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THE PRODUCTION OF MAPLE SIRUP AND SUGAR.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry,
Washington, D. C., August 15, 1912.

Sir: I have the honor to transmit herewith a manuscript entitled "The Production of Maple Sirup and Sugar," by A. Hugh Bryan, chief of the sugar laboratory, Bureau of Chemistry, and William F. Hubbard, of the Forest Service, and to recommend its publication as a Farmers' Bulletin. The part by Mr. Bryan is the result of extensive chemical study of pure maple sirup and maple sugar, which included inspections of all the sugar maple districts of the United States. Mr. Hubbard's contribution includes the descriptions of the various sugar maples and the forester's recommendations for the management and care of sugar maple groves.

The manuscript as a whole contains the essential parts of Forest Service Bulletin 59 and Farmers' Bulletin 252, which, through the cooperation of the Forest Service, it is designed to supersede.

Respectfully,

R. E. Doolittle,
Acting Chief.

Hon. James Wilson,
Secretary of Agriculture.

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THE PRODUCTION OF MAPLE SIRUP AND SUGAR.

INTRODUCTION.

The production of maple sirup and maple sugar is purely an American industry, Canada being the only country outside of the United States where they are made. At the time of the Napoleonic wars sugar was produced from the maple trees in Bohemia, and the industry received substantial means of encouragement from the Government of that country. Large groves of maple trees were planted and much attention paid to them, but, as the yield of sugar was small, and such a length of time elapsed before the trees could be tapped, the industry soon died out. At about that time the sugar beet came into prominence.

The earliest explorers in this country found the Indians making sugar from the maple tree, and in some sections, especially along the St. Lawrence River, producing it in quantity for trade. The white people began to make maple products and to apply more advanced methods to their manufacture. The crude methods of the Indians were soon improved upon, but beyond the tapping and boiling the general process remains the same as at that time. For many years, especially with the early settlers of the northern part of the United States, and even down in Kentucky and Virginia, maple sugar was the only sugar used. In the reports of the early meetings of the numerous agricultural societies are letters from various sugar makers describing their attempts to produce an article equal to the imported sugar, or muscovado, of the West Indies. Cane-sugar methods of manufacture were tried, with varying degrees of success. A few refineries for producing white sugar were built and operated with maple sugar as their raw supply. The iron kettle, birch-bark tank, wooden spiles, and old way of tapping yielded a dark, ill-tasting product, but with care and changes in methods and apparatus the products were improved. In those days many trees were killed by the crude methods of tapping, and much stress was laid upon this operation by the early writers.

To-day maple sugar and maple sirup are considered delicacies and are not produced in such quantities as formerly. The aggregate of all pure maple products and the many imitations may be the same, for it is said that were all the maple trees cut down, and thus the supply of maple sap cut off, no drop in the quantity of sirup or sugar would be noted. Within the last six or seven years there has been a renewed tendency toward the production of a better grade of maple products.

Maple sirup or maple sugar prepared by the best methods is a light-colored, pleasant-tasting product. Contrary characteristics are the result of uncleanly methods and possibly sour sap in ninety-nine cases out of a hundred, and were manufacturers to take greater care in their methods their results would show improvement. This better grade may not appeal to many people who have been accustomed to the dark, stronger grades.

In visits to the many maple camps for the collection of samples of pure maple sirup and sugars for analysis, much attention was paid to the manufacturing side. The results of the work on maple-sap sirup are given in Bulletin 134 of the Bureau of Chemistry; the work on maple sugar and maple-sugar sirup has not been completed. As these articles are to a great extent technical, it was thought the work should be compiled for the layman or the small sugar maker.

SUGAR MAPLES.

All the maples have sweet sap, but only from a few of our native species has sugar been made in paying quantities. The first place is held by the sugar maple (*Acer saccharum*) and a variety of it—the black maple (*Acer saccharum nigrum*). The red maple (*Acer rubrum*), the silver maple (*Acer saccharinum*), and the Oregon maple (*Acer macrophyllum*) are of less importance, and the box elder (*Acer negundo*) is least important of all.

THE SUGAR MAPLE.

The sugar maple spreads over a wide area, but as a tree for the production of sugar in paying quantities its range is limited to eastern New England, New York, Pennsylvania, the southern Appalachians, the Ohio Valley, and the Lake States and adjacent parts of Canada. In the Gulf States and as far north as southern Arkansas the tree is represented by a variety (*Acer saccharum floridanum*) from which no sugar is made.

The sugar maple is a stately and vigorous forest tree, capable of growing in dense stands. It bears a plentiful crop of seeds, which in most localities ripen in the early fall. These seeds germinate readily, and under favorable circumstances the entire forest floor is heavily carpeted with seedlings, the succulent, sweet foliage of which is eagerly devoured by all kinds of stock. The young seedlings are very thrifty and can stand the shade of a complete forest cover. This tolerance of shade is one of the distinguishing features of the sugar maple, and, although it is less pronounced in later years, the mature tree has one of the most persistently heavy crowns in the forest.

Seedlings, although not killed by complete shade, are kept suppressed and grow slowly; but if they have germinated in the open, or the forest above them is removed, they grow up into thickets of remarkable density. In such a condition the struggle between the young trees is so fierce that the development of even the most thrifty is seriously retarded. The species being so tolerant of shade and by nature so vigorous, no individual gives up the struggle, but does its utmost to overtop the others and gain the sunlight. As a result the stand keeps its extreme density for a long period, and each tree grows long and spindling. The forest-grown tree develops slowly on this account, and has a long clean stem and a small crown, while the roadside maple has a short trunk and a great egg-shaped crown of dense foliage. The root system tends to be shallow, with many laterals and an undeveloped taproot. In the forest this character is more marked than in field or roadside specimens, and any sudden opening up of the stand may result in loss by windfall or by a drying out of the roots.

There is no doubt that the quantity of sap that a tree yields stands in direct relation to the size of its crown, but many sugar makers believe that trees in a forest produce more sap than those in a grove. The explanation is found in the fact that the forest floor with its covering of litter and humus contributes to the vitality of the trees more than the grass carpet of a grove. To obtain a heavy sap production a complete crown cover and a rich deposit of humus are of vital importance.

Within its wide range the sugar maple appears as a predominant tree only in the New England States, New York, southern Canada, northern and western Pennsylvania, and in parts of Ohio, Indiana, Illinois, Michigan, Wisconsin, and Minnesota. In the southern Appalachians it occurs in scattered bodies where climatic conditions are similar to those of the North, confining itself chiefly to north slopes or to the coves, on moist, well-drained, rich soils where the heat of the sun is tempered. As a rule it associates with the beech, birches, and basswood, but also mixes with the yellow poplar, hickories, and other hardwoods, and with hemlock and some of the eastern spruces. At the heads of the coves and in the bottoms it often forms pure stands fit for commercial tapping, and its reproduction is everywhere excellent.

In its northern home it is a principal forest tree and often forms from 25 to 75 per cent of the total stand. It prefers a moist but well-drained soil, and seems to do its best on glacial drift or on rocky hillsides and benches. In the cool atmosphere of this region all aspects are equally acceptable, but it avoids or grows sparsely on ridge crests, generally leaving the ground in such situations to spruce or to beech. In the extreme northern part of New York State and the adjacent district of Quebec the forest growth is often almost pure maple, and even considerably farther south, where beech and birch become associate trees, the sugar maple holds its own as the dominant species. In northern Pennsylvania, at an altitude of over 1,000 feet, the mixture is much the same as it is in New York. In Ohio, Indiana, and Illinois a similar condition is found; but as the hilly country disappears the maple retreats to the richer and damper soils, leaving great areas to the oaks, chestnuts, etc. This is particularly true of the southern parts of these States. By the time the western and southwestern limits of its range have been reached it has only a scattered occurrence, even in the most favorable positions. In southern Michigan the forests are similar to those in New York, but as one approaches the pine region of the North the maple confines itself to the more fertile places. The same is true in Wisconsin and Minnesota, where the sugar maple reaches its northwestern limit in the United States.

Maple trees are often seriously injured by an insect commonly called the "maple worm," concerning which information may be had from Circular 110 of the Bureau of Entomology, United States Department of Agriculture.

In the present discussion the sugar maple is not considered as a lumber tree, for which a long stem free of branches is desired, but rather as a paying producer of sap. Under this aspect a silvicultural problem is presented radically different from that which ordinarily confronts the forester. (See p. 9.) The full and heavy crown with a large leaf surface must be developed in place of the long, clear stem. The sap flow must be continuous and plentiful. The best sap flow is where the transition from winter to spring is slow, where the days are warm and sunny and the nights frosty. These conditions do not occur throughout the entire range of the species. A locality wherein the ground thaws quickly and which has no great variation of temperature between day and night is not suitable for sap production. The "season" must be long enough, also, to insure sap in merchantable quantities. Such conditions are characteristic only in the Northern States, and as sugar making extends farther south it can be profitable only at altitudes which reproduce the climatic conditions of the North.

THE BLACK MAPLE.

The black maple is generally considered superior to all others as a producer of sap. How far this is true is uncertain. In its general silvical characteristics it is similar to the sugar maple, save in the fact that it seems to prefer lower land, such as the banks of streams and rich alluvial river bottoms. It is found in Vermont on the shores of Lake Champlain, and ranges southward, west of the Alleghenies, from Minnesota to Arkansas and eastern Kansas.

THE RED MAPLE.

The red maple has the widest range of all its family in America. The natural home of this tree is along the borders of streams and on low, swampy ground. In the North it often forms a pure growth in such places, but it is along the Ohio and the Mississippi and their tributaries that it reaches its greatest perfection. Like the sugar maple it is tolerant of shade, and seedlings sprout plentifully from the heavy crops of seeds, which ripen in the late spring or early summer. As a swamp tree it associates in the Southern and Middle States with the sweet magnolia and loblolly bay, the bald cypress, various oaks, and the red, black, and cotton gums. It does well, also, on less moist lands. It is generally of vigorous growth, but the grown trees are inclined to unsoundness at the butt. As a sugar-producing tree it enters into consideration in the Middle and Western States only where the sugar maple is not plentiful. It has an abundant flow of sap which is much lower in sugar content than the sugar maple. On account of its early flow of sap it is often tapped at the first of the season to produce the earliest maple products.

THE SILVER MAPLE.

The silver maple ranges from New Brunswick to western Florida, and west through southern Ontario and Michigan to eastern North and South Dakota, Kansas, and Indian Territory. In the North it appears in mixture with the sugar maple, but in general prefers lower altitudes and moister soils. It reaches its greatest perfection in the valleys of the Ohio and Mississippi, where it is one of the characteristic trees on the lowlands of these rivers and their tributaries. The flow of sap is plentiful and sweet, but, like that of the red maple, liable to discoloration, and the season is short and uncertain. It is, like the red maple, only to be considered as a sugar tree outside the region where the sugar maple is a dominant species.

THE OREGON MAPLE.

The Oregon maple is the only western species which can be considered as a producer of sugar. In localities where the season is favorable the sap is of good quality and the flow considerable. The tree is found west of the Cascades and Sierra Nevada, from the Canadian border to southern California. It prefers rich, moist soil, and reaches its best development in the river bottoms of Washington and Oregon. The census of 1910 reports a very small production (10 gallons of sirup) from Columbia County, Wash.

SUGAR GROVES.

GENERAL CONSIDERATIONS.

The ideal sugar grove should contain that number of trees which will give a maximum yield of sap per acre; whence it follows that the formation of a grove must consider the yield per given area rather than the yield per tree. To determine the exact number of trees that should occupy an area would take many years of experiment, but directly and indirectly there has been much information collected on the subject of sap production through a study of individual trees, and from this a number of safe deductions can be made. An equal amount of sunlight being given, the sap and sugar production is proportionate to the leaf area of the tree. This statement is corroborated in a bulletin of the Vermont Agricultural Experiment Station,[1] where it is also asserted that the sugar production of the tree depends more on the actual leaf area than on the amount of light which it receives. In other words, if a small-crowned mature tree be set free to light on all sides, the sap production will be stimulated only to a very slight extent. From this it follows that the number of trees per acre must be consistent with the greatest possible crown development of each tree in the grove. At the same time it is not to be forgotten that the maple is inherently a forest species. The large crown of foliage has an extensive leaf area for evaporation, and demands a protected soil which can keep it well supplied with water. Such soil is best found in the forest, where

[1] Vermont Agr. Exper. Sta. Bul. 103, December, 1903, pp. 117, 118.

the ground is kept heavily matted with leaves and humus, so that the sun and drying winds will have little access to it, and a comparatively uniform degree of moisture and coolness may be maintained under all conditions. Commercial sugar making is confined to a small part of the botanical distribution of the sugar maple, because of a peculiar climatic requirement. It is the gradual northern spring, with the slow yielding of the frost by the ground, which makes the sap flow long and continuously enough to give a paying production of sugar. A sudden thaw affects both the quality and the duration of the sap flow. On this account it is always desirable to maintain forest conditions in a sugar grove, for if the ground has a heavy carpet of leaves and humus, it will be less sensitive to changes in temperature.

Altitude is one of the most important factors in determining the necessary density of the sugar grove. High up in the mountains, where the summer is moist and the spring long, and in the North, the necessity of an unbroken cover is not so great as where the summer is hotter and the spring less gradual in its transition from winter to warm weather. In mountainous regions the forest can be more open, and in every large grove a section on a southern exposure will insure an early sugar season. In lower altitudes the close grove of full-crowned trees will have an advantage over a scattered stand of field trees exposed to the effects of a variable spring. It should not be forgotten, however, that trees which have developed from their youth in very open groves have stronger root systems than forest trees, and that they draw their water supply from the moist subsoil (see p. 7); but such groves have a relatively limited production per acre, and, while serviceable for a small home production, would cover too large an area to be profitable for a large undertaking.

The model grove should satisfy the following requirements as far as possible.

(1) It should contain the greatest number of trees per acre consistent with fully developed crowns.

(2) The forest cover should be unbroken, so that in summer little sunlight falls upon the ground.

(3) There should be a complete litter of humus and leaves, to the exclusion of grass and light-demanding weeds.[1]

(4) Young trees should be kept in reserve to take the place of those that fail, and to fill other openings in the cover.

(5) No grazing should be allowed in the grove, except in special cases where the cover is perfect and no reproduction is needed. Cattle not only keep back all reproduction, but also do harm by trampling and breaking the ground, so that it dries out.

(6) The grove should be made accessible by a system of roadways to facilitate the collecting of sap. If the network is complete no difficulty will be found with the underbrush, which hinders sap gathering little in the early spring when the woods are devoid of foliage.

The first three points vary in importance with the latitude and altitude of the grove, but they are always worthy of consideration.

[1] French and German experiments have demonstrated that a heavy growth of grass dries the soil, and interferes with the entrance of water even during a heavy rain.

In discussing the methods required to bring about these results, the several common types of sugar groves will be described. Logically it would be proper to begin with the treatment of a sapling thicket and continue through each stage to the mature grove, but as the earlier stages of growth are the most complicated to deal with, the order of consideration will be reversed.

THE IMPROVEMENT OF A DENSE MATURE GROVE.

A large number of groves are merely parts of the old hardwood forest, having a preponderance of sugar maple in the mixture. These trees have their normal forest form—a long, smooth stem and compact crown. There is little to be gained in actual sap production by thinning such a stand (p. 9), as it has generally passed the period of vigorous growth and would not develop larger crowns, although the sap season may be brought on earlier by opening up the grove to sunshine. The mixture can be regulated, however, and provision made for a pure growth of maple to succeed the old forest as it passes away. The usual mixture of birch, beech, elm, basswood, and ash may be gradually removed and the reproduction of maple thereby assured. This thinning should pay for itself in most localities from the resulting fuel and saw timber. In making such a thinning the following precautions should be observed:

(1) When the trees to be removed occur in groups, they should not all be cut out immediately, leaving large gaps in the forest cover, since forest-grown sugar maples have a broad, shallow root system, and are subject to windfall when suddenly exposed. The trees which crowd the best maples should be taken out first; the rest should be removed later, when the sugar trees have become more wind firm.

(2) Where several maples crowd each other and form a dense cover, those with the smallest crowns, those which are unsound, and those which show signs of bad health or decline should be removed.

(3) Young maples which show possibilities of good crown development should be cut free from interference on every side.

(4) If the grove borders on open land, it should not be thinned for a distance of at least 25 feet from its edge. This is a safeguard against damage by storms, and is particularly important in borders exposed to heavy winds.

(5) When practicable, the young growth of other species than maple should be removed.

(6) It is well to accomplish the thinning in a series of years, rather than at once and radically, thus avoiding violent changes.

(7) It is important to maintain the humus and ground moisture in every maple grove. In localities where natural forests of sugar maple are common the danger of destroying the proper soil conditions by letting in the sunlight is not great, but if a grove of this type lies where the summers are hot the cover must be broken very gradually.

THE IMPROVEMENT OF AN OPEN MATURE GROVE.

In the more settled and less wooded portions of the maple sugar producing district it is noticeable that a large proportion of the groves are old and very often overmature. They have evidently been left on favorable situations from the original forest, and as a rule no attempt has been made to renew them or keep up their vigor since the adjoining land was first cleared. A young and thrifty set of trees is a rarity among the great number of old, open, and grass-grown groves.

As a rule these groves are on small farms, where they are used quite as much for pasture as they are for sugar making. In cases where the pasturage can not be spared, and where sugar is only a small item in the farm production, there is little to be done for their improvement. When the grazing can be spared, however, and the owner desires to increase the sugar-producing capacity of his trees, it is undoubtedly better to bring about a reproduction from the old trees than by planting a new stand.

The first step to be taken in such a process of improvement in a more or less open and grass-grown grove is the exclusion of stock. After laying out proper driveways for sap gathering, the seedlings should be allowed to come up everywhere else. All unsound and dying trees should be cut out and young growth of all other species than maple removed. In a very short time the young maple seedlings will take possession of the open ground and grow vigorously where they get sufficient light. When they are 8 or 10 years old and 6 to 8 feet high, or more, the struggle for supremacy among them will begin. In each opening large enough to permit the development of a tree with a full crown, the strongest and most thrifty seedling which has a favorable position should be selected, and the heads of those within a radius of 12 feet or more about it lopped off with a corn knife. The crowns of at least two-thirds of these trees must be removed; the remaining crowns will insure a good ground protection and leaf fall until the favored tree has filled the opening. In the case of small openings the thicket should remain unthinned; the struggle between the trees will keep them all suppressed, while they will supply the necessary ground cover. The seedlings which come up under the direct shade of the old trees will never develop to any size, unless some of the large trees are removed by age or accident. Cattle may be let in the grove when it has become too tangled for convenient sap collecting and when the young growth desired for open places has reached a height of 8 or 10 feet. They will soon open up the smaller and undesirable growth. At the same time roadways should be opened and the ground kept free of fallen limbs and trees. The tall, slender seedlings will be a small obstruction in sap gathering, but a little discomfort can be borne for the sake of the undoubted advantages obtained by a ground cover.

THE IMPROVEMENT OF A DENSE YOUNG GROVE.

In many parts of the maple-producing section a second-growth forest has come up similar in composition to the original stand. The sugar maple often forms a predominant part of such a wood, and in that case all that is needed to turn it into a sugar grove is to remove a number of interfering trees, thus giving the proper number of maples a chance to develop the full crowns necessary to a maximum yield of sap per acre. Preference should be given to the younger and more thrifty stands, where the trees are just entering the period of most vigorous development.

The difference between thinning a young stand and a fully matured grove of the same type is usually that in the former case provision must be made for growing a set of full-crowned sugar trees from the more thrifty of the young maples. In a stand from 40 to 60 years old it is easy to pick the largest and best-developed specimens and favor them for the future. Some of the directions to be observed in treating a dense young grove are the same as those given for the treatment of the mature grove.

(1) Select the sound, dominant trees which show a natural tendency to a well-branched, compact crown of large size, and remove from all sides everything which tends to crowd them. If the stand is between 40 and 60 years old, leave about 100 trees to the acre; if older, leave about 75 trees. The average healthy young maple can be freed for 10 to 12 feet on all sides of its crown without the slightest danger, except in the most exposed positions.

(2) In the choice of sugar trees the position and influence of each on its neighbors must be considered. If two dominant trees crowd each other seriously, remove the least promising.

(3) In case the beech, birch, or other species are so grouped that their removal would make a serious gap in the forest, it will be well to let several of them stand, but they should be so treated that maple seedlings (which nearly always gain possession of the soil even under beech) will have light enough to come in under them. When these seedlings become established the beech or birch can be removed, and young maples favored. When practicable always cut out other seedlings than maple.

(4) Successive thinnings are better than a radical opening up of the stand, because in this way danger of windfall and drying out the soil are avoided. This method also leaves room to overcome the damage done by porcupines. These animals probably are the worst enemies of the young maple. One porcupine in a single night can strip the bark off many saplings, and to such an extent that they are permanently ruined. The sugar trees should not have more than 10 or 12 feet of free space on any side of their crowns. A thrifty maple can fill such a gap in eight or ten years, after which a final thinning may be made and the remaining weed trees removed.

(5) The edges of the grove which border upon open land should not be thinned enough to leave the stand unprotected from strong winds and sunlight. If other species are crowding the dominant maples, they should be removed; but, as a rule, the borders should remain dense and the trees should be covered to the ground with foliage.

(6) In cool situations, or in elevated regions, the thinning may be heavier than farther south or in lower lands, where more care is necessary to preserve a proper ground cover. Firewood and other timber secured by thinning should pay for the cost of the operation. The necessity for well-located roadways to take out the sap should not be forgotten.

THE MANAGEMENT OF A SAPLING THICKET.

Throughout the maple region dense thickets of young saplings are common in abandoned fields and pastures. Where a sugar grove is desired, it will pay to take such young growth in hand if no old trees are available in sufficient numbers. Left to themselves, the young trees usually become so densely crowded that even when 20 feet high they number from 2,000 to 3,000 to the acre. Under such conditions growth almost ceases even in the dominant trees, and at a time which, in normal stands, is the period of most vigorous growth.

The first thinning should be made when the saplings are about 6 or 8 feet high, if the owner feels justified in helping them at this time. The largest and healthiest trees, on an average about 12 feet apart, should be selected, and the tops of the others cut back with a hatchet or a corn knife in such a way that they can not overtake the favored individuals.

Cutting back trees in this manner can be done very rapidly. Three men should cut over an acre a day. Although there is no return in firewood or other material from such early thinnings, the young trees will be given a favorable start in their development at the most critical period of growth. The ground cover at the same time will be kept intact by the sprouts, until the selected trees fill out and close up the space with their crowns. When they are about 25 years old the dominant trees, which are about 12 feet apart, will begin to crowd each other, and another thinning must be made to give the best ones room. Experiments are under way to show how much time will be gained by this method in obtaining a stand fit for tapping. All general forest practice shows that the gain over the unthinned thicket should be at least 25 per cent.

If the thicket to be turned into a sugar grove contains older and larger trees than have been considered, a regular course of thinning should be instituted. The main points to keep in mind in this case are as follows:

(1) Choose the thrifty trees which show a tendency to good, symmetrical crown development, and set their crowns free on all sides to a distance of about 12 feet. See that the selected trees are sound and free from forks which may develop badly.

(2) Remove all long, spindling trees which are likely to bend over.

(3) For ground cover, leave all specimens which do not threaten the crowns of the chosen trees and which are capable of casting a small amount of shade.

(4) Remove all species but maple, except when they are very much suppressed. Low, broad-crowned trees of any kind will help to shade the ground.

(5) Do not disturb the borders of a dense thicket. Sun and wind must be excluded from a stand which has been suddenly opened up within, and which is unaccustomed to the new conditions.

To make this system of treatment clearer, a concrete case will be described. In the autumn of 1903 a stand of young maples in Vermont was thinned by a member of the Forest Service. The stand is situated at an altitude of about 1,200 feet, with a southeastern exposure. It came up in an abandoned meadow, which was seeded from a few old trees along a bordering wall. The dominant trees are from 30 to 40 feet in height and from 15 to 25 years old, with an average diameter for the stand, suppressed trees included, of 2 inches, breasthigh. The entire tract is very dense, and, although the extreme difference in the age of the trees is about 10 years, the difference in their size is far greater than the discrepancy in age would explain. More than half the stand is 1 inch and under in diameter, and yet

FIG. 1.—Stand of maple saplings in need of thinning.

many of these trees are as old as near neighbors three times as large. This results from the extreme vitality of the sugar maple, and shows the urgent necessity for thinning at an early age. Two plats, each 0.7 acre in size, were thinned, with the following results:

Thinning of a maple-sugar thicket, showing the number of trees per acre of various diameters in the original stand, the number removed, and number left.

Diameter breasthigh.	Number of trees per acre.		
	Original stand.	Removed.	Left.
Inches.			
0.5 to 2	1,517	755	762
2 to 4	1,042	653	389
4 to 7	309	126	183
Total	2,868	1,534	1,334

Figures 1 and 2 show the tract before and after thinning. Twelve cords to the acre of fair firewood were cut, an amount which should ordinarily pay for the thinning. The large number of small trees left after thinning is noticeable in the illustration, and is a point not to be overlooked. All trees that in no way interfered with the dominant stand and had a fairly full crown were allowed to remain as cover. There is no chance of their overtaking the favored trees, and they furnish the needful shade whereby a more radical opening of the crowns in the dominant stand is permitted. The final trees of the grove are to be selected from the trees which are 4 to 7 inches in diameter, the remainder acting as a reserve in case the selected trees should meet with accident. The heaviest cutting was made in that part of the stand which ran from 2 to 4 inches in diameter, the class which interfered most with the future sugar trees. Those individuals which gave promise of becoming members of the final

Fig. 2.—The same stand shown in figure 1 after thinning.

stand were given more room than the others. Although the cutting took away such a large proportion of the stand, it will be observed that the trees are still in close order. This will necessitate a later thinning, probably after about six years, but at present further thinning would subject the long, slender saplings to danger of overthrow and the ground to drying.

SITUATION OF A SUGAR GROVE.

The best location for a sugar grove is where the maple thrives best under natural conditions. In the Appalachian region this will be in the north coves, and in Ohio, Indiana, and adjacent States on rich, moist, gravelly soils. In the Northern States, where the maple flourishes on all exposures, the exposures to the south are generally to be preferred, because there the sap runs earlier, and the first sirup and sugar to reach the market obtain the best prices. On northern exposures and in very dense forests the sap season begins later; but if the sugar grove is to be on a large scale, it will be well to have it include both southern and northern exposures, so that the run of sap may be continued longer and not come at once in a quantity too great to be easily cared for. In the Northern States the best sugar groves are usually on rocky slopes with soils rich in humus, at an altitude of about 1,000 feet.

PLANTING A SUGAR GROVE.

The advisability of planting a sugar grove will depend partly on the locality. The problem presented is notably different in the Middle West and in the region of commercial production in the Lake States and the Northeast. In the West maple-sugar production has steadily declined and shows no sign of a revival. The planting of sugar groves in this region is, therefore, not generally advisable.

In the region of commercial production it is usually easy to find old groves, young stands of second growth, or sapling thickets which can be made productive more quickly than a plantation of seedlings. In cases where no such beginning is possible, and a plantation has been determined upon, the following suggestions may be useful:

Avoid planting the trees too far apart. This is the mistake most commonly made. Wide spacing deprives the soil of its needful protection, reduces the yield of sap per acre, and gives a poor return for the expense of planting and for the amount of land used. Planting should always be done in early spring; and as the regions in which it is likely to be necessary are usually at low altitudes (see p. 7), it will be good policy to plant the trees close enough to insure a proper ground condition from the first. This will be best accomplished by setting the trees 6 by 6 feet apart. This gives 1,210 trees to the acre, which will not prove very expensive, as small seedlings, costing about $2 per thousand, may be used, or they may be gathered from the woods, preferably in wet weather. When this is done, care should be taken to select thrifty specimens, not over 2 feet in height, and to plant them immediately.

When the young trees reach a height of about 10 feet and begin to crowd one another, the grove should be treated in the same manner as that recommended for the wild sapling thicket (see p. 14). This will give a maximum number of full-crowned trees to the acre, and the proper ground conditions will be maintained.

In most cases it will be well to cultivate the ground for one season, or possibly two, but the soil should acquire the forest character as soon as possible. Where that is not readily attainable, a maple grove is not likely to pay.

In some situations it may be advisable to mix with the maple a number of quick-growing trees valuable for posts or farm lumber, in order to secure early returns on the investment. The best species to use in this way can be determined only for definite localities. Advice in such cases will be furnished willingly by the Forest Service.

THE PREPARATION FOR OPENING.

In the spring, when preparing for the opening of the sugar season, or during the fall of the year before, roads should be cut through the bush. Any brush that is in the way should be cut down, and any holes that might overturn the cart of sap should be filled. In laying out the roads through the woods some plan should be followed that every portion of the bush may be accessible, so that when the sap is running fast and many sap buckets quickly fill the gathering pail, the latter will not have to be carried far to be emptied into the hauling tank. Furthermore, by having these roads accessible to all parts of the bush there is more assurance that all the sap buckets will be visited each day during the sugar season. The necessity for this will be discussed later.

TAPPING THE TREES.

LOCATION AND CHARACTER OF TAP HOLE.

Before tapping, the side of the tree should be brushed with a stiff broom to remove all loose bark and dirt and a spot selected where the bark looks healthy, some distance from the scar of a previous tapping. Care should also be taken to tap where a bucket attached to the spout inserted in the hole will hang level and be partly supported by the tree itself. The distance from the ground should be such as will be convenient for the collector of sap; that is, about waist high. The location of the tap hole as to the point of the compass depends much upon the tree and its location in the bush. In general it is on the south side of a tree for earliest runs, as the sun shines on this side first, the east side being next best, while it is claimed by some that holes on the north side flow longest. It is usually best to tap on the side of the tree where other trees do not shade the spot.

The main requisite in tapping a tree is a good sharp bit with which a clean-cut hole can be made. If rusty and dull, the bit cuts a rough, feathered hole, which soon becomes foul, stopping the flow. After the tapping all shavings should be removed to make the hole clean. The bark should never be cut away before boring the hole, as this shortens the life of the tree.

SIZE OF HOLE.

Among sugar makers the size of the hole is a much mooted question. All agree that it should be of such size that it will heal over in one season, or at the longest in two years. General practice seems to indicate that three-eighths to half an inch is the best diameter; then, if the season is long and a warm spell interrupts the flow, the holes can be reamed out to one-half to five-eighths of an inch, and thereby secure an increased run. A thirteen thirty-seconds of an inch bit is often used. The bit should be especially sharp and should bring the shavings to the surface. Its direction is slightly upward into the tree (see fig. 3). The slant allows the hole to drain readily.

The depth of the hole is an important point on which different makers vary. It should, however, be regulated by the size of the tree, as it is only the layers next to the bark that are alive and contain enough sap to flow freely. Toward the interior the flow diminishes. With the ordinary tree a hole not over 1½ to 2 inches deep is best; some bore in 3 inches, but this is possibly too deep. In small second-growth trees a short incision, or just through the sapwood, is best. In any case boring should be stopped when dark-colored shavings appear, even though a depth of an inch has not been obtained, as this shows dead wood and that the sapwood has been passed through.

NUMBER OF TAP HOLES TO A TREE.

It is far better to make it a rule to tap only one place on a tree; by so doing the life of the tree is prolonged. Large first-growth trees might be tapped in two and sometimes three places without injury, but it is imprudent and disastrous to tap in two places near together so that the sap from the two is collected in one bucket.

Fig. 3.—Tapping the tree.

TIME FOR TAPPING.

It is good policy to tap early in the season in order to obtain the earlier runs, which are generally the sweetest and therefore the best producers. Makers have lost half and even more of their crops many seasons by not being prepared for the first runs. It is hardly necessary to describe what constitutes "sugar weather," as all sugar makers are familiar with the term. In general, it might be said that during the middle or last part of February in the southern sections and later in the northern ones, when the days are becoming warm, the temperature going above 32° F., and the nights are still frosty, the season is ready to open. If the days are very bright, warm, and sunny, the sap will start with a rush, but soon slacken, or if a high wind starts up the flow is checked. A protracted warm spell or a heavy freeze, with days and nights of even temperature, causes the flow to stop altogether, to start up again when the meteorological conditions are right.

Mr. Phillips, of Ohio, has kept the date of tapping and also the last day of boiling for his camp from the year 1880 to date. The data are as follows, showing how the opening and closing dates of different seasons may vary.

Table showing date of opening and closing of a sugar camp in Ohio from 1880 to 1912.

Year.	Opening date.	Closing date.	Days.	Year.	Opening date.	Closing date.	Days.
1880	Feb. 24	Apr. 1	37	1897	Mar. 8	Mar. 31	23
1881	Mar. 9	Apr. 16	38	1898	Mar. 3	Apr. 11	39
1882	Mar. 2	Apr. 1	30	1899	Feb. 20	Apr. 11	50
1883	Mar. 1	Apr. 10	41	1900	Mar. 8	Apr. 14	37
1884	Mar. 12	Apr. 14	33	1901	....	....	......
1885	Mar. 27	Apr. 18	22	1902	Mar. 7	Apr. 6	30
1886	Mar. 15	Apr. 11	27	1903	Feb. 26	Mar. 15	17
1887	Mar. 2	Apr. 9	38	1904	Mar. 2	Apr. 6	34
1888	Feb. 21	Apr. 10	50	1905	Mar. 16	Mar. 29	13
1889	Mar. 11	Apr. 9	29	1906	Feb. 13	Apr. 2	48
1890	Feb. 17	Apr. 7	49	1907	Mar. 14	Mar. 23	9
1891	Feb. 13	Apr. 11	57	1908	Mar. 5	Mar. 26	21
1892	Feb. 22	Mar. 30	37	1909	....	....	......
1893	Mar. 7	Apr. 3	27	1910	....	....	......
1894	Feb. 27	Apr. 7	39	1911	Feb. 16	Apr. 4	47
1895	Mar. 23	Apr. 12	20	1912	Mar. 17	Apr. 9	24
1896	Feb. 27	Apr. 10	43				

APPARATUS USED IN THE MAPLE INDUSTRY.

SPOUTS.

The spout, or spile, as it is often called, is the tube through which the sap flows into the bucket. It is usually of metal, but often hollow reeds are used. The best forms are perfectly cylindrical, smooth, and of an even taper, making them easy to insert and to remove without interfering with the wood tissue. The perfect spout should be strong enough to support the bucket of sap safely, and for obvious reasons should bring the whole weight on the bark of the tree and not on the inner tissue or sapwood. Spouts with spurs or anchors are to be avoided, as they tend to split the bark and crush the sapwood, thereby decreasing the flow and allowing the sap to leak. The spout having a small hole is best, because one with a large hole allows the bore to dry out faster when there are strong winds. There are various forms of spouts on the market (see fig. 4) that meet these requirements, and there are also forms that can be made at home that will serve the purpose. A spout should have a hook or stop on which the bucket is to hang, unless the bucket may hang on the spout itself. It is bad policy to drive a nail below in the tree for this purpose.

Many makers use wooden reeds as spouts. These as a rule are not strong enough to hold the bucket and, moreover, soon become foul from bacteria and souring of the sap. Their use generally leads to a decreased yield and to the production of a poor-grade sirup.

Great care should be exercised in driving the spouts into the tree not to compress the sapwood or split the bark. Both conditions prevent a good yield of sap and the latter tends to a decay of the tree or a bad healing of the hole. The same care should be used at the end of the season in removing them. Perfectly round spouts with the proper taper should be easily removed by turning without injury to the tree.

SAP BUCKETS.

Buckets are suspended on the tree to catch the sap. Formerly hollowed logs or birch-bark boxes were the usual forms, and these

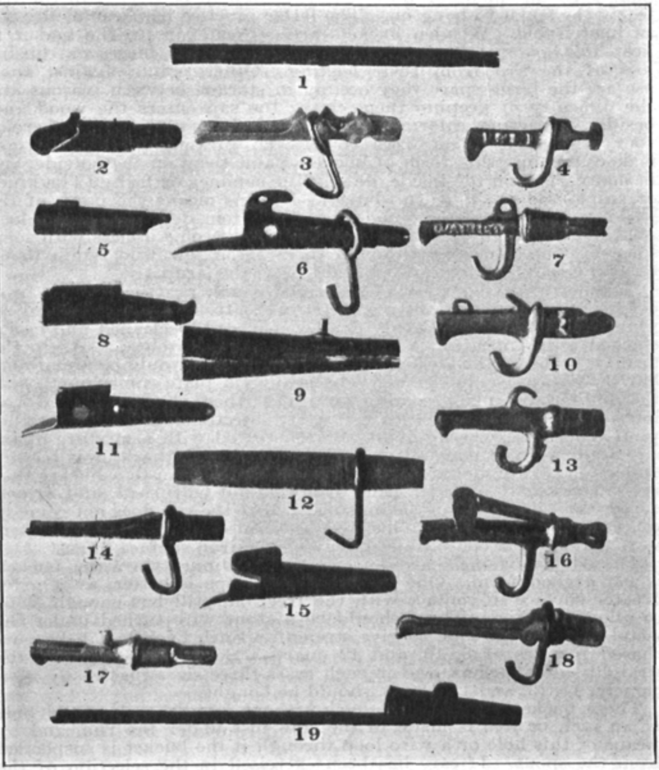

FIG. 4.—Common forms of sap spouts. (Nos. 1 and 12 are wooden; nos. 3, 4, 7, 10, 13, 16, 17, and 18 are molded metal; the others are metal bent into shape usually over forms.)

are found to-day in some of the cruder camps. Their use does not lead to the better grades of maple products, and because they are generally placed on the ground and not suspended to the tree they cause a considerable loss of sap.

Wooden buckets were formerly used almost universally and are still used quite extensively. As a rule they are heavy and do not hang well on spouts or they require a nail to be driven in the tree below the spout to hang on. The latter practice has been mentioned as inadvisable. Wooden buckets are a great care to the maker to keep the hoops tight to prevent their falling to pieces or causing loss of the sap from their leaking. Other points against their use are the large space they occupy in storage between seasons and the difficulty of keeping them clean; the sap enters the wood and, besides extracting coloring matters and flavors, they soon become sour when the warm days come. To prevent these conditions makers who use this form of buckets paint them on the outside, and in many cases on the inside, during the summer or fall. (The kinds of paint used are taken up later.) By this means the pores of the wood are filled and the wood preserved from decay. Most makers are replacing their wooden buckets as they become useless with some form of metal buckets, although there are a few who retain them, believing they impart a pleasing flavor to the sirup.

The most satisfactory buckets are of metal, practically free from corrosion or rust, and fitting well to the tree. They are light in weight, yet strong, not easily dented, are readily cleaned and easily stacked away in a small space after the season closes. As to the metal composing the bucket, the finest, no doubt, would be áluminum, but the expense is too great. The heavy tin plate comes next, with the lighter tin plate coming in order, then the galvanized-iron buckets. One form that is certainly objectionable is the "terne-plate" bucket. "Terne plate" is iron coated with a mixture of tin and lead in about equal parts. The objection to the lead is readily understood. For the same reason there is objection to a bucket that is soldered on the inside. The seams should be turned, and, if soldered, this should be on the outside, so that the sap does not come in contact with it. Objection has also been raised to galvanized buckets in that they soon begin to peel, leaving the iron surface to rust.

The widely flaring bucket, such as the ordinary tin water bucket, is not a good form. One with a gentle slope is better, as it gives greater surface in contact with the tree, but still has enough slope to allow stacking. There should be a stout wire turned under the metal forming the rim, to give strength. Such buckets can be purchased in sizes of 8, 10, and 12 quarts. Some makers prefer the straight-sided buckets, and in such cases three sizes that easily nest, namely, 11, 13, and 15 quarts, should be bought.

These buckets may be obtained without handles. A round hole of an inch or less is made in the side just under the rim, and by means of this hole or a wire loop through it the bucket is suspended from the spout. If care has been exercised in the selection of the place of tapping the tree, there will be no need of driving a nail to keep the bucket in position.

One great advantage of the metal bucket is the ease with which it may be cleaned. All parts are easily reached and there is no danger of sap remaining to sour at a later date.

It is a good plan to paint the outside of new metal buckets in order to lengthen their time of usefulness. Painting them on the inside is not a very good practice as the paint film will soon come off, especially if the buckets are scalded or washed with hot water. If they are rusted on the inside to any extent, it is best to discard them. Iron buckets or an iron exposure will always change the sap, producing a dark-colored product; therefore the use of metal buckets does not assure a light-colored, good-flavored product. Care must be used with any kind to get good results.

COVERS.

The use of bucket covers is a disputed question. During the sap season rain and snow alternate with sunshine. Uncovered buckets hung on the trees are in a position to catch all this and, in addition, leaves, twigs, bark, insects, and dirt that may be swept through the air by the wind. The rain water dilutes the sap, besides often carrying with it the dirt from the trees as tree washings, which can not be removed from the sap; the only course is to empty the bucket. Twigs, leaves, insects, and such foreign material can be removed by straining the sap, but they leave a part of their soluble matter, which can never be removed. For these reasons one would naturally expect that the use of covers would become almost universal. Objections are made to their use in that more time is consumed in removing them when emptying the buckets; also that the sap sours more quickly in covered than uncovered buckets.

FIG. 5.—Open buckets. (Too many buckets on one tree.)

Makers who always use covers say that with a hinge arrangement fastened to the spout no extra time is necessary to empty buckets, and that if any extra time is used less time is needed in boiling the sirup and a better-flavored product is obtained, so there is an actual saving of time. By fastening the cover so that the back edge is raised a little above the front, a free access of air is possible. Many of the covers on the market are arranged in that way. Many advocates and users of covers refute the claim that the sap sours more easily when covered, asserting that sap sours rather from uncleanly methods. When little or no rain or snow falls during the sap season, there is not the need of covers. It is true, however, that darker sirup results from the uncovered bucket.

Covers on buckets may form a good guide to the maker in telling how often his buckets are emptied and whether they have been emptied on that day. This is accomplished by having the two sides of the cover painted different colors, as in one case noted one side was white and the other side red. As the sap was gathered the cover was turned. Thus, in passing through the bush for the afternoon collection the buckets of the morning collection could be passed. By this means a faithful worker will be sure all of his buckets are emptied each day.

GATHERING PAILS.

One of the largest buckets fitted with a handle may serve the purpose of collecting the sap from the buckets on the trees and carrying to the gathering tanks. The usual form is a metal pail with a larger diameter at the bottom than at the top. This gives it stability and

FIG. 6.—Hauling tank.

makes it less likely to turn over when resting the sap bucket on its edge to empty. Many have flaring funnel tops. As in the case of sap buckets, these might be of wood, but are unwieldy on account of their initial weight. They should be cleaned often, in fact after each time of using. The inside bottom edge, forming an acute angle, gives opportunity for dirt to collect and may soon become foul from bacterial growth. The gathering pails hold from 15 to 20 quarts.

HAULING TANKS.

Where only a few trees are tapped, and the boiling is done close by, the sap may be carried in the gathering pails to the supply tank for evaporation, but where the sugar bush covers many acres there is need of some means of transporting the sap. The usual form of transportation is in some large receptacle on a sledge or stone boat drawn by horses or cattle. Many of the small camps use a barrel fitted with a funnel as the receptacle; this takes time to fill and also to empty when the sled is drawn up to the sugar house. Some set the barrel on end, knocking the head in and fixing a faucet at the other end for the sap to run out. Other makers use large wooden tanks, either round or square, fitted with an opening at the bottom and a standpipe (fig. 6).

There is the same objection to the use of these wooden tanks for collection as to the wooden sap buckets; but since the sap does not stay in them any length of time, the objection is not so strong. They should be painted on the inside before the beginning of the season and cleaned often when being used.

Many forms of metal tanks are made for this purpose. These forms are quite desirable on account of their ease of filling and emptying. The iron pipe at one end is loosely screwed onto the nipple at the bottom of the tank and is held upright by the lock at the top of the tank. To empty, the lock is taken out of the socket and the pipe turned downward. These tanks may be obtained in sizes holding from 2 to 6 barrels of 32 gallons each.

A flannel or cheese cloth may be stretched over the top of the tanks and the sap poured through this to remove any twigs, leaves, or pieces of dirt. This is of great importance in the production of a good grade of maple product.

BOILING HOUSES.

If the sugar bush is small and near the house or farm buildings, the boiling can be done in the summer kitchen, over the cookstove, or in a shed; but if 200 or more trees are tapped, some kind of a boiling house should be used and some attention paid to its location. In selecting a suitable place, the first point to consider is the distance from the sugar bush; it should be located in the bush or near by where no long hauls of sap are necessary and on a level spot where good drainage can be secured with higher ground near by to allow a drive where the gathering tank may be drawn up and its contents emptied by gravity. It is not a good plan, however, to locate a house close up against a high bank or cliff which would interfere with the draft for the chimney. If no low spot with a slight elevation is available, dirt can be piled up for the driveway.

A roof is not necessary, but it serves to house the sleds and apparatus, and in bad weather to keep snow and rain from the tank. After season this space is also available for the storage of the sap buckets.

The size and kind of sugar house must be regulated by the size of the camp or number of trees to be tapped. A convenient size is one in which there are at least 3 feet of space on both sides of the evaporator and 5 feet in front. The house should be at least 7 feet—and, better, 8 feet—high at the sides and covered with a well-slanting gable roof; a quarter pitch for the roof is recommended by many. There should be a ventilator as long as the evaporator in the ridge of the roof, and placed immediately over the evaporator. Many makers claim that a wooden roof is to be preferred to a metal one, as there is less condensation and dropping into the pan. Then, too, a metal roof without paint soon rusts and allows dirt to drop into the pan. In connection with the house there should be a shed for the storage of wood to be burned in the evaporator.

It is not good policy to throw up a cheap, makeshift house, as the work is carried on in a trying time of the year, and the point of the health of the maker should also be considered. The sides of the

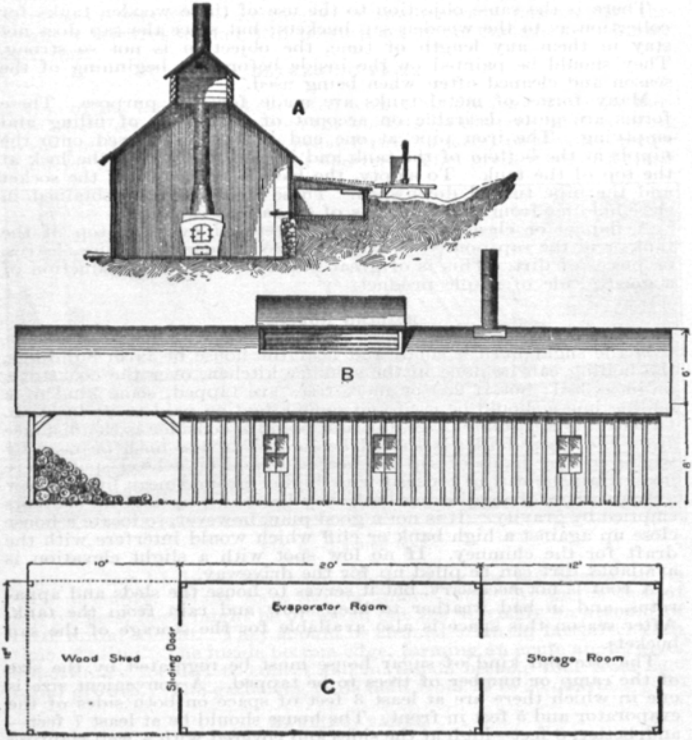

FIG. 7.—Plan of a model evaporation house: A. Sectional view, showing evaporator, storage tank, and gathering tank (on shed). B. Elevation. C. Ground plan.

house should be battened and all cracks covered over; the doors and windows should fit tight. Without these precautions the house soon becomes filled with partially condensed vapor or steam, and a cold, chilly dampness is noted, which greatly hinders evaporation. The ventilator should be capable of being opened or closed easily; the floor should be of brick, cement, or wood, and should have a slope for ease of cleaning. Brick or cement is preferable to wood, because of less chance of fire. Figure 7 shows the plan of a sugar house which is said to have cost about $125.

It is not necessary to have the small storage room as shown in C, but where sugar is to be made it forms a good place for the setting up of the "sugaring-off" pan (see p. 29). It is of special benefit to have the woodshed boarded up, but this is of less importance than the other portions of the house. The dimensions given allow for the ordinary sized evaporator, but for larger ones it may be found well to increase the width and length of the whole structure.

The storage tank should be a large one, capable of holding about a half day's run of sap. It can be made of wood, but it is better to be of metal. The wooden tanks soon fall to pieces and are constantly a source of loss through leaking. The tank should be

FIG. 8.—Iron kettle as an evaporator.

located outside the house and immediately against it. The bottom of the tank should be at least a foot above the top of the evaporator, to allow an easy grade for the tank to drain into the evaporator. This tank, which should be closely covered to exclude the rain and dirt, must be located on the side of the house next to the roadway, so that it is easily accessible to the gathering sled.

By partially burying the tank or boxing it in with wood and filling the space with leaves the sap will not freeze so easily in cold weather nor heat so soon in hot weather.

EVAPORATION APPARATUS.

Evaporation apparatus in general use may be divided into three general classes: (1) Iron kettles, (2) arch evaporators, and (3) patent evaporators.

The iron kettles are generally from 2 to 4 feet in diameter and are seldom housed. They are set on stones, as shown in figure 8, or suspended from a support. In some cases two or more are set in brickwork, with the place for the fire underneath. This form of evaporation apparatus is the crudest and seldom, if ever, yields a pleasant-tasting product. The danger of burning or scorching the sirup by the flames playing around the metal near the edge of the liquid is ever present.

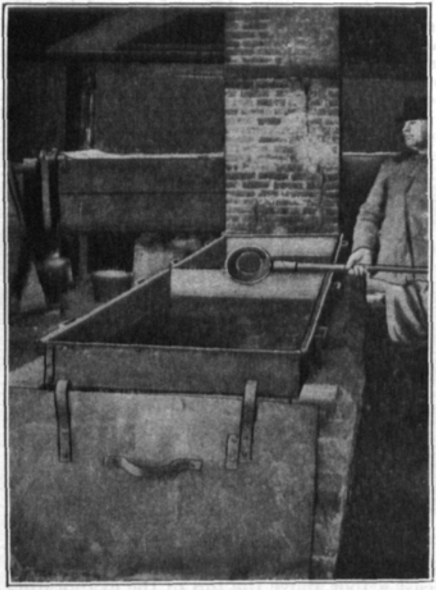

FIG. 9.—Arch with metal pans for evaporation; storage tank for sap in rear.

Another crude method of boiling is with sheet-iron pans, generally from 2 to 3 feet wide and 3 to 6 feet long. They are raised above the ground by a brick or stone work and the fire built under them. The same objection can be raised to them as to kettles, namely, the danger of scorching the sirup. They are, however, a step toward a better product. Many makers use pans made of sheet tin or galvanized iron. The former, with care in boiling, can produce a good-flavored product, but those of galvanized iron can not be recommended. Figure 9 shows such home-made pans in place. In this case there are two pans, one back of the other. The sap can be placed in the front pan and when partially concentrated be transferred to the back one or vice versa by means of a ladle. The figure shows also the brick masonry constituting the arch. Because of this arrangement this form of concentrating apparatus is generally known as an arch evaporator. In most cases the arch is constructed of brick, but quite often stone is used. It may be 3 to 4 feet wide and from 8 to 15 feet long, inside measurements. The sides are generally from 2½ to 3 feet high. Between these two walls the bottom is bricked or cemented and the walls are held together and in place by iron stays, which also serve to hold or support the pans. At the back the arch ends in a flue and a brick or metal chimney extending through the roof. In the front grate bars may be provided and an excavation made for an ash pit.

In the arch and patent evaporators it is well to build the arch during good weather and allow it to set, as when built hurriedly before the season or in bad weather it is likely to crumble and break away. It is of extreme importance to see that the top layer of the two sides are of equal height so that the pan will set level; a slight slant of an inch in 16 feet in the level of the length of the arch is of value, as it gives the sirup a tendency to run toward the back where the final concentration takes place.

The pans are made to fit the arch and are not over 6 inches deep. The edges may be turned over a stout wire to give rigidity and strength, and should be fitted with handles so that they can be readily removed from the fire. The arch can be supplied with a regular stove front containing a fire door and ash door or be fitted as in the cut with a piece of sheet metal. The former gives a better and closer fitting front and allows a better control of draft.

Patent evaporators are simply improvements over the arch evaporators, but the fundamental principle is the same. The arch is generally metal, lined with fire brick. The pans fit the form much more closely to allow a better play of heat without loss, and often have corrugated bottoms to present a greater surface to the fire for quicker evaporation. The pans are also partitioned off to give a zigzag course to the sap.

Some forms have an apparatus at the side which automatically keeps a constant level of sap in the boiling parts and can be set and regulated to keep an even depth of boiling sap. The finished sirup can then be drawn off continuously.

The iron arch with its dampers allows the best results from the fire, which are hard to obtain in an ordinary arch built of masonry. Such patent evaporators can be obtained in sizes from 2 by 7 feet up to 6 by 24 feet. The larger sizes are capable of taking care of greater quantities of sap. In general, with this style of evaporator with corrugated bottom, 1 square foot of bottom is capable of concentrating about 2 gallons of sap per hour—that is, a pan 3 by 8 feet, or 24 square feet, will evaporate about 40 to 50 gallons of sap per hour and one 4 by 16 feet, or 64 square feet, will evaporate about 115 to 130 gallons per hour. Some makers have found that about 10 square feet of boiling surface are necessary for every 100 buckets set. That is, a camp of 500 trees would need an evaporator of 50 square feet. In figuring capacity, it is well to take the minimum figures rather than the average or maximum figures.

SUGARING-OFF APPARATUS.

Where maple sugar is made as a side issue or in very small quantities, it is customary to make the extra concentration in pots over the kitchen stove, but where made on a larger scale, special apparatus is used. Figure 10 shows a homemade sugaring-off pan. These pans are much shorter than the evaporators and very much deeper, generally from 2 to 2½ feet wide by 3 to 6 feet long and from 12 to

14 inches deep. The metal is usually heavy tin or in some cases galvanized iron, but never sheet iron. The sides slant toward the bottom and the edges are reenforced well with heavy wire. The illustration shows a faucet in the pan for drawing off the thickened sirup. The arch is made of brick with a fire box and ash pit. Where there is no means of drawing off the sirup the pan should be easily removed from the fire so that when the proper concentration has been reached the contents of the pan can be immediately poured out into molds.

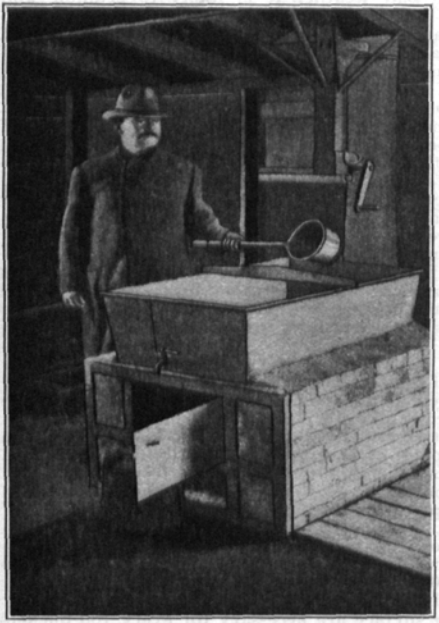

FIG. 10.—Sugaring-off outfit.

It is well to have the sugaring-off pan in a separate room in the sugar house and located so that there are at least two rafters or stringers holding the sides of the house above the pan. By attaching block and tackle to these and then having four hooks on a ring and the ring attached to the block and tackle, the hooks can be inserted into the handles of the pan and one man can easily lift the pan from the arch and swing it to the part of the room where it is to be emptied. This is found extremely convenient.

Sugaring-off pans with metal arches can be obtained. They possess numerous points of advantage over the homemade pans, the main one being the absolute control of the heat by means of dampers.

MAPLE SAP.

The discussion up to this point has been altogether along the line of apparatus used in this industry. The sap and the methods of manufacturing it into sirup and sugar will now be considered.

The flow of sap is not continuous; that is, when the tree is tapped the sap does not start to run and continue until the season closes.

It runs only when the atmospheric conditions are favorable; as a rule the run is stronger during the day than at night and quite often in the middle of the day than in morning or evening. As the changes of weather occur the sap stops, to start again when the right conditions are present, so there may be a run of sap for a day or two and a lapse of a few days before another. During a season there may be as few as two or three runs or as many as ten or twelve. Freezing weather will stop the run, as will excessive wind, too bright sun, or a warm snap.

At the beginning of the season the sap is water white, clear, and transparent and has a sweet taste, but as the season advances the color and physical appearance change. It usually becomes cloudy and yellowish and gets a peculiar odor. The composition of the sap varies considerably, depending upon the season and the tree. There is anywhere from 1 to 5 per cent of solids in the sap, of which about 95 to 97 per cent are sucrose or ordinary sugar, so the sugar content varies anywhere from 1 to 4 per cent, with an average of 2 per cent or possibly more. Besides sucrose, there is present some nitrogenous matter and some mineral matter. Reducing sugars have never been found in normal sap by the author, although many hundreds of samples have been examined.

Containing as it does nitrogenous matter and also ash, the sap is very susceptible to the growth of microorganisms, which are believed to cause the souring of sap. Edson[1] has done much work along this line and shows that the change in physical condition of the sap toward the end of the season is due to a great extent to microorganisms. When the sap is running well the danger from them is not great, but when the warm weather starts and the flow is intermittent they become very active. Therefore the sap should be collected each day and not be allowed to accumulate. It is necessary also to keep the buckets and containers clean. After each run they should be washed with warm water. This is of extreme importance in obtaining a fine grade of sirup from the later runs. One of the visible signs of sour sap is the mucous formation in the buckets. When this is noted the buckets should be cleaned out thoroughly and scalded.

The tap holes as well as the buckets become infected. This infection increases more slowly in spouts with small openings than in hollow tubes with large bore. The latter allow a drying out of the wood tissue, which drying, together with the growth of microorganisms, slackens the flow of sap and causes what does flow to be a wrong color. It is under these circumstances that reaming of the tap holes is recommended, as this removes the dry contaminated tissue. At the same time the spouts should be steamed out or fresh ones inserted. This care in the sugar bush is necessary for a good product.

"Buddy sap" is the name applied to late runs of sap, especially that running at about the time the buds in the trees start to open. It is usually green in color or may be yellowish and has a peculiar odor easily recognized. Sirup produced from this sap does not have a good flavor and is always dark colored.

[1] Vermont Agr. Exper. Sta. Bul. 151; Bul. 167.

It has been popularly believed that this "buddy" condition is due to changes in the composition of the sap within the trunk of the tree due to the renewal of vegetative activity in the tissues, and that the alteration in color and flavor is a result of this change, but Edson[1] has demonstrated that this "buddy" flavor is due to a large extent to the action of microorganisms. When this peculiar odor or flavor is noted in the sap no more sugar or sirup is made.

Other conditions of sap are known as stringy sap, green sap, red sap, and milky sap. In the first the sap is ropy or stringy and generally milky in color, the second designates one with a greenish to greenish-brown color, the third shows a reddish sediment, and the last has a peculiar milky appearance. None of these saps produce a good sirup. Although they are spoken of as "sour saps," in reality they are not sour in the strict sense of the word, as the acidity is seldom much above the normal acidity of the sap, but they are simply changed by the microorganisms. It is claimed by Edson that when holes are running this peculiar sap, if the maker will rebore the tree some distance from the old hole and put in new sterile or clean spouts, normal sap will be obtained. The season may be prolonged to some extent by this procedure, but tapping more than the second time in one season is not to be recommended.

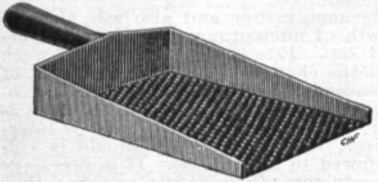
FIG. 11.—Sirup skimmer.

PROCESS OF MANUFACTURE OF MAPLE SIRUP.

CONCENTRATION OF SAP.

On frosty mornings ice is often found in the sap buckets and in some cases the whole mass of sap may be frozen. Makers differ as to whether this ice should be thrown away. Where the whole quantity of the sap is frozen it is certain that it should not be thrown away, but where ice is floating the ice should be, as the freezing water would include very little of the sugar, and the sap would, therefore, be concentrated to some extent. This method of concentration is said to have been used by the Indians.

When the sap is heated a scum forms on the surface. This is the nitrogenous matter coagulating. Should there be fine sediment in the sap as it runs to the evaporator this will be caught in the coagulum and brought to the surface, when it should be carefully skimmed off.

Figure 11 shows a form of metal skimmer which resembles an ordinary dust pan with the bottom perforated. This may have a short handle, as shown, or a long wooden pole may be attached, by means of which the scum can be raked to the near edge of the pan or kettle and then lifted off. As the concentration goes on there is a deposition of mineral matter, which may float around in the thickening sap or may be deposited on the bottoms or sides of the

[1] Loc. cit.

pans. This mineral matter, commonly known as "sugar sand," "niter," "silica," is mainly a malate of lime. Its removal will be discussed under "Cleansing and straining."

In concentrating any sugar juice there are a few fundamental facts that should be known. Sugar in solution is easily broken up by long boiling, and as the solution becomes more concentrated the temperature of boiling is raised and more decomposition takes place. Then to retain the flavor of the thin juice in the resulting concentrated sirup, it must be evaporated as quickly and at as low a temperature as possible. The time consumed in evaporation can be regulated, but the boiling temperature can not be changed except by boiling in vacuo, which on a small scale or even on a rather large scale would not be possible, as the price of installation of apparatus would be prohibitive.

When using iron kettles they should be charged and this charge concentrated, the kettles being filled once or twice with fresh sap, but a light-colored, good-flavored sirup will not be obtained by keeping up the addition of fresh sap to the boiling kettle and only "siruping off" once or twice during the day. This concentrating, then diluting, and then concentrating induces decomposition of the sugar and organic matter and therefore blackens the sirup. It is difficult, as stated before (p. 28), to obtain a fine, mild-flavored maple product from concentrating in iron kettles.

Iron pans may produce dark-colored sirup, as also may patent evaporators if they are used to concentrate sap in the way the iron kettles are used.

The way to obtain good products with pans or patent evaporators, provided the sap is not sour, is to concentrate in as thin a layer as possible, drawing off the sirup as quickly as made. Where a large single pan is used this is hardly possible, but one can put in an inch or two of sap, boil, and add more, a little at a time, so as not to stop boiling or materially change the density of the boiling liquid; then, when this charge is concentrated, the sirup should be drawn off. Care must be exercised not to allow the remaining sirup in the pan to be burned. Where more than one pan is used the sap can be placed in the one over the fire, skimmed, and partially concentrated, then transferred to the next and further boiled, then ladled to the others, the last pan being the finishing pan. As one pan is emptied the sap from the one in front is brought to it. This means allows better skimming. In patent evaporators the sap and partially concentrated sirup flow through siphons from one compartment to the other, thus doing away with the use of a ladle.

To produce the highest quality, best-flavored sirup, the sap or semiconcentrated sap should not be deeper than 1 to $1\frac{1}{2}$ inches in the evaporator at any one time. This produces a quick evaporation with the least quantity of decomposition.

CLEANSING AND STRAINING.

During concentration, as stated before, the mineral matter of the sap becomes more or less insoluble and precipitates out, a large portion incrusting the pan, and more or less floating in the semiconcentrated solution and also in the finished sirup. This makes the sirup murky and less attractive in appearance. Settling removes a large percentage of this suspended matter, and if the semisirup is filtered through flannel a greater portion is removed.

Other means recommended for removing this sediment are white of egg, whole milk, and baking soda. These are added to the sirup in the last pan and work by coagulating around the suspended matter and bringing it to the top or by liberation of a gas, causing foam to appear. Then, by careful skimming, this is removed. When used in quantities these settlers change the flavor of the sirup and, contrary to the general belief, do not render the sirup lighter in color. Baking soda, added to the finishing sirup to make it foam and bring the foreign material to the top, also tends to neutralize any acidity. Its use is a very questionable practice, for if in any quantity it darkens the sirup besides greatly changing the flavor.

This cleansing can be accomplished by allowing the finished sirup to settle or by pouring off the sirup from the evaporator through felt or flannel into the cooling cans, and as a rule this will give as light-colored sirup as when the clarifiers are used. Felt strainers shaped like caps can be obtained. Such a strainer may be 10 inches in diameter at the top and 14 inches deep. By suspending this in the neck of a large milk can and turning the edges the hot sirup readily filters through. By having cocks arranged in the settling can, the clear sirup can be drawn off from the top cock after the sirup has been allowed to stand, and then be drawn from the lower ones in turn, stopping when the sediment is reached. Double thickness of heavy flannel serves as a fair substitute for the felt. The sirup should be filtered hot, as it is very difficult to get it to pass through when cold.

DETERMINATION OF FINISHING POINT.

Commercial maple sirup weighs 11 pounds to the United States gallon. Such a sirup will have 65 per cent solids or 35 per cent water. A sirup made thinner than this—that is, containing more water—will soon sour, and one made much thicker—near 12 pounds to the gallon—will tend to crystallize. The maker has to determine the density of his product. This is often accomplished in a crude way by noting the bubbles as they break on the surface of the boiling sirup or by removing some in a spoon and watching how it pours. A more satisfactory way is either by means of a thermometer to determine the boiling point or with a Baumé hydrometer spindle to determine its density.

By thermometer: The boiling point of a liquid is influenced by its concentration and also by the altitude. Water at sea level boils at 212° F., but for every 500 feet above sea level, roughly speaking, the boiling point is lowered 1°. Therefore, at an altitude of 2,000 feet the boiling point of water is 208° F. The Vermont Agricultural Experiment Station has found that a maple sirup boiling at 219° F. weighs 11 pounds to the gallon, or is at standard density. This figure, however, changes a little, depending on the run of the sap. A first run will often boil at 217° or 218° F.

when having a concentration equal to 11 pounds to the gallon. It is necessary, then, to note the boiling point of the sirup only in the last pan to decide whether it is concentrated sufficiently. In taking this temperature, one must be sure the thermometer is correct and also that it does not touch the bottom or sides of the evaporator, but measures the temperature of the liquid only.

When a thermometer is used, if the temperature which it registers when placed in the boiling water is noted, and 7° added to this, the result will be the point at which the sirup boils when it is properly concentrated. It is of extreme importance, however, to test the

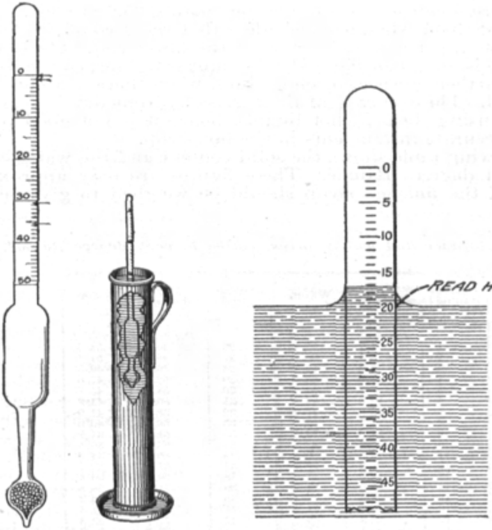

FIG. 12.—Hydrometer and its position in the liquid.

sirup again by weighing a quart or a gallon of the same after it has cooled to make sure that it has a proper density.

By Baumé hydrometer: A hydrometer or spindle is an instrument for showing the density of a liquid. Hydrometers are graduated to various scales and for various purposes. The one generally used for rough sugar work is the Baumé. The standard of graduation is an arbitrary one and varies somewhat with different makes. The usual Baumé hydrometer is made of glass and shows a graduation from zero to 50, divided into degrees, as shown in figure 12. The density is measured by floating the hydrometer freely in the liquid, which is generally held in a tall cylinder, as shown in the illustration. The point on the scale where the instrument comes to rest is considered the density. It will be noted that the surface of the liquid is curved up at the points of contact with the metal cylinder, and also with the hydrometer. The correct reading of the instrument is on a line with the surface of the liquid as shown in the cut and not at the upper edge of the curved portion. The temperature at which Baumé hydrometers are standardized is 60° F., unless it is otherwise marked on the stem of the hydrometer, so for correct readings the sirup should be cooled to that temperature. A sirup of standard density has a Baumé reading of 35.6°, but if measuring the density of the boiling liquid by drawing some out into a cylinder the density will be somewhere about 32° to 34° and on cooling 35.6° to 36°. This is readily understood when one considers that the zero of the hydrometer is at the upper end and the 50 at the lower end. On heating a liquid, there is an expansion and the liquid is lighter, so the hydrometer sinks farther down than on cooling, when there is a contraction of the liquid. The accuracy of these glass hydrometers is very much affected by using them in hot liquids, hence it is not good practice to use the accurate instruments in the hot sirup.

The following table shows the solid content and the water content for different degrees Baumé. These figures are only approximate. A gallon of the finished sirup should be weighed to give accurate results.

Dry substance and water corresponding to each degree Baumé.

Degrees Baumé.[1]	Dry substance.	Water.	Degrees Baumé.[1]	Dry substance.	Water.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
1	1.7	98.3	26	46.8	53.2
2	3.5	96.5	27	48.6	51.4
3	5.3	94.7	28	50.5	49.5
4	7.0	93.0	29	52.4	47.6
5	8.8	91.2	30	54.3	45.7
6	10.6	89.4	31	56.2	43.8
7	12.3	87.7	32	58.1	41.9
8	14.1	85.9	33	60.0	40.0
9	16.0	84.0	34	61.9	38.1
10	17.7	82.3	35	63.9	36.1
11	19.5	80.5	36	65.8	34.2
12	21.3	78.7	37	67.8	32.2
13	23.0	77.0	38	69.7	30.3
14	24.8	75.2	39	71.7	28.3
15	26.6	73.4	40	73.7	26.3
16	28.4	71.6	41	75.7	24.3
17	30.3	69.7	42	77.7	22.3
18	32.1	67.9	43	79.7	20.3
19	33.9	66.1	44	81.8	18.2
20	35.7	64.3	45	83.8	16.2
21	37.5	62.5	46	85.9	14.1
22	39.4	60.6	47	88.0	12.0
23	41.2	58.8	48	90.1	9.9
24	43.1	56.9	49	92.2	7.
25	44.9	55.1	50	94.4	5.68

[1] Taken at 60° F.

It is not to be understood that a degree Baumé corresponds to 1.7 per cent of sugar, for the hydrometer measures other dissolved solids also.

In order to determine relatively the number of degrees Baumé of the cooled sirup when the reading is made with the hydrometer at a high temperature, it is necessary to take the temperature at the same time that the hydrometer is read. Subtract 60 from the number of degrees Fahrenheit of the heated sirup (this being the normal temperature) and multiply the difference by 0.0265. This figure (which is the temperature correction expressed in degrees Baumé) is added to the Baumé reading of the hot sirup and the result is the Baumé reading of the cooled sirup. For example, a heated sirup shows a reading of 30 at a temperature of 215° F. Then—

$$215-60=155$$
$$155\times0.0265=4.1$$
$$30+4.10=34.1$$

The cooled sirup would read 34.1 or by above table have about 38 per cent water.

CANNING AND STORAGE.

After the sirup is strained or settled, it is ready for canning. Makers vary as to whether it should be canned hot or cold. Some claim that canning hot tends to induce crystallization. It is certain that when canned hot in sterile cans (steamed or washed in boiling water) there is practically no danger from fermentation. This can not be said of canning cold, although the sirup made one season is generally sold before the beginning of the next season. When made on a large scale, maple sirup is often run direct from the evaporators into barrels and so shipped, but by far the greatest number of sirup makers sell in quart, half-gallon, or gallon tin cans. These cans are generally square, with a screw cap. When being filled they are tipped slightly and then lifted by the upper edges and filled even with the screw top, which is then fastened tight with a wrench. This method applies to canning hot or warm sirup. When the cans are being filled in cold weather and with cold sirup, it is well to hold the can so that the sides are a little compressed and then fill to the top and screw the lid on. By this means no air enters and when the sides are released the can being not quite full allows for increase in volume when placed in a warmer room, without danger of breaking. Fancy maple sirup is often put up in glass and when carefully canned will keep from one season to another without souring or bursting the jar. It is best to store sirup at an even, cold temperature. Temperatures around freezing, however, should not be used, as this tends to crystallization.

CRYSTALLIZATION.

Crystallization results from making a supersaturated solution of a substance in a liquid. In the case of sirups the sucrose becomes concentrated to a point at which it is no longer soluble in the water present, and hence it crystallizes out. Maple sap, being a dilute solution of sucrose, in fact about 90 to 95 per cent of the solids in the sap being this sugar, when concentrated soon reaches a point where the sucrose will be supersaturated, and hence on cooling will start to crystallize out.

Pure water will hold in solution 66 per cent of pure sucrose at ordinary temperatures. If there is a concentration by evaporating off the water to a point where there is 66 per cent of sucrose in the resulting solution, the solution is holding all the sucrose it can without depositing some as crystals. In practice, crystallization sometimes occurs before this 66 per cent is obtained. The commercial standard gallon of sirup, weighing as it does 11 pounds to the gallon, contains at least 65 per cent solids, of which at best 95 per cent is sucrose, and should not crystallize. If, however, the resulting sirup weighs 12 pounds to the gallon, there is much more chance of crystallization.

Makers vary as to the question of the influence of hot and cold canning on the possibility of crystallization. Some claim that by canning hot crystallization is prevented, others vice versa. It seems, however, that it is more a question of the density of the product than of the heat of canning. These crystals may form in small patches or may be large individual ones. Their presence in maple sirup is often considered by some purchasers as an evidence of adulteration by addition of rock candy, which is not true to fact. Once crystallization is started, these crystals grow until solution equilibrium is attained.

Crystallization is induced in many cases by changes in temperature, the solutions becoming cold and then warm, hence it is well to store maple sirup in a place of as even temperature as possible. The first runs are more likely to show crystallization than the later ones.

MANUFACTURE OF SUGAR FROM MAPLE SIRUP.

"SUGARING-OFF."

"Sugaring-off" applies to the further treatment of the maple sirup by which it is made into a solid product. In careful manufacture of sirup, even from sour sap, a solid product may be produced by concentrating to a higher degree. But if during manufacture cleanliness has not been regarded or sour sap has been used, a solid product will not result from any amount of boiling, due to the large amount of inversion of the sucrose.

The sugar, sucrose, which constitutes about 95 per cent of the solids of the sap and, after evaporation to sirup with care, constitutes from 90 to 96 per cent of the solids of the sirup, is easily broken down or split up into two sugars known as dextrose and levulose. The former of these crystallizes easily, while the latter does not. It is the formation of these sugars from sucrose that tends to prevent the making of sugar from certain sirups. This is also the reason why late runs of sap or burned sirup or sour sirup will not yield sugar and also why some sirups will produce a hard sugar while others produce only a soft mushy sugar provided the finishing-off points are right.

Where maple-sugar making is conducted as a side line to the sirup making, the ordinary iron pot of the kitchen is filled nearly half full with the sirup and this concentrated over the kitchen fire, but where on a larger scale the sugaring-off pan (p. 29) is used. In this concentration there is a further precipitation of the malate and also a great tendency for the boiling product to froth or foam. A small piece of butter or lard or some sweet oil or a piece of fat meat, as bacon or fresh pork, run over the surface is used to allay this foaming. These may be necessary to allay the foaming at times, but great care should be used in the selection of the fat to have a neutral one with little taste or flavor and then to use it only in very small quantities, as the flavor of the product is greatly affected. If the precipitation of malate is rather heavy, the white of egg or milk may be added and this skimmed off during the boiling. Under any circumstances the boiling mass should be skimmed.

The hardness of the sugar produced is to a large extent controlled by its moisture content; also slightly by the inversion of the sucrose during the heating. As in sirup making one should "sugar-off" a charge before adding any more sirup, as this concentration and dilution and concentration again tends to blacken the product and decompose the sucrose, making hard-sugar production difficult. The proper point of stopping the boiling is best determined by means of a thermometer. Various makers have other means of determining this point, such as by dropping some of the liquid in cold water or snow, but where a product of uniform hardness is to be prepared the former method is to be preferred.

In making maple sugar some consideration must be taken of the grade and use, as, for instance, maple sugar for immediate use should be softer than that for storage and cake sugars are generally harder than tub sugar. In the first runs the boiling should be carried up to 238° or 240° F. (or 26° to 28° above the boiling point of water at that elevation) to make a medium hard sugar, while for a tub sugar (one that is sold in tubs) a temperature as low as 233° F. (21° above boiling point) can be used. With later runs of sap the finishing temperature should be 240° to 250° F. (or 28° to 38° above the boiling point). These are not absolute in all cases. The maker can experiment with the proper temperature, but to obtain a uniform product it is necessary to use a thermometer.

As to the quantity of sirup that should be "sugared-off" at one time, makers vary. Some "sugar-off" as much as 50 to 100 pounds (4½ to 9 gallons) at a time, while others only from 15 to 25 pounds (1 to 2½ gallons), the claim being that with the larger quantities the sugar is made much darker, due to the longer time consumed in boiling or concentrating.

After the thick sirup has reached the proper boiling point, it should be taken from the fire and stirred until somewhat cooled. This gives it a uniform grain and color in the mold. The finishing temperature can be made a little lower if there is vigorous stirring during the cooling period, as by this stirring much evaporation takes place. If it is not stirred the point of quickest cooling, namely, the edges, becomes hard and coarse grained and the center or part last cooled is mushy.

MOLDING.

Wooden molds are used almost altogether for large-sized cakes and tin for the smaller ones. A very convenient kind for large-sized cakes is a wooden box with the sides clamped, so that when the sugar is molded the sides can be removed. By having the sides grooved, sheets of wood or metal can be inserted and smaller cakes made from the same mold.

The mold should be dry and warm. If the mold is wet, the cake of sugar will not be of uniform color; if cold, the cake is likely to stick at the sides, causing the sugar to harden there and be soft on the inside.

GRAINED OR STIRRED SUGAR.

Grained maple sugar derives its name from the fact that it is concentrated to a high degree, then stirred continuously during cooling. A mold is not used. The finished product is, as a rule, dry and somewhat lumpy, resembling the ordinary commercial brown sugar in appearance, but, of course, retaining its maple taste. In color it varies from a nearly white to a dark brown. It has been used as a table preparation.

STORAGE OF MAPLE SUGAR.

Like brown sugar, maple sugar does not keep well in a moist atmosphere. It tends to absorb water, molds rather quickly, and if finished at too low a temperature the sugar is soft and the liquid portion drains out. Therefore sugar which is to be stored should always be boiled to a high temperature. After being taken from the molds it can be wrapped in paper, but should not be put in covered containers unless these are absolutely sealed. It is best to store the sugar in a warm room of even temperature. If the cakes are sealed without access to air, a cold place can be used, but in no case should the storage room be damp.

ECONOMIC CONSIDERATIONS.

CARE OF APPARATUS.

When the buddy sap has started to run and no more high-grade maple products can be produced it is time to close the season of manufacture. The buckets should be removed from the tree and stood upside down on the ground to dry in the sunshine. The better makers wash them, while many claim that the last sap is good to leave in the buckets, as it prevents rusting. After they are thoroughly dry they should be stacked in piles and put in the sugar house, barn, or other shelter away from the rain. In stacking, rope or straw should be placed between the buckets, so that they will not fit tight in one another. This method is of great assistance when taking the stack down at the beginning of the next season. Some buckets have a bulged circle around them, which does not allow the buckets to become wedged together in stacking. After the spouts have been removed, care being taken not to break the bark of the tree, they should be boiled in water once or twice, then allowed to dry thoroughly in a warm place before storing them in a box. The collecting buckets, hauling tank, and storage tank should be painted on the outside, and if of wood on the inside.

The evaporator should be cleaned out, the ashes removed, and a coat of asphalt paint or red iron paint given to the exposed metal parts.

The scale in the pans is best removed by boiling water in them and then using a fine wire brush. The scale, known as "sugar sand," "silica," or "malate," is a nearly pure malate of lime, the mineral matter of the sap that on concentration has been deposited in the pans when its solubility in the liquid has been reached. It has no particular economic use; some use it for scouring, and attempts have been made to use it for the preparation of malic acid. During the manufacturing season this scale should be removed from the pans after each boiling, as it hinders the boiling and requires more fuel to do the boiling.

Other methods of removing the scale are by scraping, by adding muriatic acid (hydrochloric acid) or vinegar, or by using buttermilk. Scraping weakens the pan and is not to be recommended and acids or vinegars should be used with the greatest care, as the metal of the pan may dissolve along with the scale.

After removing the scale, the pans should be washed out, thoroughly dried on the inside, and painted on the outside. They should be stored in a dry place, and turned over so as not to collect dirt or water during the summer. If a metal smokestack is used, this should be taken down, freed from soot, painted, and after drying, be stored in a dry place.

If the arch shows cracking or sagging repairs should be made during the following spring or summer rather than at the beginning of the next season. Care along these lines will preserve utensils, and they will be ready for use on a day's notice in the early spring.

YIELDS.

No very definite data can be given on the yields from the maple industry as so many factors enter into the subject. From 5 to 40 gallons of sap are obtained from a tree during a season; an average is somewhere between 10 and 20 gallons. Normal sap of an average year contains about 2 per cent of sugar, although it may vary from 0.5 per cent to as high as 7 or even 10 per cent. The sugar content varies greatly with the tree, its location, and its past growth. From one tree one can count on from 1 to 7 pounds of sugar per season, or expressed in sirup of standard density, from 1 pint to 1 gallon, though the average from year to year and from tree to tree is about 3 pounds of sugar or 3 pints of sirup. Expressing these data in other terms, it is seen that in a normal year 1 barrel of sap (32 gallons) should produce a gallon of sirup or 7½ pounds of sugar. In many camps and for many years it takes sometimes as high as 50 gallons of sap to make 1 gallon of sirup. First runs of sap are generally richer in sugar, hence take less for a gallon of sirup. From 6½ to 9 pounds of sugar, according to the kind, can be made from 1 gallon of standard sirup, with an average of 7½ to 8 pounds.

A camp of 100 trees should produce about 40 gallons of sirup or 300 pounds of sugar.

COST OF MANUFACTURE AND SELLING PRICE.

The cost of manufacturing maple products is an extremely variable figure. The season of production comes at a time of the year when little or no other work can be done on the farm, thus allowing the aid of the family and farm help for the boiling and manufacture. Moreover, since the sugar bushes as a general rule are situated on hilly country that would not be suitable for any other crop, these two items could hardly be placed at a high value in a table of costs. The individual trees of some bushes average more than those of others, and some makers use more care and obtain better yields, so, all things considered, one can hardly place an actual estimate on the cost of manufacture. Makers on a large scale claim that the cost is from 45 to 75 cents a gallon for sirup, and from 5 to 8 cents a pound for sugar. With small makers, the cost tends toward the lower limit if no help is employed, and toward the upper if help is employed. It is claimed that one man and one boy can run a camp of 500 trees and manufacture the product. There is a question, however, whether a good grade product can be produced with so little labor, as one person has to be at the evaporator all the time when the sap is boiling. A poorer grade results from loading up the evaporator and going away to collect the sap.

Ohio makers who have taken up this question of cost of manufacture believe that at 50 cents a gallon there is no profit. There have been seasons of plenty, however, when the makers were offered only 45 cents a gallon in barrel lots, and many claim they made money even at that low figure.

The grade of product is an item in the cost of manufacture. Sirup requiring only the concentrating of the sap to a standard density costs less to manufacture than sugar which requires extra evaporation. It is claimed that sirup sold in bulk at 50 cents a gallon is equal to sugar at 7 cents a pound, at 58 cents a gallon is equal to sugar at 8 cents a pound, at 66 cents a gallon is equal to sugar at 9 cents a pound, and at 74 cents a gallon is equal to sugar at 10 cents a pound, but this is hardly true as it costs at least 5 cents a gallon to turn the sirup to sugar.

The cost of placing the goods on the market varies; in the case of sirup, screw-cap cans are generally used in sizes of pint, quart, and gallon, and in the case of sugar, the fancy cake, the large brick, and the tub sugar are the usual forms.

The question as to whether the production of sirup or of sugar is more profitable can be decided only by knowing the market where they are to be sold. Maple sirup in gallon cans can be sold at from $1 up to $2, while in barrels as low as 45 cents has been paid for it. Seventy to seventy-five cents, however, is a better average price for sirup in barrel lots. Sugar sells anywhere from 7 to 25 cents a pound, depending on the grade and form. The highest price is obtained for maple sugar put up in small, 1 or 2 ounce cakes, while possibly the lowest is for brick and tub sugars. An ordinary price is about 10 to 15 cents a pound.

FARMERS' ASSOCIATIONS.

It is practically impossible to produce a grade of sirup of uniform flavor and color. The run of sap and manufacturing conditions are the principal factors influencing these qualities. A maker often finds it impossible to make the same grade on different days with practically the same run of sap; therefore to have uniformity one should mix the various lots into two or more standard grades. A purchaser does not know why there are such differences in the product and wants two successive purchases of the same brand to be of the same grade; one desires the mild, sweet, maple flavor, while another wants the stronger flavor, and in order to satisfy these demands and at the same time build up a business a number of makers could cooperate to ship their products to a certain point and then reship. This is actually being done in Vermont, and after many years' trial it has been found to be of great advantage to the individual maker.

It is to be regretted that selling in large amounts is not done more on a sliding scale, depending on color and flavor. Many organizations and buyers offer better prices for the lighter-colored and milder-flavored product, thus stimulating producers to more cleanly methods of manufacture and so to a better profit in the business. It seems safe to say that this sliding-scale method is coming more into use, for without it there is no incentive for making the better grades of sirup and sugar.

ACCESSORIES TO MANUFACTURE.

FUEL.

Fuel is an important item in manufacture. It is usually wood, although sometimes supplemented by coal. Before the winter sets in the woodshed mentioned in the description of the boiling house (p. 27) should be filled with cordwood and small brush, as green wood does not produce a hot fire and requires too much attention from the man attending to the evaporator. Wood cut in the spring and piled under cover for the next spring's work will be dry and good. The amount that will be needed depends on the kind and dryness. Some makers state that about 8 cords of wood are necessary for 500 trees; last season one man used 10 cords of wood and 5 tons of coal for manufacturing sirup from 1,000 trees, and another used 35 cords of wood with 4,000 trees.

LABELS.

In preparing labels, there is one point possibly not well understood; that is, the distinction between sap sirup and sugar sirup. Maple sap sirup results from the concentration of maple sap with or without the usual clarifiers to a standard density. Maple sugar sirup is the solution to a standard density of maple sugar which has come from a further concentration of sap sirup. It is then not correct to label a product as a sap sirup which has resulted from the solution of maple sugar nor as a sugar sirup when made from sap. Both are maple sirups. As a rule sap sirups are sweeter, pleasanter to taste, and milder than sugar sirups, and possess a peculiar indescribable property of the sap which is lost when sugar is made and redissolved.

A suitable paste for paper labels on tin cans is prepared from—

Silicate of soda	½ ounce.
Cornstarch	1 ounce.
Cold water	1½ pints.

Add the starch and silicate to the water and stir until the whole is smooth, then place the vessel in another one containing a little water and heat until the starch is gelatinized. This paste should be made often, as it soon loses its sticking properties.

PAINT.

Any paint will serve for the outside of sap buckets, gathering pails, and storage tanks. The ordinary red paint of an iron oxid base is one in common use. It is often difficult to make paint stick to metal, because of the grease on the surface, but this difficulty can be removed by washing the metal surface with soap and water or a little benzin and drying it before the paint is applied. Farmers' Bulletin 474, on The Use of Paint on the Farm, gives details regarding this and other paints and should be consulted. For the inside of such apparatus, where the sap comes in contact, it is a questionable procedure to use white-lead paints on account of the solubility of the lead. Some form of enamel would be better, but the price may prohibit its use. The iron paint already mentioned will serve admirably for this purpose.

Sap buckets should be painted in the summer or fall and then thoroughly dried before being set away. Never paint just before opening the camp, as metal buckets freshly painted inside have a marked tendency to taint the sap. There is the same objection to freshly painted wooden buckets, but in this case it will not last as long.

For the ironwork of the evaporator nothing better can be recommended than an asphalt paint or the ordinary iron paint, which should be applied after thorough scraping at the close of the season. Its use will greatly lengthen the life of this apparatus.

STATISTICS OF THE MAPLE SUGAR AND SIRUP INDUSTRY OF THE UNITED STATES.

It is a rather difficult task to obtain figures for the actual amount of maple products produced in the United States, first, because the products are made in small quantities by many farmers, and, second, because a large part of them does not reach the market, but is sold to friends of makers. The census reports for the years 1850 to 1910 give figures for maple production, sugar only having been reported in 1850, while in the other years sirup also was given. These have been arranged in order of their importance in production—first, maple sirup; and, second, maple sugar, as reported by the 1910 census, in which year reports from 79,381 farms on maple sirup and 29,444 farms on maple sugar were received.

Maple sirup production of the United States.

(U. S. Census Reports.)

[In gallons.]

No.	State.	1910	1900	1890	1880	1870	1860
1	Ohio	1,323,431	923,519	727,142	495,839	352,612	370,512
2	New York	993,242	413,159	457,658	266,390	46,048	131,843
3	Vermont	409,953	160,918	218,252	128,091	12,023	16,253
4	Pennsylvania	391,242	160,297	154,650	140,667	39,385	114,310
5	Indiana	273,728	179,576	180,702	242,084	227,880	292,908
6	Michigan	269,093	82,997	197,775	131,990	23,637	78,998
7	Wisconsin	124,117	6,625	48,006	58,012	31,218	83,118
8	New Hampshire	111,500	41,588	81,997	79,712	16,884	43,833
9	Massachusetts	53,091	27,174	33,632	13,017	2,326	15,307
10	Maine	43,971	16,024	71,818	82,006	28,470	32,679
11	West Virginia	31,176	14,874	19,032	28,696	20,209	....
12	Illinois	18,492	9,357	13,978	40,077	10,378	20,048
13	Minnesota	17,808	1,079	12,091	11,407	12,722	23,038
14	Maryland	12,172	5,825	1,021	2,043	374	2,404
15	Missouri	9,389	5,474	8,333	16,244	16,317	18,289
16	Iowa	8,596	2,662	14,413	17,766	9,315	11,405
17	Virginia	6,046	1,677	3,468	7,518	11,400	99,605
18	Connecticut	4,236	948	1,437	2,173	168	2,277
19	Kentucky	3,547	2,367	10,468	27,530	49,073	140,076
20	New Jersey	504	....	134	334	5	8,088
21	North Carolina	404	129	1,142	582	418	17,759
22	Tennessee	373	171	1,186	3,688	4,843	74,372
	Total [1]	4,106,418	2,056,611	2,258,376	1,796,048	921,057	1,597,589

[1] The totals include small amounts not reported under individual States.

The amount of sirup made in the individual States varies somewhat from year to year. Ohio leads in the six years for which the figures are given, New York standing second except in 1870 and 1860. Indiana stands third in two years, being second in 1860 and 1870 and fifth in 1890 and 1910. Vermont is fourth in 1900, third in 1890 and 1910, and sixth in 1880, falling far short of this in the other two years. The variation in these figures is influenced partly by the relative production of maple sugar, as some States use much more sap for sugar than others.

Maple sugar production of the United States

(U. S. Census Reports.)

[In pounds.]

No.	State.	1910	1900	1890	1880	1870	1860	1850
1	Vermont	7,726,817	4,779,870	14,123,921	11,261,077	8,894,302	9,897,781	6,349,357
2	New York	3,160,300	3,623,540	10,485,623	10,693,619	6,692,040	10,816,419	10,357,484
3	Pennsylvania	1,188,049	1,429,540	1,651,163	2,866,010	1,545,917	2,767,335	2,326,525
4	New Hampshire	558,811	441,870	2,124,515	2,731,945	1,800,704	2,255,012	1,298,863
5	Maryland	351,908	264,160	156,284	176,076	70,464	63,281	47,740
6	Michigan	293,301	302,715	1,641,402	3,423,149	1,781,855	4,051,822	2,439,794
7	Ohio	257,592	613,990	1,575,562	2,895,782	3,469,128	3,345,508	4,588,209
8	Massachusetts	156,952	192,990	558,674	878,793	399,800	1,006,078	795,525
9	West Virginia	140,060	141,550	177,724	310,866	490,606	....	....
10	Virginia	44,976	19,310	26,991	85,693	245,093	938,103	1,227,665
11	Kansas	40,016	....	....	....	938	3,742	....
12	Indiana	33,419	51,900	67,329	235,117	1,332,332	1,541,761	2,921,192
13	Wisconsin	27,199	4,180	128,410	488,837	507,192	1,584,451	610,976
14	Maine	15,388	5,500	84,537	153,334	160,805	306,742	93,542
15	Missouri	11,638	12,055	20,182	58,964	116,980	142,029	178,910
16	Minnesota	11,399	29,580	34,917	76,972	210,467	370,669	2,950
17	Kentucky	10,697	2,340	11,259	66,535	269,416	380,941	437,405
18	Connecticut	10,207	4,930	8,617	44,092	14,266	44,259	50,796
19	Iowa	6,173	2,320	45,120	50,710	146,490	315,436	78,407
20	Illinois	5,366	4,090	13,260	80,193	136,873	134,195	248,904
21	Tennessee	4,326	1,160	9,167	31,296	134,968	115,620	158,557
22	North Carolina	3,305	1,180	7,713	4,103	21,574	30,845	27,932
23	New Jersey	1,195	....	210	2,496	419	3,455	2,197
	Total [1]	14,060,206	11,928,770	32,952,927	36,576,061	28,443,645	40,120,205	34,253,436

[1] The totals include small amounts not reported under individual States.

As noted with sirup, the production by States varies somewhat from year to year. Vermont stands first in all the years reported but 1860, when it was second to New York. New York is second in all the years except 1860. According to these figures, these two States produced over 77 per cent of the total crop in 1910, over 70 per cent in 1900, over 74 per cent in 1890, over 60 per cent in 1880, over 54 per cent in 1870, and nearly 50 per cent in 1860 and 1850. These two States, together with Pennsylvania, Ohio, New Hampshire, Maryland, and Michigan, have produced over 90 per cent of the total maple sugar since 1880.

The money value of the maple (sugar and sirup) industry for 1910 was $5,177,809. The rank of the States is as follows: New York, $1,240,684; Ohio, $1,099,248; Vermont, $1,086,933; Pennsylvania, $417,213; Michigan, $333,791; Indiana, $300,755; and New Hampshire, $182,341.