transformation might be accomplished in 16 or 18 hours at most. Now, from what has been said on the subject of mashing the grain and the alcoholic fermentation, it is evident that the saccharification of the starch could only take place very imperfectly and partially. This has been fully demonstrated in many Belgian distilleries by examining the spent liquor, which, prior to the new law, still contained an appreciable quantity of starchy matter in the form of paste.

Then by conducting the fermentation at too high a temperature, as was and is still generally done in Belgium, the acetic fermentation is soon developed, and converts a portion of the alcohol into vinegar, which causes not only a material loss in quantity, but also in the quality of the product.

In fact, as may be ascertained by means of special rectifications, the fermented materials yield a product which is less pure and agreeable to the taste in proportion to their acidity. But a number of the larger Belgian distillers, being aware of the consequences of accelerating the work too much, do not exceed the limits fixed by the rules of the art, and, consequently, obtain far more satisfactory results than the farm distillers. Thus, while most of the latter obtain only 44 or 46 litres of proof gin (50°) from 100 kilogrammes of grain, the majority of the large distillers, who understand their business and have not too great an interest in hastening their operations and overloading their vats with work, usually obtain from 54 to 56 litres, which is, moreover, as a general rule, of better quality than that produced from the small distilleries in which the whole operation was affected in 18 hours.

**New Process Generally Used in Belgium.**—I shall now proceed to describe the process in general use in the large Belgian distilleries, where they employ the continuous apparatus operated by steam. They sprout their barley as perfectly as possible, pushing it almost to the same degree as for the white beer of Louvan; then dry it in common kilns, taking care to manage the temperature so as not to discolor the malt. This barley malt is mixed with rye principally, and in exceptional cases with wheat, more or less damaged, and with a small quantity of oats.

Some distillers also employ crude barley, especially that from northern Europe, which is very heavy and cold;* but these are an exception. Most commonly from 24 to 30 parts of malt by weight are mixed with 76 or 70 parts of rye, which is ground very fine; this mixed flour, into which sometimes 8 or 12 per cent. of oats enter as a component part, is turned into the mash tun in the proportion of 11 or 14 kilogrammes to the hectolitre of the vat, the capacity of which varies from 10 to 30 hectolitres. Before placing the flour in the vat, which we suppose to be of the capacity of 10 hectolitres, there are turned in 30 or 36 litres of cold water, and about 270 litres of boiling water; then all the flour is poured in at once, say 120 or 130 kilogrammes; the mixture is then vigorously stirred by an implement similar to that used by the brewer.

When the stirring is finished, that is to say, when there are no more traces of flour, and the mixture is homogeneous (which requires generally 20 or 25 minutes), about a hectolitre of boiling water is added while the mass is actively stirred, in order to distribute the heat as promptly as possible. So soon as the mixture is perfect the vat is covered to effect the fusion, as the Belgians say, and it is left to rest for about half an hour; after this period of rest, the mass is stirred up for a moment to put in suspension the solid substances which have fallen to the bottom of the vat, and when the mixture has been effected, which is in two or three minutes, the vat is re-covered and left to macerate anew for half or

* The brown barleys of Sweden and Norway, which weigh 66 or 68 kilogrammes to the hectolitre, are highly valued by the large Belgian and Dutch distillers who work this grain ungerminated, with from one-third to one-half of rye and one-fourth of malt prepared from the barley of the country. As the distillers say, this barley is cold, that is to say, its fermentation is neither so tumultuous nor so prompt as that of rye and of oats, but the product which it yields is quite satisfactory, and the gin of good quality.
three-quarters of an hour; after this the mass is cooled a little by stirring it vigorously, then diluted with cold water, if at the beginning of a series of operations, or with cold spent liquor clarified by rest, if the work is already commenced. In either event it is so arranged that the diluted mixture shall be at 27° or 30° C., according to the season, the size of the vat, and the temperature of the apartment. When the vats are of the capacity of 15 or 20 hectolitres, as is most usual in Belgium, and if, moreover, the cellar is well selected, that is, well sheltered from sudden change of temperature, it is cooled, usually, to 28° in summer, from 30° to 32° in spring, and 32° to 34° in winter.

It should be observed, too, that more grain is used in winter than in summer. In the latter season most Belgian distillers who do not use mash tuns with a double jacket, and only use 11 or 12 kilogrammes of the mixed flour to each hectolitre of the capacity of the mash tun, in winter increase this proportion to 14 and 15 kilogrammes.

When the mixture is cooled and diluted as much as the capacity of the vat will allow, it is ordinarily filled to within one-fifteenth or one-twentieth of the top nearly, or so as not to have the vat overflow during the fermentation. The mixture being cooled and diluted to the point desired, the ferment, previously dissolved in a little worts or tepid water, is added in the proportion of 160 or 200 grammes of yeast, in paste, to the hectolitre of the material of the operation. The ferment is well stirred into the mass, the vat covered, and the mass left to ferment quietly until it has reached the maximum of effervescence, which happens generally twelve or thirteen hours after the yeast is added. If at this time the fermentation is found to be too active, the cover is slightly raised, so as to cool the mass a little at the surface, and thus render the action less tumultuous; but it would be preferable not to be under the necessity of having recourse to this expedient to which the Belgian distillers, both great and small, are too much addicted. Nevertheless, when the fermentation is pressed so hard as to become as tumultuous as a liquid in active ebullition, as happens with those distillers who use 14 or 15 kilogrammes of flour to the hectolitre of water, it is well, by any means whatever, to moderate the action, but it would be better, as has already been said, to cool the mass by means of cold water circulating in an interior coil, as is generally done in England, or, better still, by means of a double jacket. This last means is preferable for those distilleries where the natural grain is fermented, that is, without separating the solid parts which render the washing of the fermenting vats very difficult if they contain coils. Moreover, these interior coils render it very difficult to mix the flour thoroughly with the water when this operation is performed in the fermenting vats, as is still generally the case.

When the fermentation does not appear to be sufficiently active the mixture is stirred for an instant, by raising the solid matters from the bottom and plunging the cap into the fluid, that is to say, the solids which float on the surface; the vat is then covered until the fermentation ceases entirely.

A great number of the Belgian distillers infer that the fermentation is sufficiently advanced when the cap has subsided for a couple of hours, but there are others who, less impatient and more enlightened, prefer to pay a little more into the public treasury and wait until they no longer hear any sounds on applying the ear to the wall of the vat. Better still, and this sign more easily determines with exactness the end of the fermentation, they remove the scum and other substances that float on the surface; the vat is then covered until the fermentation ceases entirely.

As to the method of conducting the distillation in
Belgium, it varies, of course, with the apparatus used everywhere else, but there is no peculiarity about it requiring special mention here.

Chemical Process.—The saccharification of grains by replacing malted barley by sulphuric, muriatic, or other acids, was, for some years, practised in France. This process, which produces an excellent spirit of very fine flavor, is not adapted to agricultural distillers, because of the necessity of saturating the residuum with lime, which, instead of producing a marc suitable for feeding cattle, is only fit to be cast on the manure pile. Besides, the decree of November 10, 1857, forbids the use of this process in France. We will, however, give a sketch of the process which was employed in large manufacturing distilleries.

The barley or unground rye was set to steep twenty-four hours in advance in twice its weight of water, containing 2 per cent. of sulphuric acid at 66°. At the end of this time the grain thus softened was crushed by being passed between two cylinders; it was then conveyed to a special vat where the saccharification was effected by the assistance of a jet of steam kept up for twelve to sixteen hours, until it was ascertained by means of the iodine test* that the saccharification was more or less complete.

This operation completed the acid was saturated by the addition of chalk (carbonate of lime), and the liquid suffered to rest for ten or twelve hours; to hasten the precipitation and the cooling, the saccharified material was drawn off into a very broad but shallow back (vat) situated below the saccharifying or steeping vat. The precipitation accomplished, the clear liquid was drawn off into the fermenting vats to be diluted with cold water so that it should contain about ten per cent. of the grain, and the temperature was lowered to 22° or 24° C., in order that it might be leavened (yeasted) in a satisfactory manner.

The deposit of sulphate of lime was washed a number of times with five or six times its volume of water and the liquid drawn off to serve for a new saccharification, or for diluting the saccharine solution in the fermenting vats.

Some distillers avoided the inconvenience of the deposit of the sulphate of lime by using muriatic (hydrochloric) acid instead of the sulphuric, taking double the quantity, which, by saturation with lime, formed a soluble compound (chloride of calcium) which produced no precipitate.

When ground grain was used the dose of acid was increased one-third, and the time of steeping reduced one-half, that is to say, to twelve hours.

The saccharification of grain by means of acids is much less easily effected than that of flour, because the acid liquid finds much difficulty in penetrating the starch cells. It was on this account that it was necessary to continue the action of steam for a longer time than was necessary for the saccharification of grain in the form of flour.

Alcohol from Rice.

Rice, like all other seeds, is saccharified by means of malted barley, and may be treated by the same methods; but the saccharification is much more complete when, like other cereals, its starch has been converted into a paste. The following is the process usually followed, viz.:

500 kilogrammes of rice, reduced to flour, are mixed with 50 hectolitres of hot water, at the temperature of 60° or 65°, in a vat having a double bottom, perforated with holes; this mixing, which may be effected by hand or a mechanical stirrer operated by steam or other power, being complete, the mass is heated to 70° by steam. This temperature must be kept up, but not exceeded, for half an hour. After this delay, the temperature is reduced to 50° by the addition of cold water, and 125 kilogrammes of ground malt, which are distributed carefully and uniformly, so as to produce a complete mixture. The vat is then covered and suffered to stand
for two hours in order that the saccharification may be accomplished.

The clear liquid is then drawn off into the fermenting vats, and the temperature reduced to 22° or 24° with cold water, and the yeast added in the usual way. This method in which a large quantity of water is used, produces the most alcohol, and possesses, too, the additional advantage of the greatest simplicity.

**Alcohol from Potatoes.**

**Analysis of the Potato.**—Independently of the water it contains, the potato consists mainly of starch and a fibrous substance which is very similar to starch.

100 kilogrammes yield as an average:

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Starch</td>
<td>16 kilogrammes</td>
</tr>
<tr>
<td>Parenchyma</td>
<td>9</td>
</tr>
<tr>
<td>Water of Vegetation</td>
<td>75</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The parenchyma and water in their turn contain various substances, viz: cellular tissue, pectose, pectin, albumen and nitrogenous matter, sugar, resin, essential oil, fatty matter, citrate of potash, phosphates of potash and lime, silica, alumina, oxides of iron and manganese.

**Selection of Potatoes.**—On account of their size, some potatoes are to be preferred for the manufacture of alcohol or starch, and for fattening cattle, while others, on account of their flavor, are employed as food for man. The varieties are multiplying daily, and each locality has its own. The qualities of soil and the peculiar methods of culture are infinitely varied, and this vegetable is undergoing so many modifications that, before a great while, it will be almost impossible to recognize its original characteristics.

The starch, however, is the portion which it is important to consider in this connection. Its quantity varies much in different species of the potato, according to the nature of the soil in which it has grown, the temperature of the season, their state of preservation, &c. &c. They contain most, just after being harvested. The best potatoes, that is, those which contain the most starch, and which, consequently, are most mealy when cooked, yield also the most alcohol. Those which are diseased, sprouted, or damaged, yield only a small quantity, and that holds in solution a principle having a bitter and disagreeable flavor. Winter is the best season for distilling potatoes, that is, from the beginning of October, when they are harvested, to the latter part of March, when they begin to sprout.

Potatoes will not bear extremes of temperature. They should be stored in cellars or store-rooms protected from the vicissitudes of the weather, and should only be taken out as needed for use. It is, however, not important to reject those which may be frozen, since it is only the water of vegetation which is attacked; the starch and parenchyma may be separated from it. It suffices to place the potatoes in cold water until they have acquired sufficient firmness to be subjected to the action of the rasp.

**Testing the Quality of Potatoes.**—To ascertain the exact quantity of starch which is contained in any given variety of potato, we first remove carefully with a brush all the earth adhering to the surface. The tuber is then cut in very thin slices, which are spread evenly and side by side on a plate, care being taken to avoid overlapping; they are then dried either in a current of heated air, or in a stove heated to 40° or 50°. It is known that they are perfectly dry when, after repeated weighings at intervals of three or four minutes, the slices are found to lose no more weight. The slices are then hard and brittle. Deduct nine per cent. of the original weight for the parenchyma, and the remainder will indicate the quantity of starch.

In making this test it is not a matter of indifference whether the tuber is cut near the middle or at the outside, because the starch is not distributed equally throughout all parts of the root. It is found in greater proportion near the outside than towards the middle. This in large
potatoes is sometimes almost transparent, and contains little more than water and tissue. Potatoes may also be tested by reducing them to a pulp on a small tin rasp and extracting the starch, which is then dried, and the weight indicates the value of the root.

Processes for Distilling Potatoes.

There are three methods of preparing potatoes, previous to, subjecting them to alcoholic fermentation:

1. By cooking.
2. By rasping.
3. By the saccharification of the starch green or dry.

These methods have but one end—to saccharify the starch, either by means of malted barley or of acids.

Distillation of Cooked Potatoes.

This method consists of five distinct operations:

1. Cooking the potatoes.
2. Reducing them to pulp.
3. Mashing, or saccharifying by means of malt.
4. The alcoholic fermentation.
5. The distillation.

Each of these operations will be described in order and as rapidly as possible.

Cooking.—The potatoes, after having been well washed, should be cooked by steam in a cylindrical vessel. A hogshead properly arranged will answer. The apparatus described by Dombasle appears to be perfectly adapted to this purpose. It consists of an iron boiler set in masonry, the upper surface of which is well covered with good mortar, and rises with a gentle inclination above and from the edge of the boiler. Upon this masonry is a hogshead with the upper head removed (or a special vat made of stout oak staves), the bottom of which should have a diameter eight or ten centimeters greater than the boiler, in order that the hogshead may stand firmly on the masonry. The bottom of the hogshead, which should be of thick wood, is perforated with a great number of holes ten or twelve centimeters wide, and fifteen centimeters long, to give passage to the steam. They should not be round to avoid the accident of being closed by the tubers fitting into them.

To facilitate the operation, the hogshead should have an opening near the bottom, closing by a door, through which the potatoes are to be drawn out when cooked, without displacing the hogshead. If the locality will permit, the potatoes should fall directly from this opening into the hopper of the crushing mill.

It commonly happens that there is some escape of steam below the hogshead where the chime rests on the masonry; this is easily stopped by a lute made of clay and horse dung. The hogshead must not be completely filled, as the potatoes swell considerably in the course of the operation.

Reducing to Pulp.—As soon as the potatoes are sufficiently cooked they are placed in the hopper of the crushing machine, to be reduced to a homogeneous pulp. This machine commonly consists of two cylinders of oak, which by their friction crush the potatoes and reduce them to the condition of paste.

Mashing or Saccharifying by Malted Barley.—When the potatoes have been reduced to a paste, the mashing is at once conducted almost in the same manner as for grain. Taking 1000 kilogrammes, for example, the process is as follows:

The paste is arranged in a vat of the capacity of 35 or 40 hectolitres, to which are added 70 kilogrammes of broken malt, and such a quantity of hot and cold water as to bring the temperature of the mass to 36° or 42° Cent., in order that the steeping of the malt may be properly accomplished. Care must be taken to stir the paste and malt with a fork as the water is gradually poured into the vat, and hermetically close the vat as soon as the stirring is finished. After a rest of half an hour boiling water is added until the whole has acquired a temperature of 60° Cent., and the mass is left to macerate three or four hours.

Fermentation.—When the mashing is completed the
mixture is increased by alternate doses of cold and boiling water until the quantity is made up to 32 or 35 hectolitres, according to the size of the vat, and in such a manner as to establish the proper temperature (24° or 26° Cent.). This point reached, two and a half or three litres of good liquid beer yeast, or two kilogrammes of dry leaven are added. The fermentation is soon under way and follows the same course as that for grain.

**Distillation.**—Potatoes, by reason of the pasty nature of the material resulting from this method of cooking, should be distilled in the apparatus discussed on pages 73 and following (in Figs. 4 and 5, Pl. IV.), or in some simple apparatus worked over the naked fire; the latter is best adapted for agricultural establishments. 1000 kilogrammes of potatoes treated as above with 70 kilogrammes of malt will yield an average of 160 litres of spirit (or 74 litres of pure alcohol) at 46° having an unpleasant odor.

**Distillation of Potatoes by Rasping and Maceration.**

The object of this process is on the one hand to avoid the expense of cooking the potatoes, and on the other the manual labor indispensably necessary, in separating the starch. The process is as follows:

1000 kilogrammes of potatoes reduced to a pulp by means of the rasping machine are placed in a vat of 22 to 25 hectolitres, and with a double bottom, on which are spread evenly 25 or 30 kilogrammes of short straw. In this position the pulp is allowed to drain for about half an hour to deprive it of a portion of its water of vegetation, which is drawn off from time to time by a cock placed between the two bottoms. After this delay 1000 or 1200 litres of boiling water are added gradually, and then 70 kilogrammes of malt previously steeped, while two men stir the whole vigorously.

After a maceration of three or four hours the clear liquid is drawn off by the cock under the false bottom, and the mass suffered to drain ten or fifteen minutes. The liquid so drawn off is conveyed immediately to the fermenting vat. In the mean time, 500 litres of boiling water are turned on to the pulp—it is stirred anew—the liquid drawn off as before, and turned in the fermenting vat with the first.

Finally, the potatoes are entirely exhausted of fermentable principles, and at the same time a proper temperature is given the liquid to be fermented, by the addition of a third charge of cold water, which, after being stirred and drawn off as before, is added to the product of the two previous operations.

The liquid resulting from the three operations just described is set to ferment by means of liquid beer yeast in the same proportion and manner as for the must of grain, or by 3 or 3 kilogrammes of dry leaven to the 1000 kilogrammes of potatoes.

By this process is obtained quite a large quantity of residuum (marc), which is excellent as food for cattle; there is no pasty material to distil, the must is quite clear, and a quantity of spirit drawn off is superior to that produced by the preceding process. It has, too, a better flavor and odor.

**Employment of the Residuum from the Distillation of Potatoes.**—The residuum resulting from the two processes just described by reason of its pasty nature constitutes an admirable article of food for cattle, but which, however, after prolonged use may prove too laxative. This inconvenience may be avoided, or remedied, by giving to the animals an addition of ground Indian corn, peas, or beans, or, better still, oil cake, &c.

**Distillation of Potatoes by Saccharifying the Starch.**

Potato starch is a pulverulent substance without taste and odor, which drains off with the water of vegetation, and which is separated from the tubers by means of many operations, the principal of which are the rasping of the tubers and the separation of the starch from the parenchyma when the potatoes have been washed and reduced to a fine pulp by means of a rasp; this pulp is placed on a sieve of hair, or metallic cloth. The pulp is well rubbed
between the hands to mix it with a stream of water which flows on to the middle of the sieve and carries off all of the starch set free by tearing the fibrous tissue of the cells which make up the substance of the root. The liquid flows through the sieve in a state of limpidity. When all the starch has been exhausted from the pulp, the waste material is thrown aside and a new supply of pulp placed on the sieve, and so on. The starch is obtained suspended in the water, and after a little while falls to the bottom of the vessel; this deposit is then mixed with fresh water and allowed to deposit two or three times successively, changing water each time; it is laid up to drain on cloths, and if it is desired to preserve it, the mass is dried in the open air, or in a drying room.

In modern starch factories manual labor is reduced to a minimum by the use of a continuous apparatus in which the washing and rasping of the tubers as well as the washing of the pulp on the sieve is effected by machinery.* They easily treat 160 hectolitres of tubers in ten or twelve hours, and obtain 16 or 17 per cent. of dry starch. The exhausted pulp retaining 2 or 3 per cent. of starch, which cannot be removed by the most energetic washing, is used as food for cattle.

Green starch, that drained but not dried, and dry starch, must, in order to produce alcohol, be first converted into sugar by the process of saccharification either by the assistance of malt or sulphuric acid.

Saccharification by Sulphuric Acid.—The following is the process by which starch is saccharified on a large scale for the manufacture of alcohol:—

To perform this operation a special vat called a saccharifier is used; a description has been given before, as well as a drawing. (Fig. 2, Pl. VI.) It is filled to about two-thirds with acidulated water (6000 litres of water with 40 kilogrammes of sulphuric acid at 60°). The temperature of this water is then raised to 100° C. by steam through the pipe c, which is connected with the generator.

The vat being prepared, 2000 kilogrammes of dry starch are taken and mixed in quantities of 100 kilogrammes in a tub with 100 litres of water, the starch mixture is then poured into the funnel d, in small quantities of 15 or 20 litres at a time, the ebullition of the mass being kept up until the whole 2000 kilogrammes having been turned in, and the decomposition is complete, which happens about an hour after the last addition of starch.

The starch in this operation passes first into a pasty state, then becomes fluid, and is converted into gum or dextrine, and is then transformed into glucose in the form of syrup. It is ascertained that the starch is entirely saccharified, and that the mass contains no more gum by taking a little of the liquid in a champagne glass, mixing with 3 or 4 parts of alcohol (90°); if the liquid contains any gum, it will be precipitated in white flocks; if there is no gum present, it is an evidence that the saccharification is complete. A few drops of tincture of iodine poured into the cold mixture without producing a violet tint indicates that the operation is completed.

The steam is now cut off, and we proceed to the separation of the sulphuric acid from the saccharine principle, by saturating the liquid with chalk or Spanish whiting (carbonate of lime). For 40 kilogrammes of sulphuric acid we use 45 or 50 kilogrammes of carbonate of lime mixed to the consistency of cream with a little water, and thrown into the vat in small quantities at a time. At each addition of the carbonate of lime through the man-hole f, a strong effervescence is produced by escape of the carbonic acid gas, which may throw the liquid out of the vat if the additions are not carefully made.

It is ascertained that the saturation is complete by the cessation of the effervescence, and more accurately still by means of litmus paper, which is no longer reddened by contact with the liquid. When the operation

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* For a particular description of the very ingenious machine used in this manufacture the reader is referred to Maspratt's Practical Chemistry, vol. ii. pp. 953 et seq.—Trans.
is finished the liquid is allowed to stand twelve hours in the same vat or another, then the clear part is drawn off into the fermenting vats. The deposit left in the vat is sulphate of lime (gypsum), a substance of little solubility.

A more highly acidulated liquid will render the saccharification more prompt; but, on the other hand, it will be necessary to increase the dose of carbonate of lime, which may injure the solution and prevent its clarifying. The dose indicated (two per cent. of acid) has been recognized for a long time as that which produces the best results.

The arrangement of the flue which conducts the vapors from the vat into the chimney (stack) prevents the disagreeable emanations which result from the process of saccharification. The essential oil of starch contains a little more oxygen and hydrogen than these last, and exactly in the proportions in which these two elements exist in water. The composition of these three substances may be represented thus:

<table>
<thead>
<tr>
<th>Starch and Dextrine</th>
<th>Glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>43.81</td>
</tr>
<tr>
<td>Water, or its elements</td>
<td>56.19</td>
</tr>
<tr>
<td>100.</td>
<td>100.</td>
</tr>
</tbody>
</table>

From which it is seen that glucose only differs from starch and dextrine by containing 7.01 parts of water, or its elements.

The saccharification of the starch of different grains by sulphuric acid is effected in the same manner as described for potato starch. The use of hydrochloric acid presents the advantage of producing on one hand quite a pure alcohol, and on the other a residuum which when neutralized by soda, may serve to a certain extent as food for cattle.

Saccharification by Malt.—This operation, the only one used at present, is conducted almost in the same manner as the preceding; only the sulphuric acid is replaced by malt. Chemists have ascertained that malted barley, like all other seeds in a state of germination, contains a peculiar principle soluble in water, neutral, and not crystallizable, which they call dextrine.

The following is the process for saccharifying 500 kilogrammes of dry, or 750 kilogrammes of green starch by malt:

The starch is mixed in a vat of 30 hectolitres with 1000 litres of cold water, taking care to agitate the whole continually to maintain the starch in a state of suspension and prevent it from precipitating.

Then are added gradually 1700 litres of boiling water. The mass at first thickens and is converted into a paste; but in proportion as the boiling water is poured in, its...
milky appearance disappears to give place to a most remarkable transparency. At this moment, 75 or 80 kilogrammes of malt, reduced to flour, to favor still more its action on the starchy solution, are added, as is done in the saccharification of grain. The whole is stirred vigorously for ten minutes, then the vat is closely covered and allowed to stand three or four hours; during this time the diastase contained in the malt acts upon the starch, and transforms it completely into saccharine matter.

The Fermentation.—The saccharine liquid obtained by either process of saccharification just described, may be transferred to the fermenting vats without being filtered; then a certain quantity of water (cold or hot, as may be necessary) is added, so that the temperature may be at 22° or 24° Cent., and the solution shall mark 7° by the hydrometer of Baumé. These arrangements completed, 1 litre of good fresh yeast, or 500 grammes of dry yeast to the 1000 litres will be sufficient to start the fermentation, which progresses very regularly, and is usually terminated in 36 hours.

Distillation.—The fermentation being finished, the liquor is allowed to rest 24 hours, then the distillation is proceeded with in a continuous apparatus. The alcoholic result is in proportion to the more or less perfect saccharification of the starch. But generally, 100 kilogrammes of the latter will produce 35 or 40 litres of pure alcohol, or from 40 to 45 litres of spirit at 95°.

The product will be sensibly increased if the spent liquor be used in succeeding fermentations, as is practised with grain and molasses.

The spirit from starch is very fine and of excellent flavor. It may be used for all purposes to which the trois-six of Montpellier is usually applied; but its greatest merit is that of improving the latter; in fact, if two parts of the trois-six of Montpellier be mixed with one part of fine starch spirit, the product will be preferable to the pure Montpellier, because it will have acquired an extraordinary delicacy.

Remarks on Spirits from Grain and Potatoes.

The spirits produced by these substances possess an odor and taste called fusel, due to peculiar oils of a nauseous odor, analogous to the essential oil of wine or oenanthic ether. These substances are produced during the fermentation of the must. They exist already formed in fermented liquors, since they distil with the alcoholic vapor when the mixture is simply heated. The spirit which is manufactured from syrup or starch prepared by means of sulphuric acid is perfectly free from essential oil. This last, then, is produced by the alteration of the albumen, or some other nitrogenous principle of the potato, which takes place during the fermentation.

The essential oil of grain spirit is composed in great part of a non-etherizable fat acid, which in composition approaches oenanthic acid, but which nevertheless differs from it in some of its properties. The oil of potato spirit, which was first noticed by Scheele, is analogous to ether. It is excessively acrid, and its vapor provokes coughing and even vomiting.

It should be observed that spirit produced from flour of grains, from which the bran has been separated by bolting, has a far purer taste and odor than that resulting from flour which has not been subjected to this operation; because it has been known for a long time that it is the envelope of the grain that contains the peculiar essential oil which causes the bad flavor of this spirit.

Potato spirit extracted directly, that is, without subsequent rectification, often acts in a most deleterious manner on the animal economy, either because it contains some acid or volatile principle, or because it contains solanine and prussic acid, as a great many chemists have stated.

Alcohol from Sorghum, or Chinese Sugar-cane.

The sorghum, or Chinese sugar-cane (Holcus saccharatus), a plant cultivated in the northern parts of China, was sent, about the year 1850, to the Geographical
Sorghum should be planted according to the varying circumstances of the season and the climate. In France it should be manifestly later than in Algeria. In the latter country the seed time is from April to June. In France the seeding should commence as soon as there ceases to be any expectation of frost.

The cultivation of sorghum is easy and not attended with any considerable expense. It is only necessary that the soil, without being wet, should continue somewhat moist during the earlier period of its development. It is proper to shelter the young plants from a too-great heat of the sun, which may be accomplished by sowing some other plant of more rapid growth, between the rows. The hills should be about 60 centimeters apart each way.*

It does not appear to require very heavy manuring, guano seems to suit best. Frequent ploughings are indispensable to its rapid growth. Throwing the earth up to the plants also favors their development. When it has attained its maximum of growth, sorghum is a slender plant, rising three or four meters, and even more on rich land, in straight thin stalks, with flexible and drooping leaves; its appearance is quite like Indian corn, but it is more beautiful. It forms generally a cluster composed of five or six stalks, terminated by a conical panicle covered with flowers, green at first, then passing through the various tints of the violet to a deep purple at maturity.

Sorghum is harvested when the seed is perfectly ripe; that is to say, when it is of a decidedly chestnut color. The plants are cut with a bill, then conveyed to the barn or factory, where they are to be consumed. The leaves are stripped off and the tops removed.

It has been ascertained that not more than two or three stalks should be left in a hill; if there are more, the stalks will be slender and will contain relatively less juice, and will be rejected by the distiller.

* American farmers have found that a greater width between the rows is preferable, as giving room for the use of the plough as well as affording space for a larger growth of cane.—Translator.
DISTILLATION OF ALCOHOL.

When the cane is left standing beyond a certain time there will be serious loss, because towards the end of November there is developed in the interior of the cane the larva of an insect, which feeds on it at the expense of the saccharine matter. It is also known that sorghum, when cut and allowed to stand in stalks for some days before it is used, loses a portion of its juice, and that the sugar begins to ferment. It is important then to avoid these sources of loss, to harvest the cane as soon as it matures, and use it immediately.

The product of the sorghum consists in the juice abundantly contained in the pith of the stalks, but the richness in sugar diminishes in the joints as we approach the top of the stalk, where the tissues more recently developed are more watery. This juice stands between that of the true sugar-cane, lacking the aroma, and that of the beet in lacking its disagreeable odor. It therefore produces alcohol devoid of taste when carefully rectified. It has also been observed that the juice of sorghum contains a natural ferment, which may serve in case of necessity to start the fermentation and transform the saccharine matter into alcohol.

The saccharine richness of sorghum juice has been the object of a number of analyses, from which it has been determined that this richness varies from ten to twenty per cent.

The earliest method in use for obtaining alcohol from sorghum is that of M. Count David de Beauregard, President of the Agricultural Society at Toulon. It consists in subjecting the cane, stripped of its leaves, to the powerful action of a rolling mill, consisting of three cast-iron cylinders placed horizontally, as is done with the true cane in America. The method requires a great motive power on account of the necessity of bringing the cylinders very close together to prevent the loss of juice. By this means only one hectolitre of juice to the horse power is obtained in one hour.

This juice or syrup is set to ferment, without being heated, by the addition of a small quantity of dry yeast (about 50 grammes to the hectolitre), and under the influence of the surrounding temperature alone. After this fermentation has run its course, and is entirely terminated, the liquor is distilled.

The method of working, which requires a considerable outlay at the start, and which demands the use of many horses or of steam-power, cannot be adopted in small agricultural distilleries. It has, besides, the objection of only producing the average of 3.75 or 4 litres of alcohol to the 100 kilogrammes of cane.

There is another method which consists in pressing the canes as above, and then macerating in water the bagasse which still contains a considerable quantity of saccharine matter; then, when the fermentation is finished, uniting the liquid resulting from the maceration of the bagasse to that from the mill and distilling, the two in the usual way.

Some colonists in Algeria content themselves with crushing the stalks of sorghum, and macerating the whole with cold water, without the addition of any ferment whatever, in a hogshead standing on end, in open sheds exposed to all the vicissitudes of the weather.

Some persons operate after the method of M. Leplay or M. Pluchard, i.e., by direct distillation of the sorghum. Our opinion is sufficiently set forth in the article on the distillation of the beet, and we may dispense with any further reference to it here. It may be well understood that the spirit obtained by either process is of inferior quality.

But of all methods used for the distillation of sorghum, the process of maceration by heat is without contradiction the best. It is, moreover, that which we have employed at Settimello (Italy), and at the large distillery of Amor-el-Ain, near Blidah (Algeria). It is managed as follows, viz.:

The stalks of sorghum, stripped of leaves and the tops, are cut in short pieces by means of a sorghum cutter. It consists of an iron cylinder armed with eight or ten steel blades arranged obliquely in connection with a pair of feed rollers, one of which is plain and the other grooved, so that the stalks are pressed forward as
they are cut. When a sufficiency of material is prepared, the cut stalks are placed in a macerator, No. 1, then covered with boiling water, or cold water, which is heated to 80° by means of a jet of steam. After an hour of maceration, this liquid is drawn off in a macerator, No. 2, where it remains one hour.

The operator should introduce into the second maceration one part of sulphuric acid [at 66°], to the thousand, diluted with twenty times its weight of water. The liquid is now drawn off into a macerator, No. 3, where it stands one hour. This last maceration completes the saturation of the liquid with the saccharine juice.

When the routine of work is well established, the juice drawn from the second maceration is always used for macerating fresh cane, during which it is more freely charged with saccharine matter. When drawn off from the cane the liquor is allowed to cool, so that it may reach the fermenting vat at a proper temperature. The second charge is made with the weak liquor, resulting from a third maceration; and the third charge is always made with pure boiling water (or heated, as has been described).

On leaving the macerators, the concentrated juice, as it reaches the fermenting vat, should have a temperature of 20° or 25° at most, and should mark an average density of 6° by the areometer of Baumé. Under these conditions, the first operation of maceration furnishes the liquor in which to dissolve the liquid leaven necessary to start the fermentation according to the capacity of the fermenting vat. The proportion used is 25 litres of fluid yeast, or 120 grammes of dry to the hectolitre of juice. This is called the "bottom of the tub."* When this bottom is in full fermentation, which commonly happens one hour after its preparation, the vat is filled successively with the liquid resulting from new macerations.

The fermentation always progresses regularly, and is finished without violence; it is completely, terminated in 18 or 20 hours, and rarely extends to 24 hours. The froth is white and light, and does not require the use of any fatty substance to cause it to fall.

After a rest of 24 hours, the fermented juice or wine of sorghum is subjected to distillation in the apparatus of Egrot, Derosne, or some other, and yields an average of five litres of alcohol at 95° to 100 kilogrammes of the sorghum cane.

The system of maceration by steam which we described in the article on Beet Spirit, may be applied as well to the treatment of sorghum.

Towards the close of the season, it sometimes happens that the sorghum juice contains so great a quantity of acetic acid produced by changes within the stalks, and even lactic acid, that it becomes necessary to saturate the juice with lime to obtain a successful fermentation. It is not important, however, to have this saturation too perfect, indeed it is better to preserve a slight acid reaction, lest too great a degree of alkalinity may interfere with the success of the fermentation. The juice so saturated should only be employed after being drawn off clear and separated from the deposit resulting from the saturation.

The distillation of the sorghum left standing and cut as required is not profitable after the month of January [in France.] After this time the cane dies, is heated, ferments, or is destroyed by larvae, as has already been said, which devour all the pith, and with it the sugar, and leaves absolutely nothing more than the external envelope.

Apparatus of M. B. Viale.—Now that we have described the various methods in use for obtaining alcohol from sorghum, we think it will not be amiss to speak of an apparatus which is readily set up in agricultural establishments, and which is used for the extraction of the saccharine juices contained in sorghum, beets, artichokes, etc. etc.

The following is a description of this apparatus. (See Fig. 7, Pl. VI.)

A. Tubular pan for concentrating the syrups.

* Footing.—Trans.