

O, tube for discharge of the condensing water.

b, cock for admission of the steam into the cauldron.

m, cock for letting out the air and afterward the water used in the condensation.

n, lever key to this cock.

o, cock for admission of the sirup into the cauldron.

p, cock for the introduction of the steam into the double bottom.

q, cock which introduces the steam into the spiral e.

r, s, return cock. *

t, air cock.

u, cock for the entry of the air.

v, cock to empty the cauldron.

Mode of operating.

We begin by driving out the air. For this purpose the vapor is admitted into the cauldron by opening the cock l. The air goes out by the cock m. It is completely expelled in a few minutes. We ascertain that the vacuum is formed, when, touching the lower part of the receiver B, we cannot longer hold the hand there. We then close the cocks l, and m, and open the cock o. The sirup of the basin D is rapidly drawn into the cauldron, under the influence of the vacuum formed by the condensation of the steam. We close again the cock o, before the level of the liquid in the basin D has opened the orifice of the immersed tube K. At this moment it only remains to introduce the steam into the double bottom and into the tube v, by means of the cocks p and q, and to open the return cocks r, s. These cocks lead to the generator the water made by the condensed steam. They have each a lateral branch furnished with a small air cock. Some seconds after the

* r, s, is not seen on the diagram. It is on the opposite side of the cauldron, in the plane of junction of the dome with the upper bottom, nearly under A.

introduction of the steam into the spiral tube and in the double bottom; the barometer is seen to rise, which had fallen at the moment the sirup entered the cauldron—an index that the sirup has attained the point of ebullition. We then open the air cock t, to let in the water from the reservoir E, and regulate its admission so as to maintain the barometer at the determinate limit.

When we suppose the operation near its end, we take the proof by means of the plummet N. This instrument consists of a copper pump or cylinder, presenting on the outside a conical entrance. It receives a piston of the same metal. The shaft of this piston bears below the handle a cone fitted in the socket, which forms the entrance in the body of the pump. A small cavity hollowed in the piston answers to an opening in the body of the pump. When the piston is carried down to the bottom and turned so that the openings coincide, the liquid enters into the cavity.

The working of this instrument consists in turning this piston with a half turn, supporting it by the handle so as to bring its cavity up. In this movement of a half turn the piston closes the cylindrical cock e'. We then draw the piston, and having taken the proof in its cavity full of sirup, we replace it in its regular position.

The sirup being judged to be baked, the workman closes the cocks p, q, r, s, t, and having let the air enter by the cock u, he empties the cauldron at the same time by the cock v, and the receiver B by the cock m, to begin a new operation.

Description of an apparatus to evaporate and concentrate liquids, applicable to the manufacture of sugar by M. Milles-Berry.

Many means have been imagined to remedy the inconveniences resulting from the baking of sugar by the naked fire, which not only exposes it to be burnt, but also to occasion the burning of the buildings by being spilt on the fire. Boiling water was first tried, kept in circulation in tubes at the bottom of the basin: but this liquid, not being capable of heating to a degree sufficient to bake the sirup, oil was employed, made to circulate in spiral tubes. Cleland, to concentrate the sirups, heated, by means of steam, tubes placed at the bottom of the basins. The liquor passing through a sieve, fell in a shower on these tubes, and was thus quickly evaporated.

Knight used for the same purpose heated air, which, passing in spiral tubes pierced with very small holes, went out through the holes, penetrated the liquid, and facilitated its evaporation and concentration.

Recognizing a well-known fact, that liquids would boil at a lower temperature under an exhausted receiver than when exposed to the ordinary pressure of the atmosphere, the sugar-refiners have abandoned the old process, and taken advantage of this means, which consists in placing vessels containing sirup in closed vessels, where they maintain a vacuum such that the liquid is kept boiling at a temperature, rarely above 40° centigrade.

It is on this principle that the apparatus of Mr. Howard is constructed.

That for which M. Milles-Berry has obtained a patent, of September 15, 1830, has for its object to keep the liquid constantly in motion, and to renew its surfaces in order to favor the evaporation. It consists in a basin with a double bottom, heated by steam, and in which turns a cylinder also heated by steam.

The liquids, in proportion as they are thick, attach to the bottom of the basin as well as to the outer and inner surfaces of the cylinder, whence they are successively taken off by scrapers suitably disposed, and fall in the basin. The whole is enclosed in a chest or envelope. The air and steam are drawn off by a box opening to the outside, and in which turns a ventilator with four wings.

The apparatus represented under different faces figs. 7, 8, 9, 10, is constructed of dimensions suited to the quantity of sirup and liquid to be evaporated and concentrated. It is fixed on a frame a, a, of wood or metal. The hollow copper basin, b, b, which receives the liquid has a double bottom. The outer part c, c, is strongly soldered and rivetted to the first bottom, in order that the space d, d, occupied by the steam should be hermetically closed.

A hollow cylinder or coffer, e, e, held in a horizontal position, is traversed by an axis or tube with steam, put in motion by a hopper, and turns in cleets or pads, fixed on the frame. This coffer, open at both ends, and which goes into the basin to about two or three inches from the bottom, is formed of two concentric copper cylinders, rivetted and soldered at their edges, so as to be steam proof. A spiral tongue, soldered to the inner side of the outer cylinder, (fig. 9,) conducts the water made by the condensation of the steam into a reservoir placed at the end of the spiral, whence it is led by hollow radii into the axis of the coffer; thence it passes by a tube into the double bottom of the basin, whence it is drawn of by a cock.

A cauldron, fixed at a suitable distance feeds the apparatus with steam by a tube furnished with a close box, f: the steam passes from this tube into a reservoir g, whence it is distributed by hollow radii h, h, in the narrow space between the two concentric cylinders of the coffer: arriving thence by the opposite hollow radii ii, into the vapor box, k, (fig, 9,) it is returned by the tube b, into the double bottom d, d, of the basin: finally it escapes, with the water of the condensation, by the cock m.

When the sirups or other liquids to be evaporated are deposited in the basin b, b, occupying there about three or four inches deep, the operation is ready to be commenced. The steam having been introduced, as we have said, the coffer is turned either by the arm or by any moving power.

To prevent the thick parts of the liquid from adhering to the bottom of the basin and on the faces of the coffer, he disposes three wooden scrapers covered with cloth, which constantly rub on the surfaces detaching the sirups or liquids, in proportion to their thickness or concentration.

The scraper n, which acts on the bottom of the basin is a wooden bar suspended by two shafts o, o, fixed to the handles of the bent axis p: this axis turning by the handle v, or by the cogging of the moving wheel, gives to the scraper a motion to and fro which moves and detaches the thick or concentrated matters at the bottom of the basin, and prevents them from adhering.

A second scraper, designed to cleanse the outer surface of the coffer, is formed of a thin and straight wooden bar q, which rests by its ends on supports fitted to the inner edge of the basin. By its inclined position it presents the cutter against the periphery of the coffer, and this cutter, being very smooth, will allow the matters taken from the coffer to flow over the scraper and fall into the basin.

Finally, a third scraper which acts against the inner face of the coffer is also composed of a wooden bar r, suspended by two arms attached about a hollow axis, but not turning with it. This bar falls by its own weight to the bottom of the cylinder, and rubs against its inner face as it turns.

The basin and coffer are enclosed by a casing S, S, of a conical form, of wood or metal, solidly fixed on the upper circumference of the frame. On every side of the casing are made openings to permit an easy access to the interior of the apparatus. The top of the same casing is closed at one of its ends by a covering conducting to a box t, in which turns a ventilator with four wings z, the axis of which has around it a small channelled pulley, which, by a cord or strap going around it, communicates with another pulley j, fixed on the end of the arbor p.

The sirups or other liquids intended for evaporation being introduced into the basin, and the vapor circulating in the spaces or chamber of this basin and of the coffer, the openings of the casing s are closed carefully, to prevent the external air from entering it. Then the coffer is turned by the handle v, fixed on the end of the bent arbor p. This arbor has a pinion a, which fits into a cog wheel b′, which moves in its turn the large cog wheel u, fixed at the outer part of the frame, or the hollow axis of the coffer.

By the rotary motion given to the coffer the heated sirup is continually stirred. A thick bed is attached to the inner and outer surfaces of the coffer, and the watery parts contained in these matters are evaporated by the heat of the steam. They are continually aired by the ventilator z, turning with great swiftness in the box t, and expelled by the orifice w.

When the evaporation is finished the concentrated matters are taken out by the valve x, placed at the bottom of the basin, and which opens by raising the balance lever y.

In case we have need to work on a large scale and accelerate the evaporation, the author combines several coffers, which he places in the same apparatus, and the surfaces of which give a greater action to the effect of the heat.

Explanation of the Figures.

Fig. 7. lateral elevation of the apparatus to evaporate sirups. The casing is represented in section, to show the interior.

Fig. 8. Bird's-eye view of the same apparatus, the casing of which is removed.

Fig. 9. Vertical and longitudinal section.

Fig. 10. Vertical and transverse.

a, a. Frame of wood or metal.

b, b. Copper basin with double bottom.

c, c. Exterior envelope of the basin.

d, d. Space in which the steam circulates that heats the basin.

e, e. Copper or cylinder, with two concentric envelopes.

f. Box with stoppers for the tube.

g. First box for steam.

h. Hollow radii fed by the steam of the box g.

i. Radii of the second vapor box.

j. Pully mounted on the axis p, and encircled with a cord which makes the ventilator turn.

k. Second vapor box.

l. Tube for the admission of the vapor.

m. Cock for letting flow the condensing water.

n. Scraper acting on the bottom of the basin.

o, o. Shafts bearing the scraper n.

p. A bent arbor making the scraper and ventilator act.

q. Second scraper inclined rubbing against the outer face of the coffer.

r. Third scraper suspended with a hollow axis l, and acting on the inner face of the coffer.

s, s. Casing of the apparatus.

t. Box containing the ventilator.

u. Cog-wheel turning the coffer.

v. Handle mounted on the axis.

w. Opening to let out the vaporized part of the liquid.

x. Valve to let out the concentrated liquid.

y. A balance lever moving this valve.

z. Ventilator with four wings.

a′. Pinion fitted to the handle v.

b′. Cog-wheel moved by the preceding pinion.

c′. Cock to open and close the passage for the vapor.

Description of some Improvements in the process of refining Sugar, by James Bell. (English patent.)

In the common mode of refining sugar, we reverse the conical moulds filled with clayed sugar, on the pots intended to receive the sirup, which flows into them through a small hole, pierced in the top of the cone. This practice has many inconveniences. 1st. It requires too much time, both to collect the sirup in a great number of pots, and pour it into the common reservoir, and to carry it from this reservoir into the cauldrons. 2d. It is difficult to determine the quantity and quality of sirup thus obtained, and the time at which we must take off the moulds. 3d. The pots being placed in the upper part, and consequently the warmest of the room, the sirup they contain is liable to turn sour. 4th. Great waste is suffered because the sirup being attached to the sides of the pot can only be got off with difficulty by the operation of scraping, and because it spills on the floor of the atelier when these pots are full. 5th. The expense for the purchase of pots, and replacing those that are broken is considerable, without taking into the account that the new pots absorb much sirup. 6th. Finally, spacious chambers are required to place them.

Mr. Bell sought to remedy these numerous inconveniences by placing the moulds on gutters proper to receive the sirup, and conduct it to a principal reservoir, whence he draws it to pour it into the cauldrons. These gutters, made of earthen ware or metal, will be of sufficient length, and pierced at distances with holes, in which is fixed the top of the cone, containing the sugar. They must be inclined, in order that the sirup may flow more easily. We can at need raise the upper part for cleaning them.

These gutters are represented fig. 11. A A are gutters on which the moulds are placed; they abut on the tunnel B, placed on the canal C, intended to receive the sirup that flows from all the moulds, and goes into the reservoir D, which is divided into many apartments, to admit the different qualities of sirup. For this purpose the end of the canal C is made so as to allow a view of the sirup. A tube furnished with a cock fitted to the lower part of each case or apartment, serves to conduct the sirup into the cauldrons. We may raise the tubes, either to clean them or to place them on such apartment of the reservoir as we desire. The quantity of sirup collected is measured by a graduated scale. We should take care to have the reservoir in the coolest part of the atelier.

New Process for refining Sugar, by Mr. Wilson.

The method in use for warming cauldrons employed in the refineries of sugar, is defective in this, that by the immediate application of fire, the sirup is often burnt, and that it requires constant care that it shall not spill in the fire and occasion the burning of the buildings. The idea was conceived of remedying these inconveniences by introducing into the basins metal tubes with boiling water. But the sirup not boiling at the same temperature as water, it was necessary to heat this to such a degree as to produce a pressure which was not always without danger.

Mr. Wilson substituted for the water whale oil, which he heated to the degree at which sirup boils, and then made to circulate in the tubes that pass through the basin.

His apparatus is composed of a cauldron of strong plate iron A, fig. 12, nine feet long, by three broad, and eighteen inches deep, capable of containing 400 pints (litres)* of oil. This cauldron sealed over a common furnace in masonry, communicates by the copper tubes E and G, with a sugar basin F, surrounded by a wooden edge, that it may retain its heat a long time. The tube G is turned in spiral at the bottom of the basin, and joined to the discharge tube H which enters into the cauldron at the opposite end. A cast-iron pump D, fixed over the tube E, draws up the oil, and conducts it thence into the spiral tube.

At the top of the cauldron is placed a mercury thermometer B, having a Fahrenheit scale, divided into three hundred and fifty parts. The tube of this thermometer is immersed in the oil, to indicate its degree of heat. When it acquires a very high temperature, the tube breaks, which admonishes that it is necessary to reduce the fire, to avoid kindling the oil in a flame.

To use the apparatus, we begin by heating the oil to three hundred and fifty degrees of the thermometer of Fahrenheit, (182° Reaumur,) then we conduct it by the pump D into the spiral, where it constantly circulates, entering again afterward the cauldron by the discharge tube H. The sirup entering into ebullition

* The old Paris pint, contained 2 pints London measure. The litre succeeds the pint of Paris in the new system of French measures, and its content is greater: the capacity of the cauldron is, therefore, over 400 qts. English measure. Litre is translated pint uniformly in this vol. [Trans.]

at 240° (90° Reaumur) we may conceive that as long as the pump will continue its action, the oil, the heat of which is much greater, will keep the sirup boiling, and this without difficulty or danger.

We have intimated that the sirup heated to a certain degree was susceptible of spontaneous combustion. The author made, on this subject, some experiments, from which it results that the sirup is decomposed at 344°, (129° Reaumur) and allows a vapor to escape, which, however, is not inflamed except at 370°, 386°, and even 398° (139°, 145°, and 150° Reaumur.) As to the oil which has also been regarded as very inflammable, Mr. Wilson assures us that it will not be inflamed at less than 600°, (226° Reaumur,) a temperature much above that necessary to make the sirup boil. M. Parthes has established that in fact it disengages steam at 350°, but that it burns at 590°, (222 Reaumur,) only with a very feeble flame, giving only eight cubic inches in four minutes to a gallon of oil, while at 620°, (233 Reaumur,) these same vapors give 32 cubic inches a minute, and burn spontaneously.

After these experiments, a doubt no longer remains of the advantage and safety of the process of Mr. Wilson, provided it be conducted with suitable precautions.

Explanation of the Figures.

Fig. 12. Lateral elevation of the apparatus designed for baking sugars, and evaporating liquids by means of heated oil.

A. Oblong cauldron of strong iron plates, like the cauldron of the steam apparatus. It is sealed in a furnace of masonry, of a medium dimension, without circulating canals, so that it may receive directly the action of the fire. Its capacity depends on the quantity of oil to be heated, or of liquid to evaporate. The larger the surface is the less fuel it will consume. It has been found that whale-oil purified is more suitable than any other for the object. We must put in it only a sufficient quantity to cover the bottom of the cauldron six or eight inches deep.

B. Thermometer placed over the cauldron, the tube of which is immersed in the oil.

C. Small tube opening by its lower end into the cauldron. It is surmounted by a long tube called a steam-flue, and communicating with the atmosphere. This tube serves for three different purposes. First, it gives vent to the air contained in the cauldron when we begin the operation, in order to avoid all pressure in the interior: in the second place, it keeps up a free communication without, in order that the pump may draw up the oil: finally, it is designed to conduct out the steam of the oil which gives a bad odor, and alters the sugar, if it gets into the refinery.

D. Cast-iron pump, the piston of which has a metallic apparatus like that of Brown. This pump which communicates with the cauldron by means of an air tube E, is put in motion by the hand, or by any other kind of movement.

F. Copper basin at the bottom of which is placed a spiral tube. It forms a continuation of the tube G, and communicates, where it goes out, with the cauldron by the discharge tube H. Through these tubes lengthened out into the sirup, the heated oil circulates, which is constantly renewed by the action of the pump. The basin is set in brick masonry, and surrounded with a wooden apparatus to prevent cooling.

I. Cock to draw away the sirup when it is baked to a suitable degree.

K. Chimney of the furnace.

Patent of Charles Freund for refining Sugar. London, 1827.

He dissolves 16 pounds of pure potash in 380 parts of water, and adds to it 1800 lbs. of brown sugar. When the mixture is perfect, he adds 25 lbs. of fullers' earth diluted in a sufficient quantity of water to form a good boil. He carries this mixture to ebullition, and stirs it often. He suspends the ebullition from time to time to take off the abundant froth that is formed. When the sirup is very clear, it is poured into a large vessel with three cocks placed one above another at certain distances. This vessel is mounted on its centre on an upright axis, the length of which by means of a screw is raised or lowered at will. About 12 hours after the decanting, the sirup is drawn off by the upper cock, and two other drawings are successively made by the two other cocks in proportion as the deposit is formed. The last requires that the vessel should be elevated with the screw, in order that it may drain at the bottom. The residuum is added to the skimmings, and when there is a large quantity, submitted to the same mode of clarification.

Refining of Sugar improved by Mr. Jenning.

This process consists in acting on the sugar with alcohol, which is made to pass through the mass by the aid of the pressure of the same liquid. This means appears to have been also proposed in France by M. Derosne. It is founded on the property that the alcohol has at 33° of dissolving more liquid than crystallizable sugar, and of dissolving at the same time much coloring matter, which, as is known, accompanies in the muscovadoes the liquid sugar or molasses. The English author recommends the application of the alcohol to the brown sugar before refining. M. Derosne recommends using it in place of the claying. This process can only be adopted when the alcohol is at a very low price. When it is concentrated it does not dissolve the crystallizable sugar. It must therefore be used in the nearest degree to this condition. With this at 38° I have been able to obtain the crystallizable sugar of grape.

Statement of the Expenses and Product of the Manufacture of Beet Sugar by M. Mutzel, director of a factory in Silesia.

Supposing the undertaker has at his disposal all the buildings suitable for the business, I shall include in the statement the cost which their construction would require, and which may be taken at about 11.250 francs, at the present price of materials and labor. But I must reckon the interest of this capital at 5 per cent. which makes 562 francs 50 cent. It requires, to rasp 10,000 quintals of beets in 100 days, at the ratio of 100 per day, 14 workmen, who on an average make from 7 to 9 quintals of pulp each. This operation requires of course 14 hand rasps, which, including their handles and frames, cost each 18 fr. 75 cent, and is in the whole 262 fr. 50 c.

Four cast-iron screw presses of the weight of 2 quintals each, including the nut, the present price being 46 fr. 25 cent. will cost for 8 quintals,	fr. 370
The carpentry and posts of these presses will not exceed	375
Casks, trays and other vessels,	563,50
Four pieces of tent-cloth, to express the pulp at 26 fr. 25 cent. ea.	105
Twenty ells of filtering canvass, at 2 fr. 50 cent,	50
One large clarifying cauldron, measuring 100 cubic feet. It is of strong plate iron, and weighs three hundred and fifty pounds. The quintal of plate-iron costs 52 fr. 50 cent. but this price is doubled by the labor, which of course makes it, for 3 1-2 quintal,	367,50
Two evaporating basins also of plate-iron, each containing 50 cubic feet, and of the weight of two quintals, which makes, including the work, 105 fr. and for 4 quintals,	420
Two copper cauldrons and a cooler of the same metal, weighing each a half quintal, at 262 fr. 50 c. the quintal, making included,	393,75
Skimmers, spoons, spouts and other small copper utensils, weighing 1 quintal,	262,50
Four hundred sugar moulds, at 1 fr. 56 c.	624
Four hundred pots, 1 fr. 25 c.	500
Total,	fr. 4293,75

Expenses of the Apparatus for distilling the Residuum.

One Papin's boiler to boil the residuum, or two cauldrons of plate-iron, weighing each 5 quintals, at 105 fr. a quint.	1050
A distilling apparatus constructed after the system of Pistorius weighing 20 quintals, at 262 fr. 50 c.	5250
Twenty fermenting casks, at 22 fr. 50 cent. ea.	450
Other casks for rum and sirup.	562,50
Expenses of transportation and other small expenses for balances, weights, hydrometers, paniers, shovels, lamps, stoves, setting the cauldrons, basins, &c.	1893,75
Total for distillation,	fr. 9206,25

This capital, which suffices for the first cost of the establishment of a factory in which 10,000 quintals of beets may be annually converted into sugar and rum, cannot deter the enterprizing speculator from giving himself to a work, the profits of which are considerable. We may see by the following calculations, based on an experience of eight years, how worthy of encouragement this new branch of industry may be.

Here is the amount of expenses necessary to manufacture 10,000 quintals of beets, as well to draw from them sugar and molasses, as rum. They are calculated according to the prices above established.

Interest at 5 pr. ct. on the capital 11,250 fr. estimated value of buildings,	fr. c. 562,50
Interest at 5 per cent. on the capital of 13,500 fr. employed in purchase of utensils and apparatus,	675
Value of 10,000 quintals of beets at 93 c.	9300
For cleansing this quantity at 2 sous pr. quintal,	1000
For rasping, do. do.	1000
For pressing, at the rate of 3 fr. 75 c. pr. 100 quintals,	375
For baking the juice and converting it into sugar and molasses at 5 fr. pr. 100 quintals,	500
100 cords of wood at 15 fr. the cord,	1500
Labor for distilling the residuum at 5 fr. pr. 100 quintals,	500
100 cords of wood for the distillation,	1500
Sulphuric acid, lime, ox-blood, animal charcoal and other ingredients, at 62 c. pr. quintal,	6200
100 pints of oil for the clarifying, at 70 c.	70
Salaries of chief refiner and distiller,	1875
Duties, excise on the rum, costs of insurance, &c.	450
Repair of utensils and apparatus,	375
Costs of transportation,	1125
Total,	27007,50

The profitable product drawn from 10,000 quintals of beets, is valued as follows, according to careful experiments, which coincide with those of many other manufacturers, and merit full confidence.

We extract from 100 lbs. (livres, 1 lb. 2 oz. Eng.) of beets 70 to 75 lbs. of juice, which give three and a half lbs. of sugar. Thus 10,000 quintals give 35,000 lbs. The brown sugar which I have obtained this winter at the factory of M. Krain is of so good quality that the merchants and distillers have purchased of me at the rate of 80 fr. pr. quintal. But I shall only value it at 71 fr. which will give for 35,000 lbs.	fr. 24,850
Although I have constantly obtained as much molasses as sugar I shall only put this product, however, at 265 quintals. This molasses which comes from the baking of the brown sugar is sold at 45 fr. the quintal, and is	11,925
The residuum of a quintal of beets after extracting the sugar and molasses, being fermented and distilled, gives from 1 litre to 2 2-5 litres of rum, which is sold at the factory at Krain, at from 75 to 93 fr. per eimer, of 80 litres; but I shall only value it at 37 fr. 50 c., and I shall not admit that the product will be less than 10,000 litres, or 125 eimers, which is,	4.687,50
Total product,	fr. 41,462,50

I do not put into the account 1500 quintals of green fodder, which turn to the profit of the establishment, nor the ashes coming from the wood consumed—because these articles are not sold.

We see that first, 35,000 lbs. of brown sugar will produce even in the most unfavorable circumstances,	fr. 24,850
Second. That 265 quintals of molasses from the baking of the brown sugar is of the actual value,	11,925
Third. That 10,000 litres of rum, the produce of the residue, will give,	4,687,50
Total product,	41,462,50
Deducting the expenses set down as above,	27,007,50
There remains a profit for the manufact.,	fr. 14,455

CORRECTION.

The reference to fig. 47, 48, 49, in note p. 35 should be fig. 1, 2, 3.

VALUABLE BOOKS,

PUBLISHED BY

MARSH, CAPEN & LYON,

No. 133 WASHINGTON STREET,

BOSTON.

THE RIGHTS OF AN AMERICAN CITIZEN, with a Commentary on State Rights, and on the Constitution and Policy of the United States. By BENJAMIN L. OLIVER, Counsellor at Law.

INTRODUCTION TO THE GRAMMAR OF ELOCUTION. Designed for the use of Schools. By JONATHAN BARBER, Member of the Royal College of Surgeons, London; late Instructor in Elocution in Harvard University.

DR. BRIGHAM'S WORK ON THE INFLUENCE OF MENTAL CULTIVATION ON HEALTH.

DR. BRIGHAM'S OBSERVATIONS ON THE INFLUENCE OF RELIGION UPON THE HEALTH AND PHYSICAL WELFARE OF MANKIND.

THE CONSTITUTION OF MAN considered in relation to External Objects. By GEORGE COMBE. Sixth edition, materially revised and enlarged.

COMBE'S PHRENOLOGY,—Do. ELEMENTS OF Do.—Do. MORAL PHILOSOPHY, in press.

GALL'S WORKS, in six vols.

Dr. Combe's work on the PHYSIOLOGY OF DIGESTION, considered with relation to the principles of Dietetics.

Dr. COMBE'S work on INSANITY.

HISTORY OF PLYMOUTH. Second edition, enlarged and corrected. By JAMES THACHER, M. D. A. A. S.

SHAW'S ARCHITECT.

Do. OPERATIVE MASONRY.

SPURZHEIM'S WORKS, Complete.

MR. MIDSHIPMAN EASY. By MARYATT.

SILK RAISER'S MANUAL, translated from the French—a new work.

MORAL PHILOSOPHY. By George Combe.