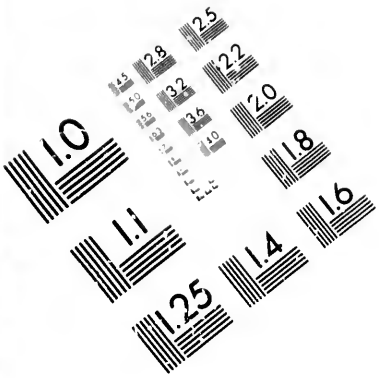

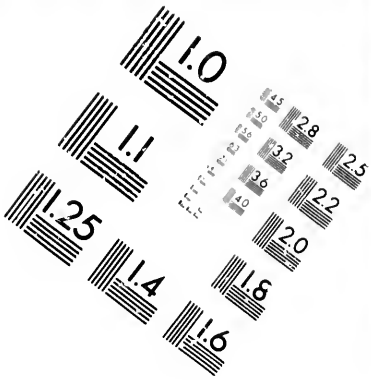

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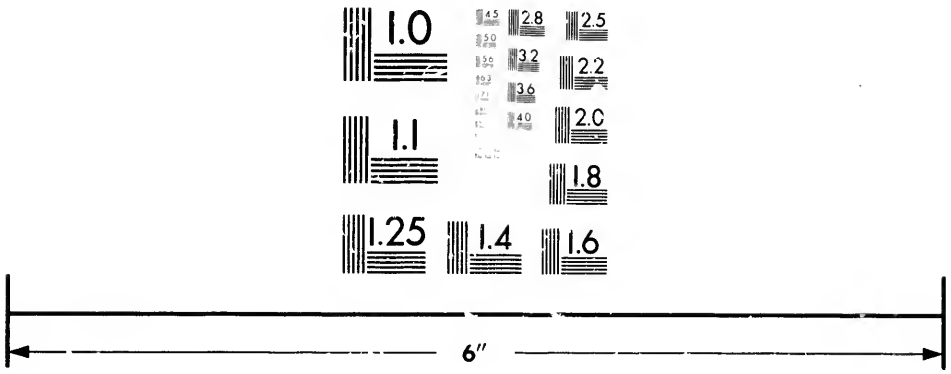

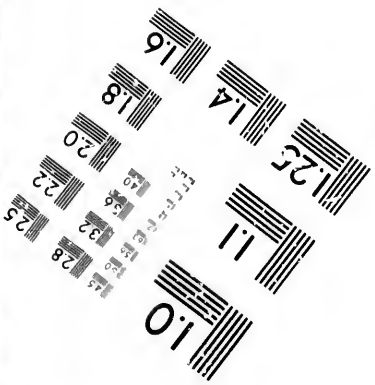

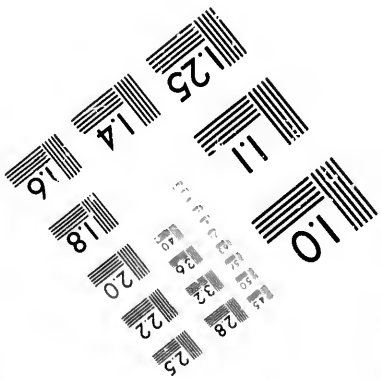

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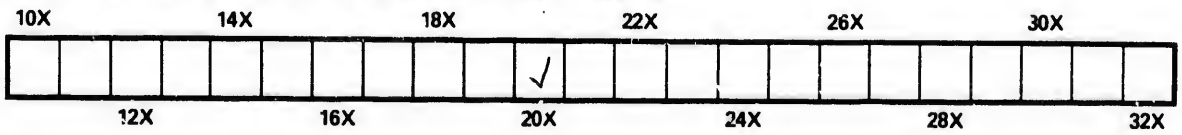

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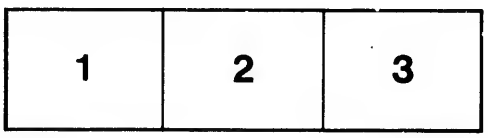
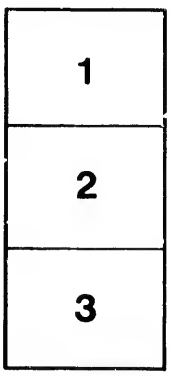
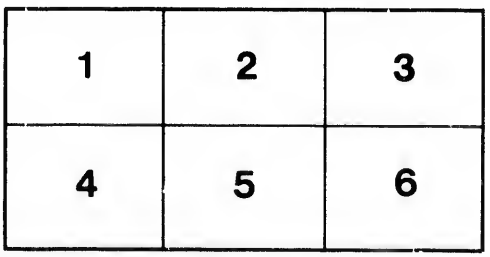






BEET-ROOT AND BEET-ROOT SUGAR:

The Description of all the Processes of Manufacture

BEING CONDENSED AND SIMPLIFIED AND ADAPTED TO THE USE OF THE FARMER AND THE SMALL MANUFACTURER, ANY OF WHOM MAY, BY FOLLOWING THE WITHIN INSTRUCTIONS, MANUFACTURE A MERCHANTABLE ARTICLE OF SUGAR, FIT FOR THE REFINER, FROM BEET-ROOT GROWN BY HIMSELF AS AN ORDINARY FIELD CROP.

BY

EDWARD LEFROY CULL,

OF THE CANADA COMPANY, TORONTO.

SECOND EDITION,

GREATLY ENLARGED AND IMPROVED.

TORONTO:

GLOBE PRINTING COMPANY, 26 AND 28 KING STREET EAST.

1874.

PREFACE TO THE SECOND EDITION.

The first edition of this little work having come to an end, and it having attracted more attention than the writer ever expected, or perhaps than it deserved, this second edition is put forth in answer to numerous enquiries from all parts of the world where the English language is spoken and English literature is read :—the East Indies, Australia, Van Dieman's Land, Britain, and the United States, have all contributed their quota to the demand for information, and it is now supplied, to the best of the writer's ability, in a popular shape. Continued experience has shown him the correctness of the views he first entertained, namely, that if we would make the production of Beet Sugar a general thing on this Continent, we must not only popularize information on the subject, but we must get the crude manufacture into the hands of *the people* instead of its being only in the hands of a few monster manufacturers who, to carry it on profitably, are obliged to combine five or six businesses in one, and not only themselves grow the beets, but convert and work up the refuse. The writer considers that the growth of the root belongs to "the farmer," and that the refuse by right belongs to "the farm,"—that the refuse, in all shapes, adds to the "fertility of the land," and thus enables the farmer to grow twice the amount of crops which otherwise he would be able to do.

It may and will be said that if the large manufacturer requires to combine the economy and skill and profits of five or six different businesses to make the manufacture of Beet Sugar remunerative,—that the unskilled farmer cannot be expected to do so with one branch of it only ; but it must be recollected that the farmer can *afford apparent* losses, which would ruin the great manufacturer,—that the growth of the root crop is to the farmer a "necessity" for the cleaning and benefit of the land,—that the beets, when grown, are mere cattle food,—and that, so long as the productions and refuse arising from those roots are kept "*on the farm*," so long you increase the fertility of the land; and although it may not *seem* to pay, yet it will be found that the sale of the roots, green or dry, or the manufacture of the crude article, will add another source of income to the farmer, and will most beneficially increase the amount of the general returns arising from the farm.

Looking at the question from a purely Canadian and American point of view, the writer believes that on this Continent, where wages are so high, the question will be entirely reversed as compared with the European Continent, and that where it would not pay the great manufacturer to hire for the whole of the multifarious operations of the production and manufacture, yet, when the operations are divided, the farmer will get a great benefit, whilst the refiner will, by the magnitude of his operations, be enabled to secure a satisfactory profit, by working up into a purer state the crude article which will flow towards him from a thousand sources, instead of his attention being divided into several channels to produce what so many others will be so well satisfied to produce for him.

Mercantile men say that if the work of the farm is reduced to a question of dollars and cents by putting a money value on all the labor done, it would not be found to show a satisfactory balance-sheet ; and yet, from these apparently unprofitable results (the work of the farmer and his family being thrown into the scale), is produced the whole wealth of the country.

The object of the writer is to improve the production of "the land." That being done, all the rest follows as a matter of course.

EDWARD L. CULL.

TORONTO, 1st November, 1873.

BEET SUGAR

AND

HOW IT IS MADE.

The following treatise is intended for the information of the Canadian public, and to assist the introduction of the "Beet Sugar Manufacture" into Canada.

The chief difficulty the writer has met with, has been the ignorance of the public on the subject of the "Manufacture of Sugar," and the almost impossibility of making people understand, that, instead of its being an unapproachable chemical process,—that the manufacture of a crude article of sugar, (from whatever source), is really one of the simplest and, indeed, one of the roughest arts, which supply the human family with the necessaries of life, and that it is one which any person of even limited capacity can master.

The manufacture of sugar until the advent of beet sugar in France, was confined to the tropics, chiefly to the East and West Indies, the material from which it was obtained being the sugar cane.

In the East Indies, China and Japan, the manufacture of sugar dates from the earliest ages, the date being so ancient that the original time of its growth is entirely lost sight of. The class of people who have made it within the British possessions were the "Ryots" of Hindostan, and the small farmer and proprietor, these have prepared the rough syrup from the cane, which they supply in small casks and earthen jars to the manufacturer of grained sugar, who is a person of only a few degrees of greater intelligence than the original grower. This second manufacturer reduces the rough syrup to coarse crystallized sugar, which is again furnished to the refiner, who converts it into loaf sugar, and into the best kinds of what is usually know as "moist sugar."

The manufacture of sugar in the West Indies was originally carried on by the negro race, under the superintendence, it is true, of white masters, but still the manipulation was entirely conducted by the colored race, and in a manner only one degree less rough than that adopted in the East Indies. Now, however, all the modern improvements in evaporation and refining are used in both the East and West Indies.

Is it to be supposed that our Canadian farmers are not far superior in intelligence to either of these classes, and therefore far fitter to undertake the manufacture of this grand staple among the necessaries of life.

The object of the writer in recommending in the following pages the use of substitutes, or cheap machinery, must not be misunderstood He does not mean for a moment to recommend the Canadian manufacturer to use any but the best and most expensive machinery that his means will afford, the best will in the end be to him the cheapest; but, to the farmer who produces the roots (which, without conversion, are mere cattle food), the writer will, hereafter, endeavor to show that by the simplest and most inexpensive means the farmer can convert his crop of roots, (or a great portion of it), into a substance that will not only yield him a better profit than his cattle, but also a quicker return; whilst, at the same time he will, (if he pleases), be able to supply his family with the most expensive staple required for housekeeping. We will now proceed to the subject for the encouragement of the growth of which this pamphlet was written, namely,

SUGAR FROM THE BEET.

The writer claims nothing absolutely new in the process set forth: the arrangement of the various processes is new; but more so by the suppression of superfluities than by additions. The new part of the process is the fact that by following the instructions hereafter given, twenty-five pounds of beet root may be manufactured into a merchantable sweet, in domestic utensils as readily as two hundred and fifty tons of beet root are ordinarily reduced in one of the monster factories of the European continent.

The most important thing the person can do who is to enter upon this manufacture is to forget all and every thing he has ever known about sugar making, particularly that which is made from the maule; and he must especially bear this maxim in mind, viz,—

Beet Root Sugar is not, never has been, and, the writer believes, never can be, made into an article of domestic use, until it has more or less perfectly been refined by a separate process.

All sugars, except maple sugar, are made at two processes—in the first the juice, whether from the sugar cane or from the beet, is defecated and boiled down to the crystallizing point; it is then set by in cisterns until the crystals have formed, when it is shovelled into barrels, and the molasses is made to drip from the sugar. The sugar is then shipped to England and America and elsewhere, and refined into loaf and into the best kinds of moist and crushed sugar.

Canadian ideas of the manufacture of sugar

are formed from the maple sugar made on the farm. This is the purest source of sugar which the vegetable kingdom supplies. It has deposited all its woody portions and impurities in the tree, the growth of which it nourishes, and we get it filtered and purified to the greatest possible extent.

Beet sugar must not be looked at for a moment with the same ideas or treated in the same manner.

The beet root contains besides sugar and woody matter, portions of albumen, pectine, and other substances, and also a flavoring matter of a strong beety odor, but chiefly large quantities of potash and salt.

Were it not for the potash and salt, and the strong beety flavor before spoken of, the juice of the beet when defecated would boil down into a pure crystallizable sugar, at once useable as maple sugar is.

It is the beety flavor and the potash and salt which we have difficulty in getting rid of. —These matters, however, yield at once to the operations of the refiner. The only portions of the extract from the beet root which in the refiner's hands are not made use of is the essential oil which causes the strong flavor, and any other imparities which ought to have been removed before it comes to his hands. The mixture of potash and salt when extracted from the syrup and purified is really worth weight for weight, at least as much as the sugar.

The following table will show the money value obtained from the entire beet root crop in France *alone*, in the year 1865-6, and it must be remembered that Germany, Belgium, Holland, Austria, and Russia, all make their own sugar, or at all events the greater portion of it, from the beet root, and in all cases it must also be remembered that the beet root industry is one that has been, and is constantly increasing.

The beet harvest of 1865-6, in France alone, produced—

275,000	Tons of raw sugar worth	£6,250,000,
100,000	Pipes of strong spirit—each pipe containing from 100 to 120 gallons, part distilled from the root direct, without the assistance of the sugar manufacturer, and part, ly from the molasses, and worth - - - -	1,350,000.
20,000	Tons of potash, worth	500,000.
1,600,000	Tons of pulp, worth	1,000,000.
		£9,100,000.

This is what is produced from the entire beet crop—not the value of the produce of the sugar manufactory.

The imports of beet root sugar at the British and Scotch ports for the first eleven months of 1871 were 134,480 tons, against 56,670 tons for the same period in 1870, and 31,060 for the same period in 1869; this shows the enormous increase of the manufacture.

Now, it is perfectly ridiculous to suppose (in the face of such a statement as the foregoing) that Canadians and the inhabitants of America generally, are going to confess inferiority to the French and Germans, and to allow it to be said, we have not nationally sufficient intelligence to make sugar from beets, when the continental nations are able to assist in supplying the world with that necessity.

Some people have been rash enough to say that our climate and soil are not fitted to produce the root rich enough in sugar to pay. This we most emphatically deny. The extended trials of the American patent office and the numerous instances of Canadian grown beets which have, during the last two years, come under the writer's hands, all show, beyond question, that Canadian beets, where well selected and well grown, are as rich in sugar as the best French and German or continental beets. If any one doubts it, all he has to do is to grow a patch of the best kinds of sugar beet in his field or garden, and following the instructions hereafter given reduce the roots to such a state that the amount of refined sugar they contain is easily proved by the ordinary tables and instruments. Others will say, and they are far the most practical. If it can be done, why has it not been done? In reply, I affirm that it is only because the manufacture has been made a mystery of and has not been understood. The chief trouble of the manufacture has consisted in the uncrystallizable sugar, and this, it is now proved, beyond a doubt, has been caused not by the sugar contained in the well grown root being inferior, but by the process adopted being imperfect. If the following instructions are carefully carried out, all difficulties and troubles as to uncrystallizable sugar will cease to be a serious obstacle.

With these few observations, I propose to lay before the readers of this little treatise, full instructions for the conversion of the root of the sugar beet into such a class of crude sugar as is best fitted for the refiner and in every way equal, for the purposes of refining to the best tropical sugar that is produced.

As the object of the writer is to tell people how to make sugar out of beets, and not to write a book, he will dispense with all dissertations as to how to grow the beet, and the various sorts, merely remarking that "the better the land is, in which beets are grown, the better will be the crop," that the beet for sugar must not be grown on black or peaty soil, nor on fresh green manure,—the land must be manured the previous season, and well prepared and ready for seeding in the fall—the seed must be sown as early as possible after the frost is out of the ground; if sown so late in the year as not to grow, it may even be sown in the fall. The ground; should all be prepared the previous fall, and be ready at once in the spring to sow the seed without further ceremony.

Grow the roots small, and close together;

take care that you do not have the leaves cut or injured—as some persons will use them for cattle feed. The more beets you have on the ground, the sweeter they are, and the more sugar you will have. All kinds of beet produce sugar, and the sugar of one kind is as good as the sugar of the best, the only difference is that their is *more* sugar in some sorts than in others, even the "mangel wurtzel" will produce sugar, but the "white Silesian beet," the "Vilmorin beet" "Carter's nursery sugar beet" are the best. At present all the best sugar beet seed is produced in France and Germany. When the cultivation of the root becomes a regular crop in Canada, we shall of course produce the seed ourselves—at present it must be imported.

Beet Sugar is obtained from the root by two processes, the one by grating or rasping the root and expressing the juice, which is then treated as hereafter described—the other by "diffusion," which consists in steeping the root in a divided state in water, and is also hereafter described. The first is the process by which the great bulk of the beet sugar made in the world has hitherto been obtained, the latter is a more modern invention and is alleged to be a far cheaper and equally efficient method of obtaining the same end. I shall describe both methods, leaving it to the reader to adopt whichever is the best suited to his means and ideas. No work of this kind would be complete without a description of both processes.

THE GRATING OR RASPING PROCESS.

To prepare the roots for sugar making they must be washed in a rolling wooden cage, and grated or rasped as finely as possible into pulp, the more absolutely and the quicker this is done the better, and the more success you will have. The pulp must be pressed in cloths or in anyway so as to obtain it as clear as possible. It must run from the press into the boiler, or if circumstances should prevent this, a little lime water must be added. Neither the pulp or the juice must be allowed to stand about, it begins to ferment immediately the root is ground, and then the sugar is destroyed. Nothing will stop the fermentation but lime water. The following are the particulars of these processes.

WASHING THE ROOTS.

The roots before being submitted to the rasp, must be thoroughly washed in a rolling cage, great pains must be taken that no dirt shall be allowed to remain on the roots when they come to the rasp, and the heads of the roots and leaf stems must be carefully cut off; and if cattle are kept to consume the portions of the root which come from the press, so that waste would not occur, the whole head of the root ought to be cut off, and fed to the cattle. It has been proved time and again that the extremity of the root end of the plant is the richest in sugar, whilst the portion which is grown above the ground is the part which contains the largest proportion of potash and salt, hence in the continental countries of Europe where the government excise duty is charged on the roots consumed; the entire portion of the root which grows above the ground is cut off and rejected for sugar purposes. Any plan which will insure perfect cleanliness in the roots, is that best adapted to the work, and the roots should be allowed to drain off all superfluous water, before they come to the rasp.

THE RASPING THE ROOTS.

The roots should be presented to the rasp endwise, and the rasp (however constructed) should reduce the root to the finest possible pulp. The pulp, should then be passed through rollers working together, which are of sufficient surface to receive and crush the pulp as it comes from the rasp. The rollers will thus reduce the pulp to a perfectly smooth paste, and burst all the cells of which the root is formed, and which cells contain the sugar.

One form of the rasp which will do a great deal of work and is very cheap, is made of a sheat of punched zinced iron fixed around a cylinder of wood, and turned by a winch by hand or by power; another form of rasp (and the best) is made of saw blades let into a wooden cylinder lengthwise, about an inch and a half apart, and fastened into the slits in the cylinder with wedges, this admits of the saws being sharpened with a file in the ordinary manner, the cylinder is then turned by hand or power, and the pulped roots caught in a proper receptacle. The roots on a small scale are presented to the rasp by hand, on a larger scale they are pressed against the rasp either by their own weight or by machinery. On a large scale the rasp is made to revolve with considerable speed. For a large manufactory the cylinder will be made of iron turned in a lathe.

PRESSING THE PULP.

The following is the old fashioned plan. There have been, and will be many improvements. The pulp must be placed by small parcels at a time, (according to the size and power of the press), on strong canvas cloths, each cloth being laid over a frame about 2 inches deep, and the size that will go into the press; the cloths must be much larger than the frames. When the frame is full, fold over the cloth first from side to side, then the ends over; then place the cushion of pulp so formed in the press; there must be a strong board, larger than the cushion of pulp, and it must rest on one board while another covers it; one board going one way of the grain, the next above crossing it, and so on, parcels of pulp and boards until you have the press full. Then put on the power very gradually, so that the juice can escape readily from the cloths, without bursting them; press to the full power of the screw, and take care to catch all the juice.

The juice should run from the press at once into the kettles, where the heat should

be raised as quickly as possible to 150° Fahrenheit's thermometer, and it should not fall below this heat, so long as the kettle is filling.

When all the juice is out that you can get out at the first operation, with the press; take the cakes of pulp, put them in hot water, and let them soak for an hour. The water must be nearly boiling, as the cakes will cool it sufficiently. When broken up and mixed with the hot water (which they should be at once), the heat ought to be between 150° and 155° (Far.); and if not so, add more hot water until that heat is attained; then cover up, and keep it all hot. This is necessary to prevent fermentation or acetification. Then proceed to press the mashed roots again, in the same manner as at first.

It is scarcely worth while to squeeze the pulp more than twice, although it ordinarily takes three pressings to get out all the sugar. If your press is sufficiently powerful you can get out all the juice at once.

Strain the juice through a fine strainer, and get the juice into the kettles as soon as possible. Neither the first juice nor the product of the second pressing must ever be allowed to fall in heat, below 150°, or souring may commence. When in the kettles, heat the juice as quickly as possible, to just boiling; then add the lime in the following manner; the juice will be very black, and dirty looking, but it will all come right with the lime.

TO MAKE THE MILK OF LIME.

Get some good, new, hot lime, slake it in boiling water; stir it up and let it settle for a minute or two, and pour the liquor off the dregs; you must leave all the coarse part of the lime behind, only take off the *milk* of lime, which must be quite smooth and without grit.

This should be made and put in a barrel; the lime must be caustic and strong; when kept under water it will keep for any reasonable time in a caustic state. When the juice boils, add some of the milk of lime to it, and stir it slowly. When you find the juice changing color, and curdle, shewing clear in spots, and when it shows signs of settling, you have put lime enough; stir the juice gently until the lime is mixed well through it, but don't urge the juice to a rapid boil; then take out a sample in a glass and see if it clears, and is the color of white wine, if so, enough lime has been put; if not, put a *little* more, but don't put more lime than enough. As soon as the juice boils, the effect will have been produced.

The following observations on straining the juice, will save much trouble:—

If the juice has been properly limed and boiled (and nothing but experience on these heads will teach the operator) there should be a thick scum on the juice which should be carefully removed with a skimmer, and set by itself. As the heat of the juice passes off, (and it should pass off as quickly as possible) the lime and other impurities will settle to the bottom of the boiler, leaving the main body of the juice clear. As straining the juice from the lime is always a very troublesome operation, the more of this clear juice you can get the better; but even when drawn off clear, it should always be strained through a linen strainer, but when clear it passes readily. When you come to the thick portions, and to the scums, they may be put into close canvass bags, and with boards between, as in the first presser when the roots are grated; pile the bags one on the other, and let the liquor exude through the bags by the pressure of their own weight; it will come through clear, or, at all events, so clear as to be easily strained. As the liquor ceases to run, pile weights on the bags, and in the end press them with the screw. The thick portions are most valuable manure. No mischief will arise from delay in this part of the process, as the lime will prevent the juice from souring or fermentation for any reasonable time.

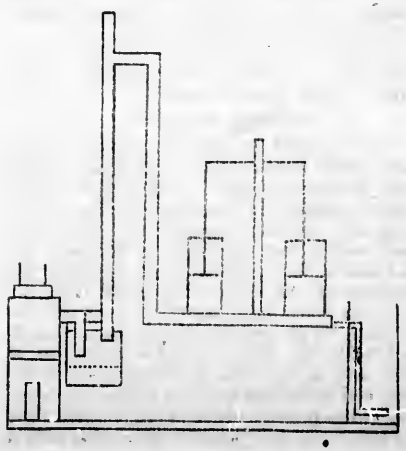
When the juice is all clear and fine it is then ready for the next process, which is called the carbonatation.

Although the juice is so clear and fine, there is still a great deal of lime in it, although you cannot see it—the sugar in the juice renders the lime in a measure soluble.

The lime which is in the juice is in a caustic state, and the object of the next operation is to remove the causticity; when this is done, the lime (before invisible) at once subsides in the liquor, and is removed by settlement and filtration. This operation is called the carbonatation, and is done in the following manner:—

It must first, however, be remarked, that on the perfection of the carbonatation, the whole success of the work will depend, and too much pains cannot be taken in rendering this part of the process complete and easily worked.

You must procure or construct a stove for burning charcoal thus:—(See the accompanying cut.)



A is the chamber of a stove, made of either cast iron or brick, with a fire grate and ash pit, and the means of putting in the charcoal at the top, and then covering up the opening. B B are pipes, made of common stove pipe iron. C is a tub containing water, with a close fitting cover of either wood or iron—iron is best and safest of course. The cover has two holes in it, into which the stove pipes fit tight. The pipe which comes direct from the stove must go down to within an inch of the water, but must not touch it. The water is to catch and retain the dust and ashes, which would otherwise pass over from the burning charcoal; the other pipe only goes just through the cover, the joints of both these pipes where they enter the cover should be made as tight as possible. There should be a common stove damper at E, turning on a centre. When you kindle the fire of charcoal in the stove, shut this damper, and let the first fumes of the charcoal and the smoke pass off into the air. As soon as the charcoal is well lighted, and the smoke and bad smell have passed off, the damper must be opened, and the cover of the stove closed, and the fumes of the burning charcoal must be sucked through the second pipe in the following manner:—

You must have a set of bellows; (common blacksmiths' bellows will answer if made large enough, or a blowing cylinder similar to those used in foundries will do even better) these must be connected with the second pipe by a flexible joint made of leather or otherwise, and there must be the means of readily working them either by hand power or machinery. To the nozzle of the bellows is fixed a flexible rubber pipe, so that when the bellows are worked, the gas from the charcoal is drawn through them, and forced through the flexible pipe. At the end of this flexible pipe is fixed a rose or a pipe pierced with small holes, and heavy enough to sink into, and keep at the bottom of the liquor. The second pipe (B) from the water vessel must be made of sufficient length to allow most of the heat to pass off before it comes to the bellows or blowing cylinder, or you will burn your bellows and leather joint and valves. If the joints of this pipe are not tight enough, paste them up with paper until they are tight.

Having this all in order, (and it must be thoroughly well done) insert the flexible pipe which is attached to the nozzle of the bellows into the liquor to be carbonated, and blow away. The passage of the carbonic acid gas from the charcoal, passing through the limy liquor in fine streams or bubbles, mixes with the lime in the juice and carbonates it, and the lime (on the liquor being rested) falls to the bottom of the vessel in a fine mud.

To prove when the corbonatation is complete, take a small quantity of the liquor in a glass, (get it as fine as possible, or filter it), then with a straw or reed, or other pipe, blow your breath through the liquor in the glass. If it remains fine, the work is done; if the breath muddies the liquor, the carbonatation is not complete, and the bellows must again be worked until the liquor, when tried, is found to remain bright and clear. When blowing the breath through the glass of liquor you must hold your nose, or else the breath will not have sufficient carbonic acid in it to prove the liquor.

The carbonatation must be done when the liquor is only just warm enough to keep grease melted on it—the generality of the books desire the carbonatation to take place in boiling liquor—but this is a grave error, as will be shown further on. Carbonic acid has the effect on hot juice of destroying the crystallizing power of the sugar. When the carbonic acid gas from the charcoal is blown into the liquor, a great deal of effervescence will take place; and the only way to keep down the froth is by the addition of a small portion of clean grease—*the less, however, the better.* When the carbonatation is complete, the liquor must be allowed to settle for a short time; the clear liquor must be strained into the boiler, and the sediment must be squeezed and filtered. The residue is most valuable for manure.

As, however, you have now lost the preservative power of the lime, the liquor will rapidly ferment, or sour, and no time must be lost in transferring it to the boiler, and getting it hot. It must be boiled until about one-fourth of it is evaporated, and it must then be strained through the bone black filter, which will be described further on.

It will come through the bone black of a very much lighter color, and almost free from disagreeable taste and smell. It must then be boiled down to a thick syrup, taking care not to burn it, and it will be ready to set by, in a warm place, to crystallize.

As the boiler is so important a part of the machinery for sugar making, it is well to describe it more particularly. Any kind of boiler will answer, such as sugar kettles, set on an arch, or otherwise, but the writer prefers the following—more particularly because experience has shown, in the Western States, that it is admirably adapted for the purpose. It is made very cheaply, is very lasting, and is extremely economical in fuel:—The shape of the boiler is long and narrow, and the heat of the fire acts on the entire length of the bottom. The sides and ends of the boiler are made of two inch pine plank, fastened together at the angles with screws, and angle pieces of wood, the screws going both into the ends and into the angle pieces. Into the side pieces there are grooves cut one-and-a-half inches wide, and one-fourth of an inch deep. These grooves must be carefully cut—*all exactly to one size*—and well and smoothly finished, so that the partitions (to be hereafter described) will all fit into every groove. If this is not carefully done there will be endless trouble. The grooves must be eight inches apart. In making the frame the ends must not come down as low as the sides by two inches. The

frame must be twelve feet long, and at least two feet wide. The bottom is made of two sheets of iron, rivetted together at the ends, so as to be water tight. It must be turned up at the ends and sides, and the angles turned in just like a large baking dish; but the ends must turn up three inches longer than the sides. Holes must be punched or drilled all along the sides and ends of the turn up, for the purpose of putting in screws to hold the iron to the wood. The turn up should be two inches at the sides, and five inches at the ends. You then have a long, shallow, iron dish—the wooden frame is made to fit into this—and then the sides and ends of the iron pan are fastened strongly into the sides and ends of the frame.

The partitions are made of wood, eight inches broad, and slide easily into the grooves. On to the lower side of each partition a piece of two-inch strong iron hoop is fastened, by screws; but this iron, although it goes quite to the end on one end of the partition pieces, does not go to the other end by two inches. When the partitions are fitted into the grooves, this vacant space is put alternately at each side, and the iron pieces bear on the bottom of the pan, so that when liquor is poured into one end of the pan it must circulate backward and forward, from side to side, until it reaches the other end.

When the boiler is to be used for heating and defecating the juice, these partitions are taken out, and laid aside; they are only used during the process of evaporating the juice previous to crystallization.

This boiler is set on two walls of brick work, going its entire length. The fireplace is at one end, and the chimney at the other.

When you are evaporating or sugaring off, the partitions must be fitted into their places there must be two vessels or tubs used with the boiler, one placed near the chimney to hold the charge; the other, at the fire end of the boiler to receive the syrup. There is a tap hole or plug in the end of one of the sides of the boiler to draw off the charge, this must be capable of being partially or wholly closed as required. A sufficient stream is let into the boiler at the chimney end, so that it evaporates as it runs from side to side; and is finally discharged from the fire end in the shape of thick syrup. When all is done, this syrup is removed to the chimney end, and again made to flow through the boiler, when it comes out all the water evaporates and is fit to sugar off and go into the crystallizing pans. In this state it will keep any length of time without fermentation or change.

The fire must be used with care and judgment, and for sugaring off, a sheet iron plate ought to be used to slide in between the bottom of the pan, and the fire; and thus take off the rashest heat of the fire, and prevent burning.

Before however the syrup is boiled down, to its thickest state, it must be strained through a filter of bone black, which we shall now proceed to describe, this is the most troublesome part of the process from the fact, that the bone black filter will only last a short time, without being reburned.

Bone black acts much more energetically on *juice* about one-quarter boiled down, than on *syrup*, therefore the filter should be used whenever the juice has been well boiled, and has been thus only in a measure evaporated, the bone black filter operates better on the hot juice than on cold, and where it can be done, the juice as well as the filter ought to be kept hot throughout the entire process of filtering.

The object of the bone black filter, is to take out the excess of lime, and the other alkaline salts in the juice, and also to purify the syrup from its bad taste; and to destroy its color. A certain portion of the sugar can be crystallized without the bone black, but the bone black should always be used where it is possible to use it.

THE BONE BLACK FILTERS.

Any one who has a potash kettle can make bone black, and can reburn the bone black when necessary, we shall describe the process with a potash kettle, leaving those who have not one to use some substitute which their own ingenuity must point out. Any thick cast iron vessel that will stand a red heat time after time, will answer, though of course not so well as a potash kettle. The regular sugar manufactories have proper machinery for this purpose, we only wish to point out the substitutes.

Collect all the bones together you can; break them up small, and fill them into the potash kettle, boil them well, steaming is better—and skim off the fat—when they are quite clean from fat, &c., and the water has been drained off, take some wet clay, cover over the bones with the clay, and apply the heat, this must of course be done out of doors, and away from the house, as the fumes will be very offensive; it should also be done out of a building; as the fat in the bones which cannot be got rid of by boiling will generate a great deal of gas as they are heated, this gas will catch fire, and burn with violence, all danger from this source must therefore be guarded against. The fire under the kettle must be urged until every thing is red hot, and until the bones are all burned, and no further smell comes from them. It would be all the better to have a fire over as well as under the kettle, but the ashes from the fire must not be allowed to get into the bone black, if any does, it must be carefully washed out, but no ashes must get in. When every thing is red hot, and the bones so well burned that no more smell or gas comes from them; cover up the whole with good clean clay earth, and let it cool, the wet clay first, and the clay earth afterwards, are to keep the external air from affecting the burning bones, if it was not for

this, you would not have "bone charcoal;" but white bone ashes, which would be worse than useless. When the kettle is cold, remove the clay earth, and afterwards the clay, which was wet and was on the bones.

Take out the bones which now ought to be all perfectly black and tasteless. Make a good heavy rammer of hard wood, cut it to fit the bottom of the kettle, and then pound up the burnt bones little by little in the kettle, a good potash kettle will be plenty strong enough, (there is no fear of your pounding them too fine)—as you proceed you should sift the powdered bones through a sieve, a fine sieve like a timothy sieve will answer, throw back what will not go through, and pound it over again.

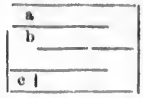
When you have got as much as you want according to the size of your works, (but for a few acres of beet three bushels would answer), put this bone charcoal in a tub with a false bottom, have the bone black about three feet thick—there must be room enough above it for the syrup or juice, when all is done, leach boiling clean water through it, so long as it has either smell or taste, then let it run dry, and the filter will be ready for the juice.

As soon as the filter is found to lose its effect, you must sprinkle boiling water on it—if done gradually the water will take out all the syrup which the bone black retains, the syrup will at first come through of its full strength, the liquor will then get weaker, until finally nothing but water will come, the weak liquor must be used in the fresh ground roots, and thus no loss will take place.

Hot water well washed through the filter will for a time renew its purifying qualities, when it will act no longer, it must be reburned in the potash kettle, the loss from reburning is very trifling, if it is done with judgment.

BOILING DOWN FOR CRYSTALLIZATION.

This requires a good deal of judgment, and the greatest care must be taken not to burn the syrup, but at the same time the evaporation must be as rapid as possible, and must be continued until all the water is off, when ready to set by, the liquor will, on being cooled, draw out in a string between the finger and thumb the string will break and the ends turn back in the shape of a hook, and it is the shape of this hook by which you know whether the syrup is boiled sufficiently, nothing but experience will show this, altho' it may appear that you have got all the water off, yet the syrup, on cooling, will sometimes seem to get thinner again, and in this case it must be reboiled. In other cases it will get thicker and crystallize in the course of a short time, when it is set by to crystallize, it must be in *shallow* vessels and in a warm place, and the syrup must be kept at about the heat of new milk, or blood heat. If you have not proper convenience for this you should make a place, thus, make a fire place of mud, or bricks, or stones, if you have them, but mud will do, from this make flues with mud walls backwards and forwards until you have filled up the size of the crystallizing



house, make it thus, a, fire place; b, flues; c, chimney. The flues and fireplace may, in the first place, be covered with sticks to hold up the mud, these will afterwards burn out, and the mud will bake strong enough to support itself; the whole should be covered with mud to the thickness of at least six inches, the chimney may also be built of mud and sticks, and carried to a sufficient height to ensure a draught, the sides and top of the house should be of board made quite close, and the roof must have a good overhanging to throw off the water. Mud building is strong enough so long as you keep it dry; the chimney must also be defended from the wet by a roof, but, of course, there must be plenty of exit for the smoke. A fire of chips or any refuse wood lighted in the fireplace, will soon bring this mass of mud flues to a good heat, and when it is once warm stop the chimney and close the fire door; a little fire, lighted once or twice a day, will keep it hot. The crystallizing pans must stand on the surface of the flues and fireplace. The building must be as low as convenience will allow, and for fear of fire it ought to be erected at a safe distance from buildings, of course a good brick building would be better where expense is no object.

In four or five days the syrup will commence to crystallize from the top, the crystals should then be stirred down, and more will form, they seem to increase fastest from the top. When the crystallization is complete, the syrup will be ready to barrel up for sale to the refiner, or if you wish it you can proceed to further operations with it as hereafter described, or where you do not want to make sugar for yourself, but mean to dispose of the syrup to the refiner, the syrup may, as soon as ready, be poured into casks while hot and bunged [illegible] for sale *if the water is all out of it*, it will keep for any length of time.

This is as far as the writer recommends the farmer or small manufacturer to go, but as there are many who may wish to pursue the subject to a greater extent, the instructions to that end are given further on. Before proceeding, however, the writer cannot urge the following general observations too strongly on the mind of the reader.

There is nothing in the foregoing processes which a person of ordinary intelligence and information cannot do. The processes are simple, and the result, an article of a certain commercial value.

Refiners of sugar want to get their crude materials with as little done to them by people who do not understand refining as possible; as they have certain processes to go through, and they do not of course want to have to amend the blunders of other persons. Any attempt at partial refining, or the use of chemicals by the producer, is quite as

likely to be wrong as right, for the after processes. The difficulty with beet sugar has always been the crystallization, and the getting rid of the potash and salt, and the trouble has been what the Germans and French call "slime sugar;" but if the foregoing rules are *exactly* followed, there will be no slime sugar or treacle—scarcely enough to enable you to get off that portion of the syrup which contains the salts, and which must be got out from the mass with the turbine. If you proceed to the second operation, bear these few rules constantly in mind. In the first operation when you add the milk of lime to the juice to clear it:—

1st. Never keep the lime in contact with the *hot juice a minute longer than you can help it;* the lime cannot be dispensed with to clear the juice, but its action on the hot juice produces more or less of slime sugar.

2nd. Do not agitate the juice with the lime in it, more than enough to mix, or you will spoil your filtration; the larger the flakes remain in the juice the better it will filter

3rd. Never carbonate at any other than a cow milk heat. If you carbonate hot, as most of the books tell you, you will make slime sugar.

Of course, throughout the whole process of boiling, heating, and evaporation, you must be extremely careful neither to burn, nor even brown the syrup. The syrup will be always highly colored; but if it has not been burned, all the color comes out without waste in the after processes, and if the process of evaporation is conducted in the best manner, the sugar which crystalizes out of the colored syrup, will be nearly, if not quite white. The burned sugar can never be recovered.

The foregoing instructions are the result of *actual experiment*, and may be relied on as the result of experience of two years' continual experiments on a working scale.

We shall now proceed to discuss the process of "Diffusion."

There is another process for the extraction of sugar from beet root, which is called the "Diffusion process," and it is now almost universally adopted throughout France and Germany—great numbers of the factories being altered from the old grating and pressing process to the diffusatory process, which is thus described:—

Roberts' Diffusion Process is now acknowledged to be the most economical of any, both in first cost and in working. The apparatus which is used is hardly liable to get out of order, and requires very little attention, while the operations are cleanly and free from filth. Of this process, Mr. Post, United States Consul at Vienna, Austria, wrote, in 1867, as follows:—

"The new process recently invented by "Mr. Julius Robert, a sugar manufacturer, "of Seelowitz, Austria, is working a com- "plete change in the manufactories here, and "will doubtless exert a great influence on an "extended introduction of beet sugar manufacture in the United States, and it is "adapted to extracting the crystalline sugar "from either sugar cane or beet root."

In the United States (and Canada) where labor is so expensive, this innovation must prove of incalculable importance The only thing required in this new process not necessary in the old, is an additional supply of water, an article tolerably plentiful and cheap wherever this manufacture is likely to be introduced in our country,

That this process is really the great improvement claimed, no longer admits of dispute. Mr. Robert has thoroughly tested it in his factory, and has adopted it, as have also many other factories. Since 1867, no less than 130 of the old beet sugaries of Europe have discarded their old process for the new one.

The apparatus for this process, as well as the principle of its action, is different from that of any other. While the other processes are to extract all the juice from the beet, this process extracts only the crystalizable sugar contained in the juice, and leaves most of the impurities in the cells. To accomplish this result the Beet roots are cut up in small thin slices, and put into a number of vats, which are connected by pipes running from the bottom of one vat to the top of the next succeeding. Water of a certain temperature, (it must be hot, nearly boiling) and of a quantity proportioned to the weight of the beet root in the vats, is mixed with the material in the first vat, and allowed to remain until it takes up a portion of the saccharine matter, or, so to speak, until the sugar in the vat is equalized between the water and the beet root; that is to say, if the beet root contains 8 per cent. of saccharine matter, the water will take up 4 per cent.; this water is then forced into the the second vat filled with the cut slices of beet root.

The water already contains four per cent. of sugar, but the beet having eight per cent. it will again equalize itself, and when forced into the third vat will contain 6 per cent. of saccharine matter; in this way the water becomes more and more impregnated with saccharine matter, until it contains almost as much as the beet itself. To return to the first vat we find that the first application of water extracted one half the sugar or four per cent., when this water was forced into the second vat; the fresh water which forced it out and supplied its place extracted two per cent. more before the saccharine matter became equalized between the water and the beets. This water is then forced into the second vat, and the fresh water which supplies its place finds the beets containing but two per cent of saccharine matter, and the next filling finds but one per cent., and in this way the water is extracted to within one half of one per cent.

It is said that by this process the raw material of syrup is much purer than when extracted by any other method, that from the same beets one half per cent. more of crystal-

line sugar is obtained than by the application of pressure ; the expense of pressing-cloths, and the cleaning and renewing them, are done entirely away with ; the expense for motive power and machinery is considerably reduced, and the expense of manual labor is much less, requiring but one-fourth the number of laborers necessary for the pressing process.

Within a short time Mr. Robert has introduced a modification of his original apparatus. In this modification the series of vessels is abandoned, and one single chamber is employed instead. In the centre of the chamber is a feeding cylinder containing a feeding screw, driven by gearing from above. The sliced beet root is passed through a hopper to the bottom of the feeding chamber, whence it passes out through openings into the outer cylinder of the diffuser, and gradually rising to the top, is carried off by a regulating rake, driven by independent gearing. From the top of the diffuser, water is slowly supplied through small pipes, meeting in its descent the most exhausted slices as they rise to the discharge level, and passing through to the richer material as it becomes more and more saturated. At the bottom, it issues through perforations or outlet pipes, and is carried off to a cistern, where it is heated, and then returned upon the beet by the central feeding tube, by which the beet is supplied to the diffusing chamber. This apparatus, which has answered well at beet sugar and spirit works, has also been applied to cane sugar factories, where it promises good results.

The heat of the liquor or water supplied must be sufficient to *kill* the vegetable life in the root, as the diffusion process does not take place, or affect the skin of the sugar cells, until the *vegetable life* is destroyed. The heat required in the mass is at least 140° Farenheit, and from that up to nearly boiling.

The shape into which the roots are sliced is such that they will not lie close together, but allow the water of diffusion readily to percolate to every part. Long finger-like pieces, cut into a triangular shape, are considered the best, although some cut the roots up into small square masses, and others into fine oblong square pieces. That process is best which keeps the mass most open, and the pieces of root from packing together.

This process does not, however, do away with the necessary defecation with lime—less lime may be necessary, and the scums and curdlings will be less in amount and easier to get rid of, but the lime process must be used until the juice is properly defecated and cleared from impurities.

The carbonatation, as already described, must also be applied to the juice, and the entire process, with the exception of grating or rasping and pressing, must go on as before given.

The spent slices, when not wanted to be fed at once, may have all the waste water taken out of them by being centrifugalled, and the water so obtained will save so much of the sugar, and can be used in the diffusion vessel instead of fresh water. Cattle do as well on the spent slices as on the pressed cake.

PURIFICATION OF THE SYRUP.

The great object in the purification of beet root sugar, is the getting rid of the potash and salt, and other saline matters. In the first instance this was done by repeated strainings through bone charcoal, but that being very troublesome, and expensive, several other plans have been tried, and are generally now adopted.

The first of these plans is the "Osmose" process, which is founded on the fact that certain substances and mediums allow readily the passage of salt through them, while the medium prevents the passage of the sugar, except in a very small degree. The principle is an extended one, and is known under the name of "dialysis," but as we only want to show how the process is used in the manufacture of beet sugar, we shall not go into the general question.

The usual machinery adopted for the Osmose process is the "Osmogene," and is thus described by Crookes, in his admirable work on beet sugar :—

"The apparatus consists of about fifty "cells, separated by sheets of parchment "paper, laid flat, and connected at the edges "all round, the space between each pair of "sheets being fully half an inch. Each "sheet is supported by a cross piece of wood, "and a network of twine. The whole ar-"rangement is about four feet long, and "three feet high. By a peculiar arrange-"ment of connection the syrup admitted "from below passes through every second "division, while water admitted from above "also passes through every second space, "and at last flows off from below, at a "strength from 1° to 2° B, or say 1° to 2½° "Twaddle (this strength is caused by the "salts taken out of the sugar). Owing to "the high diffusive power of the salts, as "compared with that of sugar, the former "readily pass through, together with only a "comparatively small portion of the sugar, "which may be saved as before, by fermen-"tation—whilst the potash, and salts are "saved by evaporation, and burning. This "will no doubt appear to many too delicate "a process to work on a large scale, but "experience proves that it works well, and "that six such machines are sufficient for a "manufactory working daily about 250 tons "of beets."

MODIFICATION OF THE OSMOSE PROCESS.

The following modification of the Osmose arrangement originates with the author, and has been highly approved of by one of the best sugar engineers in France, who says he shall adopt it in his works in future, as it admits of being cleaned, and renewed better than the ordinary system. It takes more room, but that is a small matter

compared with its other advantages. The new system is as follows : Construct a long trough, about 30 inches wide, and 12 feet long. The width must be made to suit the parchment paper, and the length must be made to suit the premises. If you want greater length, make two or more troughs. Let the sides and ends of this trough be about two inches deep, and it must be made water-tight with paint, or with pitch run into the angles. Good paint, or any good cement, is better than pitch, but the latter will answer. This is to hold the water. Then construct another trough of a smaller size, so as to fit easily into the first, but the bottom of this inner trough must be made with *very* narrow slats, or a network of twine, or wire, the meshes of which must be about an inch square ; the wire should be brass, as it will oxidize less than iron. This is to bear the weight of the thin stratum of syrup. The net-work must be covered with the parchment paper, which must be fastened down so as to be water tight. This may be done with thin strips of wood, nailed down over the edges of the paper, and through to the bottom, or sides of the frame of the inner trough. Water is put in the outer trough, and the inner trough is made to float on the water. You will thus have water on one side of the parchment paper, and syrup on the other side. The water is let into one end of the outer trough, and is made to flow towards the other end, where it is drawn off. The syrup is made to flow on to one end of the parchment paper bottom of the inner trough, and to cover the whole of the parchment paper in a thin stream, and to flow off at the other end, so that the water *very gradually* flows one way and the syrup flows the other way. The current of both liquids, however, is extremely slow. During the passage of the syrup, it parts with the potash and salts through the parchment paper, and into the water, whilst a little water comes through the parchment paper into the syrup. The salts can be recovered from the water by evaporation, where it is worth while, which it will not be on a small scale. After a time, the paper will refuse to pass the salts. It can then be cleaned and renewed by a slight scrubbing with water weakly acidulated with sulphuric acid. Use a corn broom for the scrubbing, but you must, of course, be very careful not to tear the paper.

This is the osmose principle, and when once well understood, the operator can make his "osmogene," as the troughs are called, in any way which will best suit him, or his premises or means allow.

The following is a new method of removing the salts from the syrup. The writer has not yet tried it, but as it forms the subject of an English patent, taken out by Mr. Duncan, of London, England—the great sugar refiner, who has large beet sugar works at Lavenham, Sussex, England—there is no doubt of its being well adapted to the end proposed.

The following is the description taken from the English magazine, "The Sugar Cane :"

NEW METHOD OF REMOVING POTASH FROM SACCHARINE SOLUTIONS.

"The plan now under consideration consists in adding to the cold syrup sulphate of alumina, so as to form an alum with the whole of the potash present. The solution is then well stirred, and after a few hours standing, the alum separates out in the form of small crystals, technically known as "alum meal." The clear liquor is then run off, and immediately neutralized with milk of lime, finishing up with a little chalk, so as to prevent the necessity of removing any excess of lime by carbonatation. It is possible to use chalk only, but the amount of effervescence is then very great, and the chalk should therefore be added little by little.

"In working this alum process, the solutions should be quite cold. It is also advisable to operate as quickly as possible, consistently with a due separation of the alum, as otherwise more or less sugar would become inverted (that is, not crystallizable).

"Every one part of potash in the syrup requires for conversion into alum about 9½ parts of sulphate of alumina, out of which 2½ parts are required to convert the potash into sulphate, and the remaining 7 to combine with the sulphate of potash, so as to form alum. If the liquor contains any sulphuric acid, either free or combined, the 2½ parts of sulphate of alumina required to convert the potash into sulphate, may be partly or entirely dispensed with.

"When once the liquor has been neutralized (with the lime and chalk), it is heated and filtered in the usual way.

" The precipitated alum (or alum meal) is washed free from syrup with three consecutive washings, using one-third of its weight of cold water each time. These washings, after neutralizing with lime and chalk, are used to dissolve up a fresh quantity of the raw beet sugar."

The alum meal is easily dried in a centrifugal machine, or by pressure, or other suitable means.

The sulphate of alumina has the following composition :—

Alumina,.....	15.41
Sulphuric acid,.....	35.99
Water, ...	48.60
	100.00

It should be as free as possible from iron, and should not contain more acid than given in the analysis.

The solution of sulphate of alumina generally used contains one third of its weight of sulphate of alumina, and has a density of about 24° Baumé.

Instead of using a solution, the dry sulphate of alumina, in a finely ground state,

may be added to a syrup, and when alum separates under these circumstances, the liquor is actually concentrated to some extent. This, of course, saves evaporation.

The rapidity of settlement of the alum is accelerated by throwing into the mixture a quantity of "alum meal."

Experiments made with beet syrup at Mr. Duncan's sugar works, at Lavenham, have conclusively shown that by means of sulphate of alumina, potash may be almost entirely separated from syrups, not more than 0.2 per cent. (that is two-tenths of one per cent.) being left in solution. By again concentrating the mother liquor, and repeating the process, the whole of the potash may be practically removed.

The advantages of the process are—

1st. The removal of the potash, and ammonia from syrups, without much dilution.

2nd. The removal of a great deal of the coloring, and albuminous matters, and a considerable improvement both in taste and odor.

3rd. The alum produced is equal in value to the sulphate of alumina used, so that the process is comparatively costless.

4th. The plant (or utensils) required is of the simplest description, the cost of labor small, and the entire process is of a continuous, and rapid character.

It will naturally be asked by unscientific practical persons, "What is sulphate of alumina, and what does it cost?" In reply, sulphate of alumina is a natural production in the ground, and occurs in many places like sulphate of lime, or plaster. It is caused by a natural combination of sulphuric acid, and clay, and this substance is found in large quantities wherever alum works are established. Alum is a triple salt, and it requires the presence of the three elements, sulphuric acid, alumina, and potash, to make it. Where these three elements meet they rush together and form alum. In the alum manufactories they introduce the potash to the sulphate of alumina. In the before described process, the sulphate of alumina is made use of to draw the potash out of the beet syrup, and thus get rid of it from where it is not wanted, and is mischievous. There is also alum made with soda, and also ammonia alum, and as all the three alkalies, potash, soda, and ammonia are present in beet syrup, the foregoing process attacks, and removes the soda and ammonia, as well as the potash. There is no doubt that this will prove a most valuable discovery, and tend greatly to the success of the manufacture of beet root sugar.

Another portion of Mr. Duncan's process consists in using tartaric acid instead of sulphate of alumina. This is added to the expressed liquor, and the admixture of it with the potash in the juice, when the admixture is made in the cold, forms tartrate of potash, or cream of tartar, which is all but insoluble in cold liquor. It sinks in the juice, and is removed as before described with the turbine, &c. The tartrate of potash so obtained, can by well-known means, which every manufacturing chemist understands, be again converted into tartaric acid, and so used over and over again *ad infinitum* at very moderate expense.

The Turbine or Centrifugal Machine.

The next operation after crystalization, to render the sugar useable, is to free the crystallized sugar from the molasses, which are very badly flavored. For this purpose, the mass into which the boiled juice forms is first mixed with a *little* water, just enough to render it somewhat fluid, and it is then put into the turbine and whirled rapidly round. The outside of the "basket" of the turbine is made of fine wire cloth, or in large concerns of very finely perforated copper; and the rapid circular motion throws the molasses through the small perforations, leaving the sugar behind; this is, after a short time, (and when no more molasses comes from it) sprinkled with water, and again put in motion, when the water cleanses the crystals of sugar, and again flows out with the molasses, leaving the sugar clear in the basket. On the large scale a jet of steam is used instead of the water. The sugar is then taken out and dried, either by stove heat or otherwise, and the work is finished. This sugar is quite useable, although it flavors somewhat of the beet, but when properly centrifugalled with water or steam, the beety taste is scarcely perceptible, and it is quite good enough for all ordinary household purposes. All the salts, and most of the beety flavor, passes off with the molasses, which are then further purified, either with the osmose process, the sulphate of alumina, or tartaric acid as before mentioned, or with phosphate of ammouia, and then set by in a warm place; this at a considerable interval, often many weeks, but sometimes less, produces a second crop of crystals, and afterwards a third crop. The remaining molasses is, by the great manufacturers, fermented and distilled into spirit, and the wash or slop which results from the still is evaporated and burned into potash; but, on a small scale, the farmer will not do anything more than take the first crop of crystals, or possibly the second as well, and the remaining molasses he will feed to his cattle and pigs. It is a most fattening thing when used *in very small quantities*, and mixed with other food. In this case, the potash and salts at once passes to the manure heap, and adds greatly to the fertility of the farm.

For farmers or small manufacturers, the turbine is thus made: A wire cage, with an iron frame constructed on an iron spindle, stands upright. The lower journal is a pointed steel toe; the upper a well turned journal. The cage is open at top, but the bottom and sides are covered with the fine wire gauze, on a small scale, or with finely perforated copper, on a large scale. This spindle and cage, set in a proper frame, is

made to revolve very rapidly with a multiplying power, either by cog wheels or drums, and its speed is urged until the required effect is produced, and the molasses are ejected from the sugar; the speed required is very great.

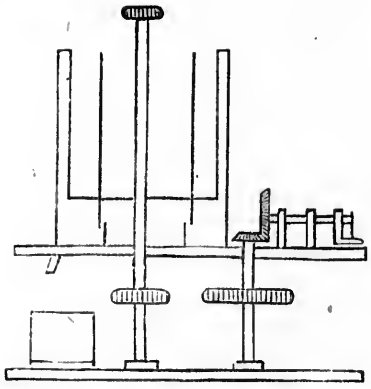
Below is a cut of such a machine as might be made by an ordinary mechanic, and used by the farmer or small manufacturer; but on a large scale, the turbine must be obtained from a machine shop. They can be obtained ready to erect from Europe, or from H. J. Booth & Co., Union Iron Works, San Francisco, California, which enterprising firm have constructed several Beet Sugar works in California, which are meeting with great success; they make all the machinery. Where they can be had, these turbines are also used instead of presses for separating the pulp from the juice of the grated root; and where the diffusion plan is used, the sliced roots are, as before stated, dried with it. It is a most valuable machine, and the manufacture of sugar, in a useable shape, from the beet could not be carried on without it.

For a detailed description and plate of the turbine made on a manufacturing scale. I must refer the reader to a more elaborate work on beet sugar than the present.

THE FARMERS' TURBINE.

Procure a wooden tub, about inches diameter, and inches high. The hoops should be driven on from the top, but there should not be much flare to the tub. Standing in the centre of this vessel is a pipe, or cylinder, made of galvanized iron, strong, and tight, and this cylinder is passed through a hole in the bottom of the tub, and is well secured to it by a flange nailed on to the outside of the bottom, so as to be tight. This tub is to contain the molases, and all joints about it must be very tight, for molasses will leak out where water will not. This tub is fixed to a strong bench, or table, which must be well stayed to the floor, or building, as the motion of the turbine is very powerful. Underneath the bench, or table, on which the tub stands, there is a bridge tree fixed for the toe of the spindle to work in.

The spindle, and basket of the turbine may be constructed of wood, although iron would, of course, be much better. If of wood, the spindle must be turned, and of about three inches diameter, well feruled on each end. In the lower end is driven a steel blunt point, which works in a tallow box on the bridge tree. The upper end must have a turned, or well filed iron pin inserted. This is to bear against the upper bar, which is fixed above the tub. On the spindle fits a small iron wheel, well secured with points, or rivets, which passes down through the cylinder in the tub, and rests on the bridge tree; into this a large iron wheel is made to work, driven from below the bench, and which wheel is turned by a winch. There should be a fly-wheel attached in this case; also belts, and pulleys may be used instead of cog wheels. The following is a sketch of the concern.



The cylinder through the bottom must be large enough to allow the small wheel by which the machine is driven to pass freely through it, and the tub must be of sufficient diameter to allow of the basket and spindle of the turbine to be freely lifted in and out of it, so that when a charge is done, the basket and spindle may be lifted out, and the sugar emptied out of it, and be replaced ready for another charge, without jamming in the cylinder and against the sides of the tub.

There must also be a metal sleeve fixed to the bottom of the basket, which covers and comes down below the top of the cylinder. This is for the purpose of preventing leakage or dripping of the molasses through the cylinder, and this sleeve must be made large enough to allow the basket and spindle to be lifted freely in and out when it is required to be moved to empty out the charge,

I have purposely omitted all lengths and sizes in the foregoing description. The size of the turbine will entirely depend upon the amount of business to be done, and any ingenious person can get one constructed with the instructions here given. Belts and drums can be used as well as cog wheels, and in some cases are more advisable.

Beet sugar is finally reduced into refined loaf sugar by repeated filterings through large cylinders of bone black, and by several other processes of filtration and purification. I do not pretend to give such instructions as will enable any person to refine sugar on a great scale, and should not have alluded to the subject at all if I could have avoided it.

The refining of sugar has always been one of the "monster businesses," doing an immense amount of work, and requiring an enormous capital.

WORKING DRIED BEET ROOT.

One great advantage of the new process of diffusion is the power it gives of using dried beet root, and thus enabling small factories to work the whole year, instead of working

only during the beet season. All practical people know that a factory out of work decays and destroys far faster than whilst it is in full operation. The great argument in favor of monster factories has always been, "You must have them so large as to work up your whole crop in five months," and therefore everything must be on a great scale. The consequence has been that the factory ceased working for seven months, to the great loss of all concerned. No manufacturing business can work profitably by fits and starts. To do things in the best possible way they must be done continuously.

Beets are dried by being cut into slices, and then exposed to air and heat, so as to get the surface moisture off as soon as possible. Those who can dry apples can dry beets without instruction. Those who have or can construct a drying kiln will, of course, use it. Everybody understands the use of a kiln, and so I shall not describe it. The roots will, in all cases where possible, be cut up by machinery—an ordinary root-cutting machine will answer all purposes.

Those who have neither kiln nor machine may proceed in the following manner, but the kiln and machine is best. Cut the roots up in slices across, taking care to cut up the whole of the bottom of the root, and be very careful of the lower and small slices, for they afford not only the most but the best sugar.

Provide some strong iron wire. Cut some sticks of any common wood across into sections of about two inches in diameter and a quarter of an inch thick. Cut the wire into lengths of from two feet six inches to three feet, and sharpen one end of the pieces on a grindstone. Fit on one of the sections of wood to each wire, and bend the end, so as to prevent its slipping off. Separate the large slices of beet root from the small pieces, have one parcel to the right and the other to the left. Set your wires upright on a bench, having made little cleats to hold them in a vertical position. Now take a small piece of the root in one hand, string it on to the wire until it touches the bottom, then string on a large piece, then a small one, and so on until the wire is nearly full. Then bend over the upper end in an open curve, so that you can hang the string of roots on a stick. Proceed with the rest, doing the work as quickly as possible, and hang up the wires as fast as done in an open, airy place—where the sun shines, if possible—at any rate, out of the damp, and rain. The roots thus prepared will dry, and shrivel up very quickly, and completely, and as there are no two extended surfaces lying together, no change in the roots will take place. When you have enough done, you should have a small building heated with a stove, and pipes, and finish drying the roots in that. You must be careful that the cut roots always get plenty of air, to prevent mould, or rotting. Persons will soon learn expertness in the foregoing process, and will operate with both hands, and thus prepare a very large amount of roots in a day. The roots, when dry, should be thoroughly dry, so as to crush, or grind, if necessary. The crooked ends of the wires may then be straightened, the dried pieces run off, and the wires used again. In selling dried roots you can always insist on getting paid according to quality. Those best done will bring the highest price. Roots thus prepared either with the wires, or kiln, will dry into about one-tenth of their original weight, and thus save carriage, and hauling. The value of such dried roots, if well done, will be from forty to fifty dollars per ton, or a greater value than barley, and, of course, can be carried to market as great a distance as that grain.

The dried roots can be used by the diffusion process, and leached with water in the same manner as with green roots, or, if leached with strong spirit, as is done by the "Schützenbach" method, the result is a purified, refined sugar, of the first quality, entirely free from salts. As the spirit will not dissolve the salts, although it does dissolve the sugar. This is, however, a process that requires great capital, and extensive premises. Schützenbach, of Gallicia, in Europe, employs this method. In his factories he works up some millions of tons of roots annually, and employs many thousands of hands.

Those who prepare dried roots, should feed the upper third of their roots to the cattle, and reserve for drying the lower portions, they will thus be sure of the best results.

In an address on the agriculture of the Old World, lately delivered by the Hon. J. R. Dodge, before the Rural Club of New York, has says, speaking of agricultural progress in Austria :—

"The beet sugar interest is prominent, "having now 199 factories in operation," (these, it must be recollected are of immense size and capacity) "of which 126 are "in Bohemia. The average price of dry "beets is four florins and eighty kreutzers "per centner, or about $2.40 for 136 lbs." (Equal to $35.40 per ton of 2000 lbs., but this price will, of course, be governed in a great measure by the state of dryness in which the sliced roots are brought to market).

"The industry gives employment to 31, "858 men and 18,939 women ; the wages of "the former ranging from 18 to 80 cents per "day, and of the latter from 13 to 75 cents."

It will, therefore, be seen that the preparation of beet roots by drying is now a recognized institution in one of the principal centres of the beet sugar industry.

SUCRATE OF LIME PROCESS.

There is another process in the beet sugar manufacture, which is too important to be passed over in silence. The writer gives it in the language of others, merely remarking that there seems some uncertainty about it, and that although, in his own case, he has repeatedly succeeded in the process, so much so as to lead to every hope of success, with

absolute certainty; yet in other cases he has failed, without being able to find a reason for a faifure. He would also say, that others must have found the same difficulties, or, most assuredly, the "Sucrate of Lime process" would have, by this time, displaced all others—so simple is it, and so effectual when it is successful. The writer recommends all who may enter on the manufacture of beet sugar to try it on every opportunity; and, if possible to bring it to perfection, and establish the process as a certainty. When this is done, they will need no other.

The following description is abridged from the Report of the Commissioner of Agriculture of the United States:—

The mode of forming the "sucrate" is as follows:—After the ordinary juice is obtained by any of the foregoing processes, and has been properly defecated with lime, it is evaporated until it attains a gravity of from 30 to 32° Baumé (*i. e.* about as thick as ordinary maple molasses), it is left to cool. It is upon this *cold* juice that sucratation is effected, for as the sucrate of lime dissolves in a hot liquid it is necessary to act on the syrup cold.

The sucrating vessel is of cast iron, circular, furnished with a lid traversed by a pinion or arbor, with spokes or pallets, and a hopper, worked by rack work, to allow the lime to fall in scattered shape and in proper quantity, into the syrup, while the latter is agitated with the pallets. This hastens the combination of the lime with the sugar. The quicklime has been slacked with a small quantity of water beforehand, so as to bring it into the shape of a fine dry powder. By the agitation, crystals form and agglutinate, and the mass heats somewhat, the grains of sucrate, increase in size, become more dense, and by constant stirring, fall to the bottom in masses; and if the agitation is continued long enough, the whole liquid would become a solid mass; before however this point is reached, and when only half of the liquid is sucrated in the vessel, the sucrate formed is removed, is placed on a sieve and drained and dried, the other half of the liquid which remains in the vessel is strengthened by adding new and cold syrup of 30° to 32° Baumé, and half sucratation is again effected as above; this is repeated up to the last batch of the days work. When the last batch is sucrated completely—as this last operation contains all the saline matters of the whole liquids united—it is set aside as impure sugar, and treated separately.

The sucrate thus obtained may be dried still further in the air, until it loses from twenty-seven to thirty per cent of its weight, when it will be found to contain, in one hundred parts, seventy parts of sugar, twenty of lime and ten of water. This substance may be washed in cold water, and thus be greatly purified, and it may then be put up in boxes or bags, without fear of its undergoing any change. It is neither affected by time or insects, and for all practical purposes, is imperishable.

The apparatus necessary for a manufactory of this kind (in addition to the ordinary machinery for rasping or diffusion), and which will work up nine to fourteen millions of pounds of beet root, is two large defecating vessels of sheet iron, two evaporating basins, and the sucrating vessel as described, with the necessary sieves and strainers.

This sucrate of lime may be made in the winter and stored by for summer employment. When it is to be reduced into sugar, it is dissolved in hot water and carbonated; the lime, as a carbonate and inert, now settles out of the purified syrup, and is removed by filtration and the ordinary filter presses.

This process of Rousseau promises to produce a revolution in the manufacture of sugar from the beet. Rousseau has also invented a new animal black, to be used in the place of bone black. He says that he proved to his own satisfaction that the decolorizing property of bone black lies entirely in the nitrogenized portions of the bones, and that bone charcoal made without these nitrogenized portions will not decolor. (In this, however, most authorities differ from him.) In his new black he replaced the phosphate of the bones with clay, which he calcined with twenty-five per cent. of horse manure, or even with night-soil—although this, of course, would never be used in practice—and thus obtained a most energetic and concentrated "animal black," and this at so cheap a rate that it is cheaper and easier to make new black than to restore the used black by reburning. The spent black forms most valuable manure. By the use of this new black the filtrations are reduced one-half, and the expense of this part of the process is greatly lessened, which is a most important point.

If he is correct in his statements, the best and cheapest animal matter to mix with the clay would be the "graves," or refuse of the soap and candle manufacturer, or scraps and trimmings of hides from the tanner. Whatever animal substance is used is, of course, thoroughly purified and deodorized by the burning at a red heat with clay.

Toronto, Canada,
1st Nov., 1873.